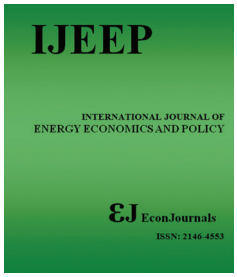


International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2018, 8(4), 110-119.

A Regression Analysis of Determinants Affecting Crude Oil Price

Wajdi Hamza Dawod Alredany*

Dhofar University, Foundation Program, Salalah, Sultanate of Oman. *Email: walredany@du.edu.om

ABSTRACT

Studies and researches have been carried out on factors affecting crude oil prices; however, in most of these studies factors that have contributed to the fluctuation in oil prices, e.g. days of forward supply, convenience yield, underinvestment and geopolitics have been ignored. The importance of financial variables and geopolitics has also increased volume of transactions that would today represent about thirty-five times the oil traded in the physical market. This paper describes a new model of the most important variables that affect crude oil prices by using a new technique called principal component analysis (PCA) that can capture the Fundamental and geopolitical variables. Results indicate that fundamentals and the role of organization of petroleum exporting countries are the most important variables that affect crude oil prices.

Keywords: Oil Price, Regression Analysis, Organization of Petroleum Exporting Countries
JEL Classifications: E39, C13

1. INTRODUCTION

Historically, oil prices have witnessed two major stages, the first stage started from 1859 when the oil was discovered till 1970, when organization of petroleum exporting countries (OPEC) was established and established itself as one of the important players in oil market. The second stage started from 1970 till present where new producers and government companies have entered the market such as oil of North Sea, the Gulf of Mexico and the opening up of Russia.

Recently, the demand of oil has increased in markets emerging in countries such as China and India. This increase is expected to continue in future, possibly at a more moderate rate (EIA, 2008); however, the supply of oil during this period has also increased to some extent. Additionally, it is important to consider distribution, concentration of oil reserves and production of oil in markets. The fact cannot be neglected that a large portion of oil supply in the Middle East provides OPEC with market power to control oil prices by simply adjusting volumes. This explains that the supply of oil market is under oligopoly, managed by a few sellers.

Many conferences have been held to identify factors that determine oil prices in order to avoid shocks and instability in oil market and to minimize their effect. For example, the conference in October 2009 by minister of France economy concluded that the last crisis in 2008 had led to a huge upsurge in oil financial markets and led way to new variables such as; "under investment in new production capacities, speculation by some financial actors, financial investors, and the functioning of financial oil markets" (Chevalier, 2010; Aregbeyen and Fasanya, 2017).

Many studies and researches have examined factors affecting crude oil prices that have contributed to the fluctuation of oil prices. Nevertheless, the last oil price crises in 2008 led to a high global refinery utilization though refineries did not respond fast enough to raise the demand of oil. Moreover, Kaufman et al. (2008) argued that there is empirical evidence that speculation and futures markets played a major role in past crises, as it also resulted from a crisis in the housing market and financial variables (Hamilton, 2008; Almutairi and El-Sakka, 2016).

The focus of this research was to increase the knowledge and understanding of crude oil prices behavior through an analytical and empirical study. Therefore, this research aims to answer the question whether oil price is determined by OPEC variables. Oil prices movements in the last two decades has witnessed many changes; in supply side, the emergence of new producers of oil like Canada, Alaska and North Sea oil. In addition, some of the oil wells have become economic due to the increase in oil prices. In

demand side, the big increase in economic growth of East Asian countries such as China, India and Malaysia. China has become the second largest country in the world in oil consumption, which reflects the changes in the content of demand equation. Moreover, the new instructions on environment pollution have encouraged the use of light oil, which contains less sulfur. These instructions have increased the pressure on refining utilization. Therefore, refining utilization will be highlighted in this study to show that it might be a bottleneck.

2. LITERATURE REVIEW

In general, the evolution of oil prices can be divided into two stages; first, the period of 1860-2000, which was the beginning of quiet, oil supplies adequately meeting all oil demands and ensuring market stability. The prices were very low according to exhaustible theory; the price of oil must increase at least at a rate equal to the rate of interest (Hotelling, 1931). The second period is from 2000- till present. The period has witnessed the emergence of OPEC as a new force and the use of oil as a weapon. In addition, the entry of new producers in the oil market like Canada and the North Sea and the emergence of national companies that have contributed to weaken the control of the cartel of oil companies. This period also reflects the interactions between the market fundamentals (supply and demand) and financial variables (speculation and future markets). New theories have appeared such as bubbles theory to explain the changes in oil prices. In addition, the importance of future markets and speculation has increased while the market power of OPEC has also emerged as a dominant producer in terms of production capacity and oil reserves.

2.1. First Stage: Oil Price Before 2000

In its origin in the middle of the 19th century, oil market was driven by a demand for light kerosene, a by-product of refined kerosene. However, after the invention of the combustion engine and automobiles, gasoline became the main product in the market. The first discovery of crude oil in the United States was in Pennsylvania in 1859, by (Edwin Drake) which started its production rate at 30 mb/day. However, the price of crude oil had not appeared on the commercial scale until 1860, when the oil price was 9.59 dollars per barrel which dropped after 1 year to become 0.49 dollars per barrel as shown in Table 1. Such a massive decline in just 1 year was mainly because of the competition between monopolistic companies as well as the excess oil exploration done at that time.

