Iran. Econ. Rev. Vol. 21, No. 3, 2017. pp. 519-541

Historical and Variance Decomposition for Oil Price, Oil Consumption, OPEC and Non-OPEC Oil Production

Somayeh Azami[*1], Shahram Fattahi[2], Mehdi Rezaei[3]

Received: 2016, September 28 Accepted: 2017, March 1

Abstract

In this paper, the behavior of the real oil price and OPEC and non-OPEC oil production during 1973-2013 are modelled. Interactions among OPEC, non-OPEC oil production, global oil consumption, and the real price of crude oil are estimated using a Structural VAR model (SVAR). After providing evidence for the structural breaks in oil price in 1996, the results indicate that, according to variance decomposition analysis, during the two periods of 1973-1996 and 1997-2013, OPEC oil production responded significantly to positive shocks of global oil consumption and non-OPEC oil production responded significantly to shocks of OPEC oil production. During the OPEC era (1973-1996), real oil price responded significantly to positive shocks of OPEC oil production and during the new industrial age (1997-2013) responded significantly to positive shocks of global oil consumption. According to historical decomposition, the cumulative effects of structural shocks of non-OPEC oil production and price on OPEC oil production are greater than the cumulative effects of structural shocks of OPEC oil production and real oil price on non-OPEC oil production. Also, cumulative effects of structural shocks of OPEC oil production on real oil price are greater than cumulative effect of structural shocks of non-OPEC oil production on real oil price**.**

Keywords: OPEC Oil Production, Non-OPEC Oil Production, Global Oil Consumption, Oil Price.

JEL Classification: Q_{43}, E_{32}, E_{31}.

1. Introduction

Hamilton (2013) defined five major periods during which significant

---

1. Department of Economics, Faculty of Social Science and Education, Razi University, Kermanshah, Iran (Corresponding Author: sazami_econ@yahoo.com).

2. Department of Economics, Faculty of Social Science and Education, Razi University, Kermanshah, Iran (sfattahi@ razi.ac.ir).

3. Department of Economics, Faculty of Social Science and Education, Razi University, Kermanshah, Iran (mehdirezaei4051@gmail.com).

changes in oil price have occurred: let there be light (1859 -1899), power and transportation (1900 -1945), the early postwar era (1946 - 1972), the age of OPEC (1973 - 1996) and a new industrial age (1997 - 2010). Among significant events that occurred during the “age of OPEC”, we can refer to OPEC embargo on those countries that supported Israel (1973-1974), Iranian revolution (1978-1979), Iran-Iraq War (1980-1981), the great price collapse (1981-1986), and the first Persian Gulf War (1990-1991). East Asian Crisis (1997-1998), resumed growth (1999-2000), Venezuelan unrest and the second Persian Gulf War (2003) and growing demand and stagnant supply (2007-2008) were the events that occurred during the new industrial age.

In this paper, the behavior of real oil price and OPEC and non-OPEC production behavior during 1973-1996 and 1997-2013 are modelled. Interactions among OPEC and non-OPEC oil production, global oil consumption, and real oil price are estimated using a structural VAR model (SVAR).The contribution of this study is to analyze the behavior of the real price of crude oil, OPEC and non-OPEC oil production by taking global oil consumption into account. Gately (2007) stated that in comparing OPEC to non-OPEC oil production as a combination of world oil production, it is important to recognize that oil consumption in OPEC countries is rapidly increasing. Gately et al. (2013) point out that since 1970 domestic consumption of OPEC oil has risen steeply and that collectively in recent years OPEC oil consumption approaches that of china. They argued that this result would be associated with major consequences for OPEC oil production, export level, and global oil price. Kilian and Hicks (2013) indicate that rapid growth of emerging economies led to increase in the real price of crude oil during 2003-2008. In the following, the existing literature is reviewed. Stationary of oil prices, with respect to exogenous and endogenous structural breaks, is the subject of section three. Research model and the time path of its variables are explained in section four. Model estimation and conclusion are given in section five and six.

2. Literature Review

How oil production or oil consumption affect oil prices? On the other hand, how oil production and oil consumption are affected by oil price? Global supply and demand and its associated changes, seasonal changes, growth pattern and global economic condition, weather conditions, speculation, dollar value, and prices of other energy carriers are among the major and minor factors that have direct impact on crude oil price.