The table shows the annual average crude oil price from 1860 to 2012. The prices were very low in the beginning as compared to the prices nowadays, even if we consider the price index for inflation. The table also shows, low prices for the whole period until 1970 when the oil prices ranged <$3 per barrel. For the period 1948 till the end of the 1960s, oil prices ranged from $2.5 to $3.0/barrel and stayed stable during the period 1958-1970 around $3.0 per barrel. One of the major consequences of the OPEC formation was that it prevented the reduction of posted prices since its beginning. Though OPEC was not effective in the beginning, even though in the 1967 Arab-Israeli War, it did not function successfully. This ineffectiveness can be explained by the behavior of international oil companies that tried to ignore the cartel completely and by using the principle of "divide and rule." They tried to deal with each country separately and since the countries were not that united, this policy was successful to some extent.

In summary, oil prices during this stage were very low and stable as compared to recent years. The cartel dominated oil market in all its stages from exploring until marketing. But the cartel's control began to decline slowly owing to many factors such as; the emergence of OPEC, new discoveries of oil in the middle east, nationalization of oil in Iraq, Iran and other countries and so on.

2.2. Crude Oil Prices from 2000 – Present

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

2.2.1. 2000-2003

This period was characterized by the stability of oil prices between 22 -28 $/b. OPEC succeeded in organizing its production measures in order to keep oil prices stable at the level agreed upon by all members. It was useful from their experience in previous years when prices fell to 10 $/b in 1998. However, the second Gulf War in 2003 did not significantly affect the stability of the price (Chevalier, 2010). During this period oil prices, which had sustained its rise due to the growing US and global economy, suddenly crashed with the increase in production coming from Russia and events like attacks on World Trade Centre in 2001and political effects that resulted a fall in the oil prices.

A few other events in 2002 kept crude oil price stable around $30 per barrel (p/b) such as OPEC's decision to reduce their production quotas by 1.5 mb/d; Iraq's disagreement with UN decision to send back arms inspectors to Iraq that put a great pressure on the oil price. By mid-year 2002, the EIA issued data showing that oil stocks fell to their lowest levels in the last 20 years around $32 for WTI oil price. This decline can be explained due to the general strike in Venezuela and the geopolitical events in the Middle East at the same time (EIA, 2007).

2.2.2. 2003-2008

This period witnessed an upward trend in oil prices. The Oil price of West Texas Intermediate (WTI) increased to 60 $/b and then to 80 $/b as a result of a combination of factors such as:

- The increase in global demand due the world economic growth especially of the emerging countries in east of Asia;
- The significant increase of oil demand from China and India, especially in the last 10 years in line with the evolution in these two countries. In fact, many analysts argued that China and India have reshaped the landscape (Annual Energy Outlook, 2006).

Table 1: Annual average crude oil price for the period 1860-2012 in $/pb

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

Source: http://inflationdata.com/inflation/inflation_rate/historical_oil_prices_table.asp

- The global demand of oil exceeded global refining capacity in 2004, especially after the new instructions of energy agency that urged the use of light oil, for reasons related to the environment and reducing the risk of environmental pollution. Thus, these instructions increased the pressure on refining utilization and thereby raised the price of oil.
- The rapid growth in the financial field - the volume of transactions increased to about 35 times a day from the oil trade in the actual market (Chevalier, 2010).

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

As said earlier, the early price increase in 2003 was generated by the political events in the OPEC member countries that made oil market unstable. Moreover, Venezuela faced problems in production because of strikes and political changes in January followed by the threat of the US invasion of Iraq resulting in high pressure on prices. especially United States depended much on the Iraqi oil reserves. During the US invasion, in the mid of March, the Iraqi production declined resulting in a big loss of production capacity in Iraq and price rose to $31 p/b. Similarly, Nigeria also faced political unrest at the same time, when violence broke among several ethnic groups in the Niger Delta area. Simultaneously, the demand for oil was continuously increasing

during this period, especially from Asia Pacific due to the increase in the rate of economic growth for these countries. On the other hand, the US witnessed a very cold winter in 2003, which made a significant increase in US domestic consumption. Thus events in Iraq, Venezuela and Nigeria combined together resulting in an increase in the global demand and price spike in 2003. Political turbulence in Saudi Arabia also encouraged the increase in oil prices to $42 p/b, quoted as highest in nearly two decades at that time, according to NYMEX.

Despite numerous attempts by OPEC to maintain crude oil prices and prevent abrupt risings, there are still many indicators which reduced non-OPEC production and increased oil prices. First, it was the Russian government's decision to freeze all the assets of the bank accounts of Yukos (one of largest oil producers in Russia). Second, oil market strikes in September 2003 inflicted by Hurricane Ivan, which hit the Gulf of Mexico and made about 61-percent production loss.

In late 2005, the oil price witnessed a small downtrend when Nigeria resumed its production after the conflict in Niger Delta area. In addition, British petroleum also began its first commercial crude oil production from the Central Azeri field in the Caspian Sea. This resulted in the price rise once again reaching $58 p/b in April 2005. This increase in oil prices is also attributed to concerns of the weak dollar for a long time. In July and August 2005, the price continued to raise severely due to several disruptions in production resulted from natural disasters in Gulf of Mexico such as storm Cindy, Hurricane Emily, Hurricane Dennis and Hurricane Katrina. These disasters made severe damages to Gulf of Mexico production facilities. In addition, they had a significant impact on oil refineries in the area. As a result, refining capacity declined about 2.2 mb/d, and drove the price of crude oil to rise to $66 p/b in September 2005. As a response to the previous hurricanes, United States government had tried to reduce the pressure on oil supply by releasing 30 million barrels of crude oil from the SRP.