The factors that have the greatest effect on global oil demand may be economic growth of different countries that is an incentive for increased energy needs, population growth, amount of savings, raised productivity and increased price (especially fuel consumption in the transport sector). It should be noted that demand for crude oil is a sub-demand or derived demand, since, in fact, demand of demanders is to use oil products and total demand for oil products makes demand for refiners of crude oil. Due to global economic growth and growth of energy increase for this purpose, and to predict energy consumption at all levels (of course, natural gas and coal will have the highest growth), Department of Economic and Social Affairs of international organization has estimated per capita income growth rate equal to 2% per year for developing countries and oil share relative to total primary energy will be reduced but will still have the first place among other energies and of course America (the largest energy consumer)'s dependence to imported oil also increases.

Regarding supply, price control is one of the factors that affect this issue. Sometimes, the amount of supply changes to cover market demand (which also affects the growth of prices) and sometimes countries use oil for political purposes so government decisions and their political positions can be regarded as a factor affecting oil supply. In the global oil market, oil-producing countries are divided into two categories of OPEC and non-OPEC. Market price is one of the most important factors that affect the amount of oil production of non-OPEC countries. Past experience has demonstrated that with rising price of oil, Non-OPEC oil production increases. However, remaining underground reserves and growth of global demand due to world economy growth has been also effective in supply level of non-OPEC countries. World oil prices have been largely influenced by OPEC ability to regulate supply of remaining oil reserves. Production and supply increase by non-OPEC countries will reduce oil prices, even more. This will be compensated for by decreasing OPEC production and stabilizing oil prices so as to make OPEC successful in controlling dependent production.

The relationship between OPEC and non-OPEC oil production and oil prices are widely discussed in empirical literature. Ramcharran (2001) used target-revenue theory and data from 1973 to 2000 and concluded that OPEC members reduce oil production to stabilize price and to increase oil revenues. Dées et al. (2007) employed a structural econometric model (policy simulations) and data from 1995 – 2000 and argued that real oil price is affected by oil market and OPEC behavior. Policy simulations indicate that OPEC decisions about quota and capacities used by its members have significant impact on oil prices. Kaufmann et al. (2008) used Vector Error Correction Model (VECM) and explained that real price of crude oil have positive impact on OPEC members' production, in general, and the size of the effect depends on the capacity of oil reserves. Simpson (2008) employed ARCH and GARCH models and data from 1982-2007 and suggested that since early 2003, a significant increase was observed in oil prices. The increase is largely due to changes occurred in oil supply. In this study, the most important factor that caused OPEC oil production influencing on crude oil prices was structural lag in OPEC's production. Li (2010), based on Granger causality test and cointegration test, concluded that if OPEC is able to affect oil prices through its collaboration with other members, we expect a general connection between OPEC oil production and oil price as well as oil price and non-OPEC oil production and these three can affect each other. Kolodzeij and Kaufmann (2014) used CVAR model and proved that reductions (increases) in OPEC oil production raise (lower) oil prices and direct link between these two suggests a positive relation between oil prices and transportation costs. Kisswani (2015) used causality and cointegration tests and data from 1970- 2012 and concluded that OPEC oil production makes no change in oil price. Ratti and Vespegnani (2015) used SVAR model and showed that OPEC oil production during 1974-1996 was more affected by non-OPEC production and then during 1997-2012 was affected by oil price. Cumulative effects of structural shocks of oil price and non-OPEC oil production on OPEC oil productionis greater than cumulative cumulative effects of structural shocks of oil price and OPEC oil production on non-OPEC oil production. Loutia et al. (2016) used EGARCH model and showed that the impact of OPEC's announcements on oil prices (i) evolves over time and among decisions, (ii) is more significant for production cut and maintain.

Few studies investigated the relationship between oil consumption and oil prices. Gately (2007) showed that if OPEC expands its oil exports by enough, fast OPEC oil consumption growth continues and this requires OPEC countries to increase their oil export by 60% untill 2030 which is very challenging. By profit maximization and price reaction function,Wirl (2008) showed that rising oil prices in the 2000s resulted from low demand elasticity, high growth in newly industrialized countries, and lack of development of required production capacities; the results of this study are approved by Smith (2009), Hamilton (2009), Alcosit and Geraris (2013), Fattouh et al (2013), and –Huppmann (2013). Kilian (2009) employed SVAR model and took global oil production, indicators of real economic activity, and oil prices in to account to conclude that oil prices are affected by global oil demand. Using Ordinary Least Squares regression and cointegration methods and data from 1971 – 2010, Gatelyet al. (2013) indicated that there was a nine-fold increase in Saudi Arabia's oil consumption in 40 years which is 37% faster than its income growth. They pointed out that of OPEC's domestic oil consumption is rising since 1970 and in recent years OPEC oil consumption has approached to China's oil consumption and this result has major implications for OPEC production, export levels, and world oil prices.Kilian and Hicks (2013) indicated that rapid growth of emerging economies led to increase in the real price of crude oil during 2003-2008. Based on expansion of world oil supply, Rowland and Mjelde (2016) showed that more impacted countries are relatively more politically unstable and are more influenced by global oil demand. Also, considering policies to reduce world oil demand, oil production are decreasing.