Likewise, in 2006, European production also faced difficulties through worker strikes in one of the largest oil refineries. Labor conflicts in the Netherlands and Nigeria had already affected oil production, while political instability started again over the Middle East. All these events had put greater pressure on the oil price.

Hence, several factors have made upper pressure on oil prices and contributed to the rise in oil demand in 2006 but a weakened oil supply due to natural disasters and geopolitical instability. OPEC though adjusted its oil output levels, and attributed the rise in oil prices to lack of excess global refining capacity, but not to lack of production by OPEC members.

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

2.2.3. The Period 2008-until Present

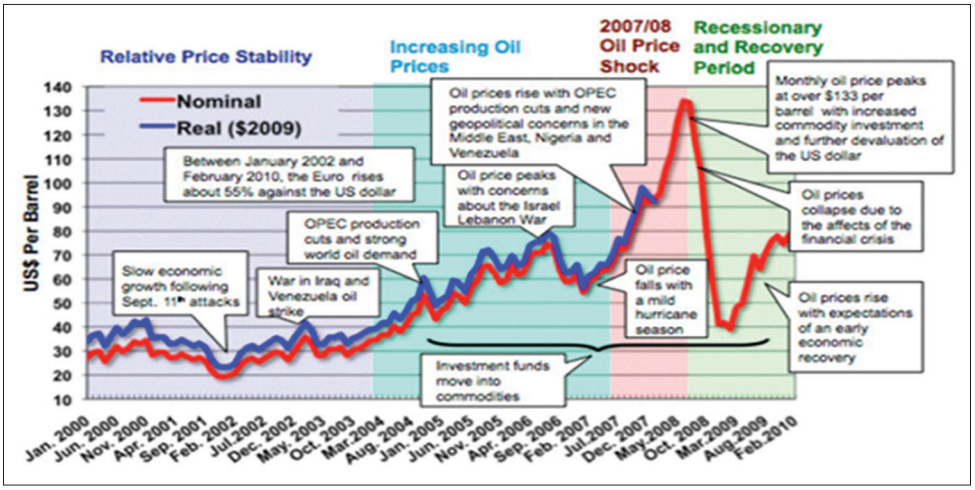
In the early part of 2008, oil prices reached new levels and broke all-time records. In January, 2008 trading was done at a price $100 p/b; in March, the price reached $ 110 p/b and increased again in April to $119 p/b. This increase was due to the political events between US and Iran; when the U.S. Navy opened fire on one of the Iranian boats when they reached the port. The oil prices continued to rise robustly making it the biggest 1-day raise in history. By the end of the month, London Brent Crude was trading at $ 147 p/b. The main driver for this price increase was probably the political instability in the Mid-East and they were afraid of the possibility of Israel's attack on Iran. The price jump was also due to the tautness between the U.S and Iran (the second largest member in OPEC); and a fair action taken by OPEC to block the Strait of Hormuz. By the end of July, the price of oil jumped down to $128 p/b and in August declined to $113 p/b, finally by the end of 2008 summer the price came done once again to $100 p/b.

In the beginning of September, 2008 a Hurricane hit the Gulf of Mexico, which was considered heart of the US oil refineries. Eventually the oil price declined to about $100 p/b and in late September, it fell down below $100 p/b when the US Congress failed to pass the 700-billion-dollar bailout program. In October, 2008 oil traded between $ 70 and 78 p/b. This drop can be seen as effectiveness of the US bank rescue plan to re-establish demand and OPEC production cuts. Meanwhile the US dollar had also become stronger and the decline in European demand was supporting the oil price decline (EIA, 2008).

The crises period of 2006 can be summarized as follows: WTI oil prices increased in the beginning of 2008 and reached around 147 $/b by July of the same year. Many analysts see that this crisis was caused by economic factors that resulted in loss of confidence in banks and the customers withdrew all their deposits from the banks. This action led to the bankruptcy of many banks. But after July of 2008 oil prices fell down once again to <40 $/b by the end of the year. Analysts like (Kaufman et al., 2008; Kaufman, 2011 and Mobert, 2007) argued that the decrease in oil prices was due to the financial adjustment and falling in oil demand at the same time as shown in Figure 1. The figure shows the evolution of WTI monthly oil price during the period from January 2000 to February 2010 in nominal and real dollars of United States. This figure clearly shows how the crisis took place in 2008, followed by great depression of 2009 and how prices started to rise again in 2009 upto 80 $/b. This increase can be explained as due to a reduction in OPEC production to protect oil prices and due to the increase in oil global demand.

In summary, during the period between 1970 and 2000, OPEC became the dominant party in the oil market instead of a cartel of oil companies. This control however gradually decreased due to the emergence of new producers and success of IEA members to reduce their dependence on OPEC oil by finding new sources. Finally, the emergence of financial crises in Russia and Asia was also seen as a new type of crisis. This led to emergence of a call for cooperation between producers to prevent further decline in oil prices.