3. Endogenouse Structural Breaks

Priliminary studies on stationary of oil prices were carried out using Augmented Dickey Fuller (ADF) and Philips-Perron’s (PP) tests. These conventional and valid tests have numerous advatangous in determining data stationary; however, they do not consider possible breaks of variables'processes which may result in false inferences about the existence or non-existence of unit root in time series. In this case, Pindyck (1999) showed that oil prices are non-stationary. Perron's (1989) leading study showed the impact of structural shift on the unit root tests and analytically-experimentally proved that structural shift in stationary time series can result in spurious unit root. Gulen (1997) carried out Perron's (1989) Dickey Fuller unit root test with an exogenous structural break (February 1986) found that 2 series of 15 series of cash price and 3 series of 13 series of contractual prices of US and non-US crude oil are stationary at 5%. In his second study (Gulen, 1998), using Perron's (1989) Dickey Fuller unit root test with an exogenous structural break (February 1986) for Nimax's self, 1, 3, and 6 month data during March 1983 – Octobere 1995, he failed to reject hypothesis of a unit root for oil prices. Perrons (1989) specified an exogenous structural break while researchers such as Zivot-Andrews (1992), Lumsdaine-Papell (1997), and Lee and Strazicich (2003 and 2004) proposed hypotheses for determining the date of endogenous structural change. Sirlits (1992) published the first research that tested stability of oil prices with an endogenous structural break. He employed ZA (Zivot-Andrews (1992)) test to reject unit root hypothesis for future prices of daily Nimax energy between July 1983 and July 1990. Sadorsky (1999) employed ZA and PP tests for measuring monthy data of US oil from January 1947 to April 1996. Both tests indicated that real crude oil prices are stationary. Lee et al. (2006) and Postail and Picchetti (2006) measured unit root nature of crude oil prices for two endogenous structural breaks. Lee et al. (2006) carried out LS (Lee and Strazicich's (2003 and 2004)) unit root test with two structural breaks during 1870-1990, once with a linear trend and once with a non-linear (quadratic) trend. In the linear test with two endogenous structural breaks (1896 and 1971), all natural resource prices were stationary. In the non-linear test with two breaks (1914 and 1926), 5 series of 11 series of natural resource prices were approved as having a unit root. Using annual data and LS test and considering 2 endogenous structural breaks in the intercept and trend during 1861-1999, Postail and Picchetti (2006) indicated that the prices stationary. They found that with annual data, length of a sample period is an important factor in determining the stationary of the variable. Maslyuk and Smyth (2008) studied cash and self price of WTI crude oil and Brent from 1991-2004 as well as LS test showed that each series of oil price can be identified as a random walk process and that, based on events that impacted on global oil markets, endogenous structural breaks are significant.With ZA, LP (Lumsdaine-Papell (1997)), and LS tests, Ghoshray and Johanson (2010) could not reject unit root hypothesis for monthly data from January 1975 to Decembere 2007 with two endogenous structural breaks. Generally, stationary of oil prices are rejected by most of the researchers. Research findings mainly depend on the break selected for model and data frequency. Researches that confirmed stationary of oil prices were mainly based on LS test and annual data with 50-140 years length.

4. Data Sources, Variables and Model

The research methodology is based on Kilian (2009) but global oil production growth is divided to two parts of OPEC and non-OPEC oil production growth based on Ratti and Vespegnani (2015) and economic growth is replaced with global oil consumption growth. A SVAR model is considered for annual data from 1973 to 2013, a 40-year period. Structural Vector Auto-Regressive model (SVAR) is defined as:

$$B_o X_t = \beta + \sum_{i=1}^{j} B_i X_{t-i} + \varepsilon_t \qquad (1)$$

Where j is optimal lag length and is determined by appropriate lag determining criteria, ε_t represents mutually and serially uncorrelated structural shock vector. The vector X_t can be expressed as:

$$X_t = [dlogOOP_t, dlogNOOP_t, dlogOC_t, dlogOP_t] \qquad (2)$$

Contemporaneous restrictions are considered as the following equation:

$$B_o X_t = \begin{bmatrix} 1 & 0 & 0 & 0 \\ C_{21} & 1 & 0 & 0 \\ C_{31} & C_{32} & 1 & 0 \\ C_{41} & C_{42} & C_{43} & 1 \end{bmatrix} \begin{bmatrix} \Delta logOOP_t \\ \Delta logNOOP_t \\ \Delta logOC_1 \\ \Delta logOP_t \end{bmatrix} \qquad (3)$$

In Ratti and Vespegnani (2015), contemporaneous restrictions are based on Kilian (2009) and are expressed as:

$$B_o X_t = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ C_{31} & C_{32} & 1 & 0 \\ C_{41} & C_{42} & C_{43} & 1 \end{bmatrix} \begin{bmatrix} \Delta logOOP_t \\ \Delta logNOOP_t \\ \Delta logGGDP_t \\ \Delta logOP_t \end{bmatrix}$$

ΔlogGDP is growth in global GDP. Given the three restrictions, in Ratti and Vespegnani (2015), results of the study are approved.

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ C_{21} & 1 & 0 & 0 \\ C_{31} & C_{32} & 1 & 0 \\ C_{41} & C_{42} & C_{43} & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ C_{31} & C_{32} & 1 & 0 \\ C_{41} & C_{42} & C_{43} & 1 \end{bmatrix}, \text{ and } \begin{bmatrix} 1 & C_{12} & 0 & 0 \\ 0 & 1 & 0 & 0 \\ C_{31} & C_{32} & 1 & 0 \\ C_{41} & C_{42} & C_{43} & 1 \end{bmatrix}$$

OPEC Oil Production (OOP), Non-OPEC Oil Production (NOOP), and Oil Price (OP) data are derived from US Energy Information Administration (EIA) website and global Oil Consumption (OC) data are taken from BP website for 1973-2013. Since monthly OC data was not available, annual data are used. Figure 1 depicts OOP and NOOP time routes. OOP and NOOP values are defined by logarithm in million barrels per day.

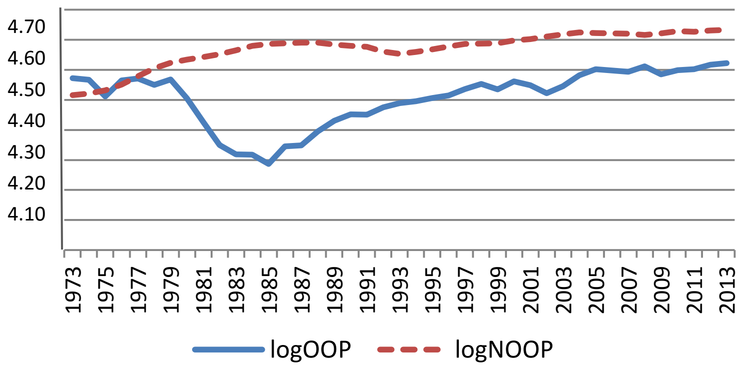

Figure 1: OPEC Oil Production (OOP) and Non-OPEC Oil Production (NOOP) Time Routes

OPEC oil production had a declining trend from 1980 to 1985. During this period, due to lowered demand for OPEC oil caused by non-OPEC supply and use of alternative resources, OPEC oil production experienced a change in behavior. Saudi Arabia, the regulator of the first half of the 1980s, was rulled out in the second half of 1980s to take back its lost market share and OPEC adopted quota share system. From 1985 to 2007, OPEC production witnessed an almost increasing trend. It seems that oil production of non-OPEC countries has been more stable over the years. Oil supply of non-OPEC countries indicates a light increasing trend.

Figure 2 depicts the time route of real oil price. Values are defined in logarithm of real oil price (in USD) that are presented based on price index for 2000.

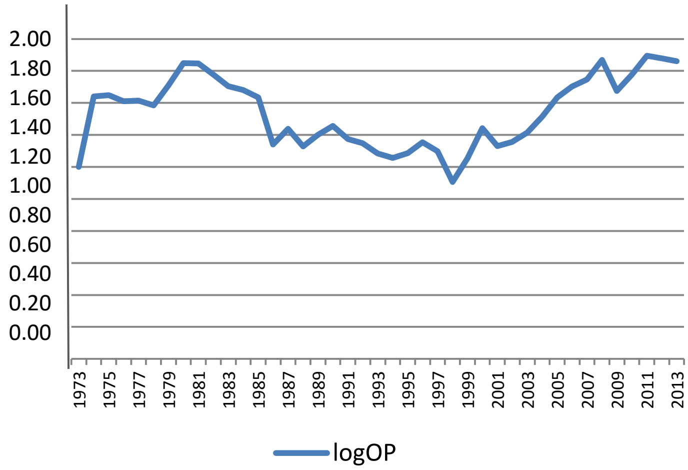

Figure 2: Oil Real Price Time Route

During 1980s, due to elimination of US price controls over oil industry (1981), lowered global demand for oil (1973-1983), and Saudi Arabia policy change from regulating to striving to take back its lost market share, crude oil real price reduced globally. During 1990s, after Iraq invasion of Kuwait, to compensate for Iraq and Kuwait oil, Saudi Arabia increased its oil production so as to meet the market demand. One of the most important events of this period can be the collapse of the Soviet Union which paved the way for international companies to find new sources. Emergence of new producers such as