Figure 1: West texas intermediate oil prices 2000-2010



Source: Canada energy and U.S. Energy Information technology (2010)

The period 2000- until the present has also faced many events: Such as instability in oil prices, political events, emergence of OPEC as an influential force in oil market and emergence of new forces such as China and India. There was also a growth in future markets and increase in speculation with the emergence of new theories to explain the fluctuations in price of oil and presence of a global fear that the crisis could come back again.

2.3. OPEC's Role

Oil crisis in 1973 encouraged many writers and analysts to write about market power who described OPEC as the dominant producer in oil market during this period. Salank (1976), for instance, was one of the first analysts who used the concept of Nash-Cournot equilibrium. This concept meant that, some players ignored the other player's reactions. As a result, other producers took the path of price from the dominant producer and affected the marginal producers. Hamilton (2008) also studied the share of OPEC production over the past 5 years, and argued that although the numbers published for the production cannot be trusted because of cheat in the quota and non-compliance with the specified production ceiling. In addition, he found consistency between the share of OPEC and real production.

The dominant model emphasizes the structure of OPEC as a cartel. In this model, there is one dominant producer. Saudi Arabia sets the price, for instance, and allow the other OPEC producers to sell any quantity of oil they wish, to cover the rest demand. Therefore, Saudi Arabia was the swing producer, trying to absorb the fluctuations in supply and demand in order to maintain monopoly prices to protect member interests. With such an arrangement, the monopoly firm is easy to operate. This approach runs the risk of inducing sufficient new production outside Saudi Arabia, thus, making the strategy unworkable and ineffective for the dominant producer.

The problem that faced the dominant producer was how to choose a price that maximizes its wealth over a period of time. It can set high prices, which induces the competitor fringe, and it must accept the decline in future market shares and profits. Alternatively, it may choose to set low prices to deter entry and expansion of fringe competitors depending on the rate of discount.

We can also question the credibility of OPEC by looking at the ads reserves of member countries. Its proven reserves in excess of what seem exactly the amounts of production per year, and by the changes in the sizes, which are almost non-existent.

However, OPEC i9n order to be able to use its strength in oil market, needs to achieve two factors: First, to create spare capacity given the flexibility to respond to market changes in case of shortage or surplus. Hence, according to statistics announced by the energy information administration (2009), OPEC's spare output capacity was averaged 2.8 million b/d during the period 1999-2009 and by 2013 OPEC expected to have spare capacity output of approximately 6 million barrels a day. Saudi Arabia has the largest capacity among OPEC's members as well as in the world due to Aramco's huge expansion in 2008 (US Energy Information Administration, 2009). The second factor was the internal discipline to control production which was verified in the last period, although the fraud exists, but the rate is lower than the market in the eighties.

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

3. METHODOLOGY

The study adopts linear regression analysis. All variables are in logarithms (except the dummy) because it helps to transform large numbers to small ones and it is easier in terms of taking the differences between variables (Holden, 1997). In this section quarterly FOB crude oil prices are taken, data set contains 96 observations from Q3, 1986 to Q3, 2010. The length of the data sample is also subject to data availability. The data are obtained from secondary sources like; World Bank, United States energy information administration, international energy agency, penn world tables, statistical review of world energy, annual statistical

bulletin, international monetary fund and intercontinental exchange. Thus, the main sources may come from the channels below:

- Data for oil prices obtained from the monthly energy review (various years).
- Annual values for OPEC capacity obtained from Erik Kriel of the US DOE/EIA.
- Quarterly values for OPEC capacity interpolated by assuming a constant rate of change between annual observations.
- Data for OPEC production obtained from the OPEC annual statistical bulletin.

3.1. Data

Table 2 presents a summary of descriptive statistics of the variables, which include sample mean, standard deviation, skewness and kurtosis, Jarque- Bera statistics and P-value.

Table 3 presents a summary of descriptive statistics of the variables, which includes sample mean, standard deviation, skewness and kurtosis, Jarque-Bera statistics and P-value.

The mean and the median of all variables are close together. It indicates that the variables are normally distributed, which are symmetric about their means. In addition, the Jerque-Bera test also indicates the variables that follow normal distribution except the Dummy variable for Gulf War and future prices. From the computed values of Jerque-Bera[1] for all the variables are less than the critical value equals to 9.21, at 1-percent significance level. Hence, the null hypothesis of normality is not rejected for all the variables. The Jarque-Bera (JB) test is based on the classical measures of skewness and kurtosis. As these measures are based on moments of the data, this test has a zero breakdown value, which means a single outlier can make the test worthless (Oztuna et al., 2006).

Researchers including (Mabro, 2006; Mobert, 2007; Fattouh, 2007; Hamilton, 2008, 2009 and 2011; Kaufman et al., 2008; Kaufman, 2011; Tiwari, 2015; Ozturk, 2015; Katircioglu, 2017; Okere and Ndubuisi 2017; Hsu and Tsai, 2017) argued the significant changes in oil prices and adopted specific variables to analyze reasons for oil price changes.