Russia, Kazakhstan, Tajikistan and Azerbaijan greatly influenced world oil marketin this period. During 2000s, given the oil market changes from 2000-2008, rising oil prices may be attributed to factors such as US budget deficit, its impact on global prices, economic development of China and India and increased demand for oil, devaluation of dollar as compared to other currencies, continuation of the nuclear dispute between Iran and West, and growing speculation in the market.

Figure 3 depicts global OC time route. Global OC values are defined by logarithm in million barrels per day.

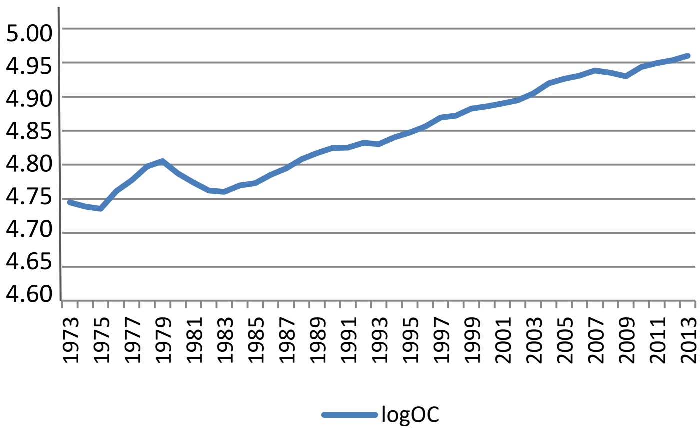

Figure 3: Global Oil Consumption Time Route

Sharp increase in crude oil prices in 1979 and 1980 made industrial countries to take further oil saving and effective measures by replacing oil with other sources of energy. So, reducing trend for global oil consumption continued from 1979 to 1983 and after that, because of economic growth, world population growth, and energy consumption growth, we were witness of increasing oil demand until 2013.

5. Model Estimation and Empirical Results

In economic modeling and econometric of time-series, stationary of time-series variables should be examined. Time series data is one of the most important types of data used in the empirical analysis. Post-1990 researches have shown that stationary hypothesis (mean and variance of variables are time-independent and constant over time) has proved to be wrong for many of macroeconomic time series and most of these variables are time-dependent and non-stationary. Studies have shown that in case of failure of stationary hypothesis, employing F-statistic and t-statistic may be misleading and it would be more probable that the obtained results are only a spurious regression with no actual balanced economic relationship.Therefore, variables have to be examined to see whether they are stationary or not. To do so, the generalized Augmented Dickey Fuller (ADF) unit root test is employed. Test results are given in table 1.

Table 1: Test for Unit Root*

Level	ADF	Difference	ADF
$LogOOP_t$	-3.317	$dLog(OOP_t)$	-4.779
$LogNOOP_t$	-2.700	$dLog(NOOP_t)$	-3.568
$LogOC_t$	-2.813	$dLog(OC_t)$	-3.727
$LogOP_t$	-1.843	$dLog(OP_t)$	-5.493

* The test is conducted in the constant trend state.

Resource: Research Findings

Results indicate that unit root hypothesis for all variables in levels cannot be rejected at 5% significance level but the hypothesis can be rejected for these variables in first differences at 5% significance level.

When there is a structural break in economic variables, conventional unit root test, including generlized Augmented Dickey Fuller (ADF) (1979) and Philips-Perron (1988), give misleading results (biased toward not rejecting the null hypothesis when there is a structural break in the time series data (Perron 1989)). Since during the investigation period we witnessed the emergence of several events in the global oil market, the possibility of structural breaks in the time series of the model is very strong. Accordingly, to avoid misleading results, a unit root test with structural break is employed to examine stationary of model variables as follows. For this purpose, Perron’s (1997) unit root test, which assumes an endogenous structural break, is used here. The test results are given in figure 4. The test suggests a significant structural break in 1996.

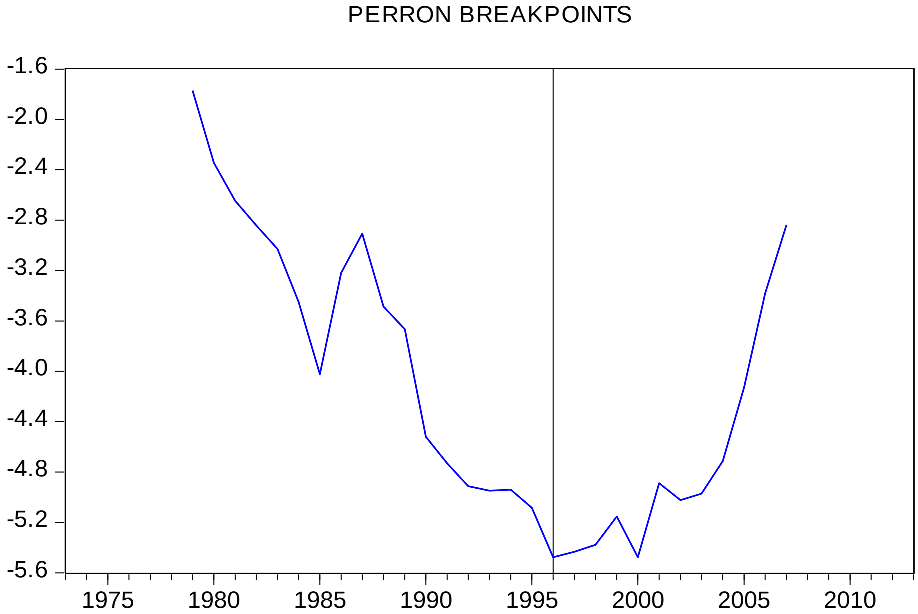

Figure 4: Structural Breaks and Perron's (1997) Unit Root Test

Results in table 2 demonstrate that null hypothesis of unit root for real oil price with a single structural break in intercept and trend cannot be rejected. These results confirm that real oil price, even where there is a structural break, has a unit root as well as Hamilton (2013) claim, i.e. important structural break occurred in the oil market in 1997.

Table 2: Perron's (1997) Unit Root Test with a Single Structural Break

Critical value at 5%	Critical value at 1%	t-statistic
-5.59	-6.32	-5.47
Null hypothesis: $LogOP_t$ has a unit root with a single structural break in intercept and trend.		

Resource: Research Findings

To evaluate existence of a long-term relationship between the model variables, a cointegration test is used. In presence of structural breaks in model variables, conventional cointegration tests may create false integration. So, considering the examined period of this study, during which potential structural breaks has occurred in the global oil market, the effects of structural changes should be considered in order to avoid creating false cointegration. To perform cointegration tests in presence of structural breaks, Gregory-Hansen cointegration test can be used. In order to extract their test statistic, Gregory-Hansen used three patterns of level shift (C), Level shift with trend (C/T), regime shift (structural change in direction) (C/S). The results are reported in table 3.

Table 3: Gregory-Hansen Cointegration Test

Model		Level			Regime			Regim and trend		
Statistic		ADF	Z_t	Z_α	ADF	Z_t	Z_α	ADF	Z_t	Z_α
		-4.87	-4.93	-30.44	-3.97	-6.12	-39.91	-6.04	-6.08	-39.27
Critical values		%1	%5	%10	%1	%5	%10	%1	%5	%10
	ADF	-58.8	-5.28	-5.02	-6.51	-6.00	-5.75	-6.89	-6.32	-6.16
	Z_t	-5.77	-5.28	-5.02	-6.51	-6.00	-5.75	-6.89	-6.32	-6.16
	Z_α	-63.64	-53.58	-48.75	-80.15	-68.94	-63.42	-90.84	-78.87	-72.75

Resource: Research Findings

As clearly indicated in table 3, in all three patterns of level shift (C), Level shift with trend (C/T), and regime shift (C/S) absence of long-term relationship among $LogOOP_t$, $LogNOOP_t$, $LogOC_t$, and $LogOP_t$ are approved. Saikkonen and Lutkepohl (2000) stated that most of the variables of time series experience a structural break due to occurrence of exogenous events that may occur during production process of the variables. Hence, they believed that it is necessary to calculate and estimate the changes in the time series level to properly understand cointegration order of a system of equations. Thus, for examining relationship relationship between equation variables, Saikkonen and Lutkepohl (2000) cointegration test is employed. Results of the test are summarized in table 4.