3.2. Model Specification

Oil price equation in this model is used as an instrument to calculate OPEC effect on crude oil prices as follows. At any given price, oil demand determines the quantity of oil supplied. Non-OPEC producers adjust their production according to the new

Table 2: Descriptive statistics for the crude oil prices model

Descriptive statistics	LRP	LRIGS	LOPCAPUTIL	LOECDDAYS	LFUT4	TLCY	DUMMY4
Mean	1.602	3.330	−2.290	−1.078	1.449	0.087	0.960
Median	1.575	3.312	−2.308	−1.081	1.329	0.100	1.000
Maximum	1.930	3.551	−1.714	−1.024	2.0919	0.159	1.000
Minimum	1.359	3.126	−2.850	−1.126	1.1239	0.001	0.000
Standard deviation	0.129	0.096	0.201	0.024	0.2579	0.040	0.197
Skewness	0.575	0.464	0.221	0.196	0.9019	−0.569	−4.695
Kurtosis	2.637	2.478	2.838	2.413	2.4959	2.508	23.042
Jarque-Bera	6.066	4.720	0.923	2.073	14.6029	6.400	2040.979
Probability	0.048	0.094	0.630	0.355	0.001	0.041	0.000
Sum	160.181	332.990	−228.969	−107.787	144.885	8.737	96.000
Sum Sq. Dev.	1.635	0.920	3.997	0.057	6.563	0.160	3.840
Observations	100	100	100	100	100	100	100

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

Table 3: Measurement of OPEC variables and sources of data

Variables	Description	Measurement	Source of data
$OP_t^{caputil}$	Capacity utilization for OPEC. Denotes the rate at which the processing capacities of the available refineries utilized.	$\left(\left(\frac{OP^{Pro}}{OP^{Cap}} * OP^{Quo}\right) / \left(\frac{OP_t^{Che}}{\text{global oil demand}}\right)\right)$	Monthly energy review
OP_t^{Che}	OPEC cheat is the difference between OPEC production and OPEC quotas,	$OP_t^{Che}=OP^{Pro} - OP^{QUO}$	Monthly energy review
OP_t^{Quo}	OPEC's production shares in mbd.	See eq. 3.3	Monthly energy review
		$PROD_{OPEC}=DEM_{World} + \Delta Stocks_{OECD} - NGLS_{Natural\ gas\ liquid} - PROD_{Non-OPEC} - PG_{Process}$	
$RIGS_{total}$	Total oil rigs	Rig count, an indication of drilling activity	Baker Hughes BHI International Rig Count
$Days_t^{OECD}$	Days of forward consumption	OECD days ratio of OECD's oil stocks divided by Q OECD	OECD
$War^{Gul\ 1}$	Dummy variable added to explain the first gulf war 1990 in Iraq.		
$War^{Gul\ 2}$	Dummy variable added to explain the second gulf war 2003 in Iraq.		

price. In sequence, OPEC will equilibrate supply and demand as a swing producer. The oil price equation measures to what extent the OPEC responds to satisfy the call for its oil due the measure of capacity utilization and production relative to quotas.

For the objective of this study (that oil prices are determined by OPEC variables), a PCA is suggested for following reasons:

PCA is a multivariate statistical technique, which calculates the principal directions of variability in data and transforms the original set of correlated variables into a new set of uncorrelated variables. The new uncorrelated variables are linear combinations of original variables. These principal components represent the most important directions of variability in a dataset. Therefore, PCA can be considered as a powerful tool for analyzing data (Smith, 2002; Stock and Watson, 2002; Bernanke et al., 2008; Zagaglia 2010; Tatyana, 2010).

Generally, PCA has two main objectives (Tatyana, 2010).

- To discover or to reduce the dimensionality of the data set.
- To identify new meaningful underlying variables.

In this study the price of west texas intermediate (WTI) has been used in regression. Being a reference oil for North America, WTI has high quality oil due to its low sulfur content and its low density (Energy Information Administration, 2006). The corresponding future contracts traded at New York Mercantile Exchange (NYMEX) are the most liquid futures contracts worldwide. In addition, NYMEX is the world's largest commodity market. For this reason, this data series is especially suited for the purpose of this research although several futures market variables are included in the econometric specifications.

3.3. Selecting Variables

The main objective of this study is to identify the main OPEC variables that affect the price of crude oil. Thus, in order to achieve this goal the following variables are selected.

3.3. Total Oil Rigs

The cost of developing new oil wells has a large impact on the supply side. As it reflects the upward movements in the costs associated with exploring new oil fields. According to Baker Hughes, if the number of active rotary rigs is increased, it could be an indicator for oil supply products. The number of rotary rigs has increased significantly during last 10 years. In addition, total rotary rigs may be considered as an instrument to measure upstream investment in crude oil industry. Also, they provide an indication for current level of oil production. Hamilton theory explains an inverse relationship between total rigs and price of oil. When the number of rigs rises, quantity of oil extracted also increases. This leads to an increase in oil supply but decreases oil prices accordingly. Therefore, we assume a negative relationship between number of rigs and crude oil price, ceteris paribus.

3.4. Days of Forward Consumption

OECD days as a variable represents the duration of forward consumption and stocks of OECD crude oil. We can calculate it by dividing the stocks of OECD over demand of crude oil. Mobert (2007) used OECD stocks to create a variable called Days of Forward Consumption. In addition, Kaufmann et al. (2008) found an inverse relationship between days of forward consumption and crude oil prices: As the number of days of forward consumption increase, there will be a negative effect on crude oil prices. However, the sign could be positive or negative, depending on the shortage or surplus in oil market. In other words, if Market instability increases for any reason such as an economic shock, there will be an increase or decrease in oil reserves for a certain number of days of consumption. Although this variable is used as a strategic reserve to protect the OECD economies for security reasons, but it can also be used for speculation in oil prices.

3.5. OPEC

Globally total oil production nations are divided into two groups: OPEC and non-OPEC. The significant of OPEC nations increased as they stated 40% of world production of crude oil, 55% of exports of crude oil, and more than 66% of world reserves of crude oil (OPEC, 2009), while North Sea oil and Canada have felt a steady decline. Therefore, the following indicators can show the impact of OPEC on oil prices (Mebert, 2007; Kaufman et al., 2004, 2008 and 2009):

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

Hamilton (2008) has studied the share of OPEC's announcements for the last 5 years; he found that some members were producing above the level specified for them, and some of them less. Hence, we assume that there is an inverse relationship between OPEC cheats and price of oil.

4. FINDINGS

Conflicts lead to an increase in market instability and fear of interruption supplies, pushing the price of oil towards the top. In addition, the role of OPEC in oil market is a main dominant of oil market as we mentioned. Table 3 shows the selected variables.

4.1. Multicolinearity

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

The presence of multicollinearity usually results in an overstatement of the standard error, i.e. the standard error tends to be large, leading

Table 4: The correlation coefficient and Collinearity Statistics

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics
	B	Std. Error	Beta			Partial	Part	Tolerance	VIF
LOECDdays	0.495	0.315	0.092	1.571	0.119	0.161	0.087	0.890	1.124
LOPQUO	0.476	0.145	0.301	3.280	0.001	0.322	0.181	0.362	2.761
LRIGS	0.962	0.091	0.721	10.515	0.000	0.737	0.582	0.650	1.538
Dummy	−0.073	0.037	−0.112	−1.976	0.051	−0.201	−0.109	0.952	1.050
tLOPCPU	1.603	2.084	0.076	0.769	0.444	0.079	0.043	0.314	3.183
tLopcheat	54.801	50.571	0.073	1.084	0.281	0.112	0.060	0.666	1.500

Table 5: Correlation matrix for crude oil prices model

Correlations	Lrp	LOECDdays	LOPQUO	LRIGS	Dummy	tLOPCPU	tLopcheat
Pearson Correlation							
Lrp	1.000	0.065	0.436	0.809	−0.071	−0.500	0.328
LOECDdays	0.065	1.000	−0.223	0.052	0.033	0.192	−0.121
LOPQUO	0.436	−0.223	1.000	0.303	0.060	−0.756	0.016
LRIGS	0.809	0.052	0.303	1.000	0.017	−0.485	0.420
Dummy	−0.071	0.033	0.060	0.017	1.000	−0.067	0.170
tLOPCPU	−0.500	0.192	−0.756	−0.485	−0.067	1.000	−0.311
tLopcheat	0.328	−0.121	0.016	0.420	0.170	−0.311	1.000
Sig. (1-tailed)							
Lrp	-	0.262	0.000	0.000	0.241	0.000	0.000
LOECDdays	0.262	-	0.013	0.303	0.371	0.028	0.115
LOPQUO	0.000	0.013	-	0.001	0.276	0.000	0.436
LRIGS	0.000	0.303	0.001	-	0.433	0.000	0.000
Dummy	0.241	0.371	0.276	0.433	-	0.254	0.045
tLOPCPU	0.000	0.028	0.000	0.000	0.254	-	0.001
tLopcheat	0.000	0.115	0.436	0.000	0.045	0.001	-
n							
Lrp	100	100	100	100	100	100	100
LOECDdays	100	100	100	100	100	100	100
LOPQUO	100	100	100	100	100	100	100
LRIGS	100	100	100	100	100	100	100
Dummy	100	100	100	100	100	100	100
tLOPCPU	100	100	100	100	100	100	100
tLopcheat	100	100	100	100	100	100	100

Table 6: KMO and Bartlett's test

KMO and Bartlett's test	
Kaiser-Meyer-Olkin measure of sampling adequacy.	0.622
Bartlett's Test of Sphericity	
Approx. Chi-Square	2022.433
df	55
Sig.	0.000

to small "t" value and a high coefficient of determination. The usual procedure when multicollinearity exists is to drop the offending variable or alternatively to drop the variable that provides lesser contribution towards model improvements. A simple procedure to determine which variable to drop is to calculate the correlation matrix. The correlation matrix on Tables 4 and 5 represents the correlation coefficient and Collinearity Statistics for the variables used in this study.

On another hand, if the VIF is a reciprocal of tolerance (1/tolerance), the larger VIF values indicate a greater variance of regression weight of predictor. Therefore, the VIF value is >10, this indicates multicollinearity. The VIF and Tolerance are expressed as below:

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

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

4.2. PCA

PCA is a statistical technique that deals with a large number of (correlated) variables and reduces them to a smaller number of uncorrelated linear combinations, called principal components that account for the most variability in original variables. More details about PCA can be found in Jolliffe (2002). PCA has a long history as a statistical technique for analyzing time series. It is also applied to all kinds of financial markets, becoming an extremely useful and fruitful technique in multivariate analysis, assisting, in particular, in estimation of several multi-factor financial models and in identification of main risk factors in large portfolios of correlated financial assets (Bai, 2002). Moreover, for PCA, it can be applied to determine factors that can explain variations of crude oil prices. In order to do so, factors described above are used to build seven principal components that may represent a linear combination of initial factors.