Table 4: Saikkonen and Lutkepohl (2000) Cointegration Test Results (Orthogonal Trend)

r_0	LR	P-value	%1	%5	%10
0	29.91	0.1886	41.58	35.76	32.89
1	12.51	0.4482	25.71	20.96	18.67
2	6.33	0.2072	13.48	9.84	8.18

Resource: Research Findings

As clearly indicated in table 4, absence of cointegration and long-term relationship among $LogOOP_t$, $LogNOOP_t$, $LogOC_t$, and $LogOP_t$ are approved.

Before estimating SVAR model in equation (1), its optimal lag should be determined. According to table 6, optimal lag 1 is reported for the system variables.

Table 5: Optimal Lag Determination

Lag	LogL	LR	FPE	AIC	SC	HQ
0	251.5979	NA	$1.8\times e^{-11}$	-13.38	-13.209	-13.3227
1	284.4160	56.766*	$7.34\times e^{-11*}$	-14.29*	-13.42*	-13.985*
2	294.9475	15.939	$1.02\times e^{-11}$	-13.997	-12.429	-13.444
3	311.34	21.26	$11.09\times e^{-11}$	-14.08	-11.754	-13.2029

Resource: Research Findings

5.1 Results of Impulse Response Function (IRF)

5.1.1 OPEC Era

Figure 5 shows the response of variables in model (1) to the structural shocks during 1973-1996. OPEC oil production growth impulses have negative impact on non-OPEC oil production and oil price. Shock to OPEC oil production has a positive and significant impact on oil consumption. Such impulse has a positive long-lasting and significant impact on OPEC oil supply. Non-OPEC oil production growth impulse has a negative and significant impact on OPEC oil production while it

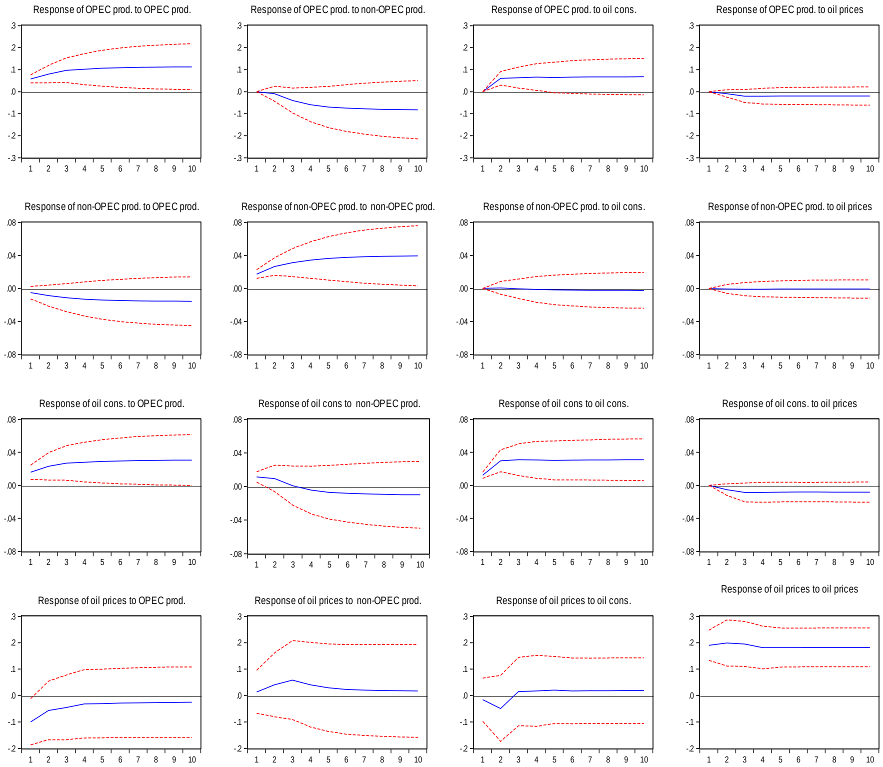

Figure 5: The Impulse Response Effects of the Structural Shocks during the OPEC Era (1973-1996)

leaves almost no impact on oil price and oil consumption. Such impulse has a positive and long-lasting impact on non-OPEC oil supply. Oil consumption growth impulse has a positive significant impact on OPEC oil production and oil consumption. This impulse has no effect on non-OPEC oil production and oil price. Price impulses have no significant impact on OPEC and non-OPEC oil production. This impact has a negative, small and significant impact on oil consumption. Price response to this impulse is positive and long-lasting.