Table 7: Principal components analysis

Principal components analysis	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10	PC 11
Standard deviation	5.390	1.981	1.324	1.084	0.692	0.308	0.168	0.040	0.007	0.006	0.001
Proportion of variance	48.997	18.007	12.038	9.851	6.290	2.801	1.525	0.366	0.064	0.056	0.005
Cumulative Proportion	48.997	67.004	79.042	88.893	95.183	97.983	99.509	99.875	99.939	99.995	100.000

Table 8. Pattern Matrix

Variables	Component 1	Component 2
LWD	0.938	
LWS	0.935	
LFU4	0.912	
LOPQUO	0.880	0.460
Lrp	0.793	
LRIGS	0.653	−0.409
LCY1	−0.627	
LOECDdays		
nlOPCPUtil		0.992
LOpcheat		−0.887
Dummy04		

Table 9: Component correlation matrix

Component correlation matrix		
Component	1	2
1	1.000	−0.145
2	−0.145	1.000

KMO and Bartlett's Test of Sphericity is used to measure sampling adequacy that recommend checking the case to variable ratio for the conduct of analysis. In most academic and business studies, KMO and Bartlett's tests play an important role for accepting sample adequacy. While the KMO ranges from zero to one, the world-over accepted index is over 0.6. In addition, the Bartlett's test of Sphericity relates to significance of a study and thereby shows validity and suitability of responses collected to the problem addressed in this study. For Factor Analysis it is recommended that the Bartlett's Test of Sphericity must be <0.05. The results of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's test of Sphericity are significant as shown in Table 6 which indicate the suitability of data for structure detection.

Table 7 shows the results for seven principal components. According to this method, each principal component is constructed in such a way that variance is maximized. In our particular case, the first principal component PC1 explains 49 % of variance of data set, while principal components PC1, PC2, PC3, PC4 together account for 89 % of total variance in data set. Scree plot is used to determine the number of component analysis as shown in Figure 2. It is clear that the first two components can explain the most variation in oil prices. Since the first principal components explain around 63 % of total variance of data set.

Based on the results of principal components analysis, seven main variables are chosen from eleven variables considered. The choice is made by simply estimating the distance between each single factor and a chosen axis that should be minimal. Since the first principal components explain around 49 % of total variance of data set, seven factors that are located should be as close as possible to PC1 axis chosen and as shown in Figure 3.

Figure 2: Scree plot for the principal component analysis

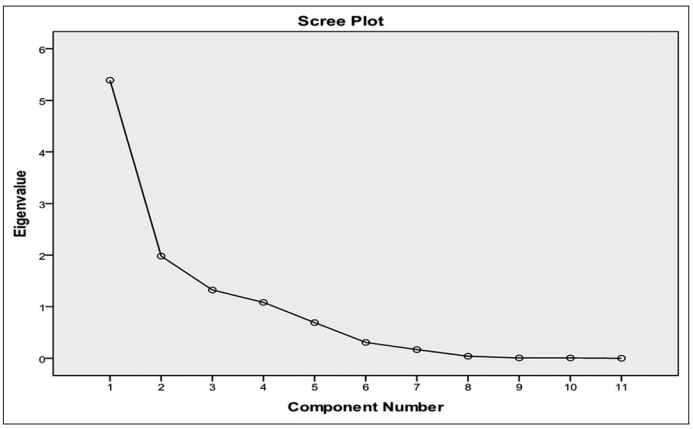


Figure 3: Component plot in rotated space

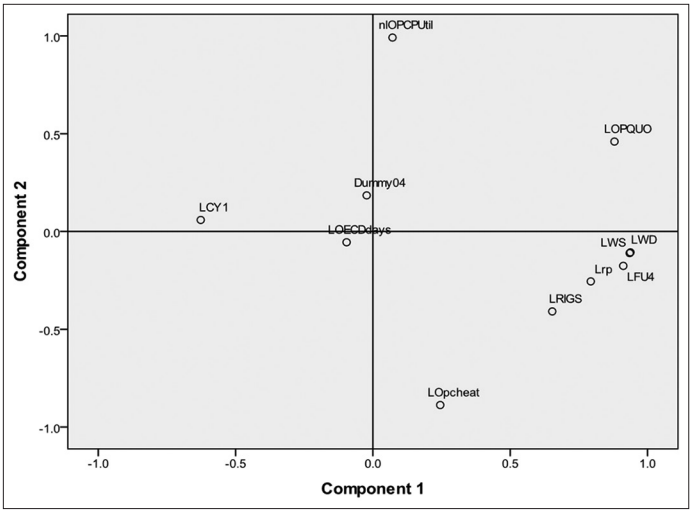


Figure 3 Plot of factors in PC1-PC2 coordinate system - factors corresponding to the points lying along with the horizontal axis assumed the important factors.

Tables 8 and 9 give evidence that a use of PCA substantially improves the results according to Eigen values. Now almost all estimators are significance, positive signs except for convenience yield and OPEC capacity utilization. The Component Correlation Matrix shows very low correlation between PCA1 and PCA2 (0.15) which gives more evidence that the number of components extracted is correct.

5. CONCLUDING REMARKS

In this study, we have examined the relation between crude oil prices and main OPEC variables. PCA shows that seven variables are vertically aligned which supports that oil prices

are determined mainly by OECD days, OPEC supply and total oil rigs.

REFERENCES

Almutairi, H., El-Sakka, M.I.T. (2016), Determinants of housing prices in an oil based economy. Asian Economic and Financial Review, 6(5), 247-260.

DOE, U., Admin, E.I. (2005). Annual Energy Outlook 2005, with Projections to 2025. DOE/EIA, 383.

Aregbeyen, O., Fasanya, I.O. (2017), Oil price volatility and fiscal behaviour if government in Nigeria. Asian Journal of Economic Modelling, 5(2), 118-134.

Bai, X., Russell, J.R., Tiao, G.C. (2002), Kurtosis of GARCH and stochastic volatility models with non-normal in- novations. Journal of Econometrics, 114(2), 349-360.

Bernanke, B.S., Boivin, J., Eliasz, P. (2008), Measuring the effects of monetary policy: A factor-augmented vector autoregressive (FAVAR) approach. Quarterly Journal of Economics, 120(1), 387-422.

Chevalier, J.M., Baule, F., Lasserre, F., Odonnat, I., Viellefond, E., Laffitte, M. (2010), Report of the Working Group on Oil Price Volatility. French Ministry for the Economy, Industry and Employment.

Energy Information Administration, 2007-2010.

Fattouh, B. (2007), The drivers of oil prices: The usefulness and limitations of non-structural models, supply-demand frameworks, and informal approaches. EIB Papers, 12(1), 128-156.

Gileva, T. (2010), Econometrics of Crude Oil Markets (Doctoral Dissertation, Thesis Submitted to the Department of Economics, University of Paris).

Hamilton, J.D. (2008), Understanding Crude Oil Prices: National Bureau of Economic Research.

Hamilton, J.D. (2009), Causes and Consequences of the Oil Shock of 2007-2008: Brookings Papers on Economic Activity. p215-261.

Hamilton, J.D. (2011), Historical Oil Shocks (No. w16790). National Bureau of Economic Research.

Holden, K. (1997), A comparison of forecasts from UK economic models and some Bayesian vector autoregressive models. Journal of Economic Studies, 24(4), 242-256.

Hotelling, H. (1931), The economics of exhaustible resources. The Journal of Political Economy, 39(2), 137-175.

Hsu, T.K., Tsai, C.C. (2017), Explore the impact of the trading value, the oil price and quantitative easing policy on the Taiwan and Korea stock market return with quantile regression. Asian Economic and Financial Review, 7(1), 15-26.

Jolliffe, I.T. (2002), Principal Component Analysis. 2nd ed. New York: Springer-Verlag.

Katircioglu, S (2017), Investigating the role of oil prices in the conventional EKC model: Evidence from Turkey. Asian Economic and Financial Review, 7(5), 498-508.

Kaufmann, R.K. (2011), The role of market fundamentals and speculation in recent price changes for crude oil. Energy Policy, 39(1), 105-115.

Kaufmann, R.K., Dees, S., Gasteuil, A., Mann, M. (2008), Oil prices: The role of refinery utilization, futures markets and non-linearities. Energy Economics, 30(5), 2609-2622.

Kaufmann, R.K., Dees, S., Karadeloglou, P., Sanchez, M. (2004), Does OPEC matter? An econometric analysis of oil prices. The 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(4), 550-558.

Krichene, N. (2002), World crude oil and natural gas: A demand and supply model. Energy Economics, 24(6), 557-576.

Mabro, R., editor. (2006), Oil in the 21st Century: Issues, Challenges and Opportunities. USA: Oxford University Press.

Mobert, J. (2007), Crude Oil Price Determinants (No. 186). Darmstadt Discussion Papers in Economics. Monthly Energy Review (various years).

Okere, K., Ndubuisi, P. (2017), The role of stock market development on economic growth in OPEC countries: Does oil price movement matter? Fresh evidence from Nigeria. Asian Journal of Economic Modelling, 5(2), 194-207.

Oztuna, D., Elhan, A.H., Tiiccar, E. (2006), Investigation of four different normality tests in terms of Type 1 error rate and power under different distributions. Turkish Journal of Medical Sciences, 36, 171-176.

Ozturk, F. (2015), Oil price shocks-macro economy relationship in Turkey. Asian Economic and Financial Review, 5(5), 846-857.

Smith, L.I. (2002), A tutorial on Principal Components Analysis Introduction.

Stock, J.H., Watson, M.W. (2002), Macroeconomic forecasting using diffusion indexes. Journal of Business and Economic Statistics, 20, 147-162.

Tiwari, A.K. (2015), Oil price and exchange rate in Malaysia: A time-frequency analysis. Asian Economic and Financial Review 5(4), 661-670.

Outlook, A.E. (2009). Energy information administration. Department of Energy, 92010(9), 1-15.

Zagaglia, P. (2010), Macroeconomic factors and oil futures prices: A data-rich model. Energy Economics, 32(2), 409-417.