5.1.2 The New Industrial Age

Figure 6 shows the response of variables in model (1) to the structural shocks during 1997-2013.OPEC oil production growth impulses have negative and significant impact on non-OPEC oil production. This impulse has no significant impact on oil consumption and oil price. An unanticipated shock has a long-lasting and highly significant impac on OPEC oil production growth. Non-OPEC oil production growth impulses

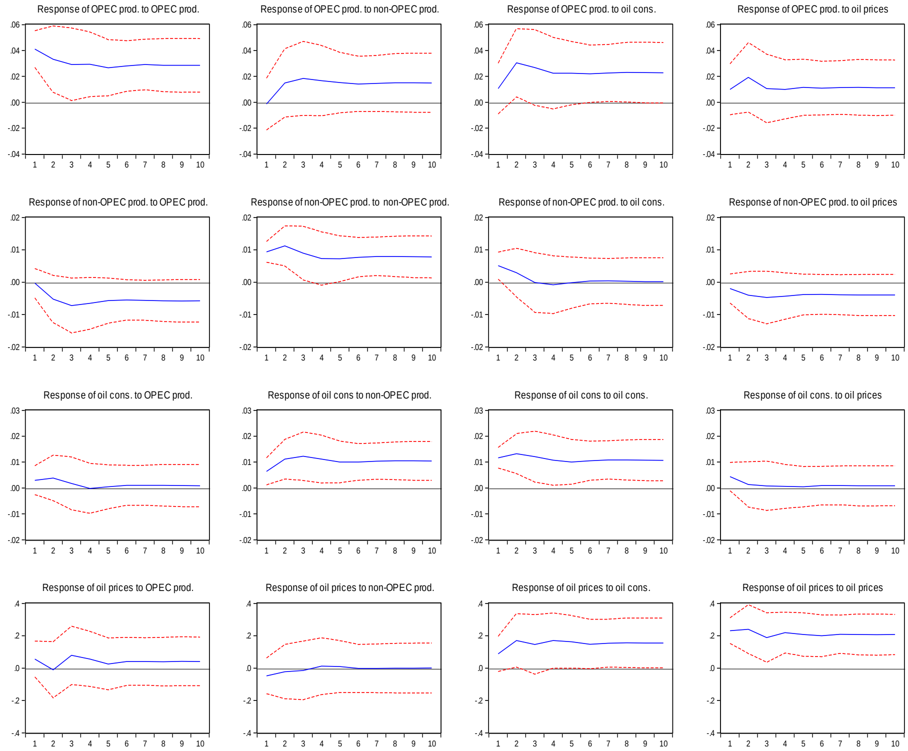

Figure 6: The Impulse Response Effects of the Structural Shocks during the New Industrial Age (1997-2013)

have positive and significant impact on all model variables, except price. This shock has no effect on price. The effect of positive oil consumption shock to OPEC oil production, oil consumption, and oil price is positive and significant. Non-OPEC oil production response to positive oil consumption shock is not long-lasting but it is positive. Price shocks have no significant impact on OPEC and non-OPEC oil production. It has also no effect on oil consumption. Price response to this impulse is positive and long-lasting.

5.2 Historical Decomposition

Cumulative effects of structural shocks to OPEC and non-OPEC oil production on real oil price are described in figure 7. This figure is drawn based on model (1) estimations. According to figure 7, Cumulative effects of structural shocks to non-OPEC oil production on oil price are relatively smaller than Cumulative effects of structural shocks to OPEC oil production on oil price.

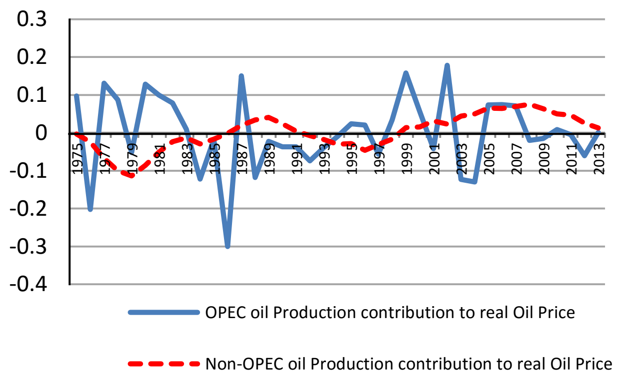

Figure 7: Cumulative Effects of Structural Shocks to OPEC and Non-OPEC Oil Production on Real Oil Price

Cumulative effects of oil price structural shocks on OPEC and non-OPEC oil production are depicted in figure 8. According to figure 8, Cumulative effects of oil price structural shocks on non-OPEC oil production are relatively smaller than cumulative effects of oil price structural shocks on OPEC oil production.

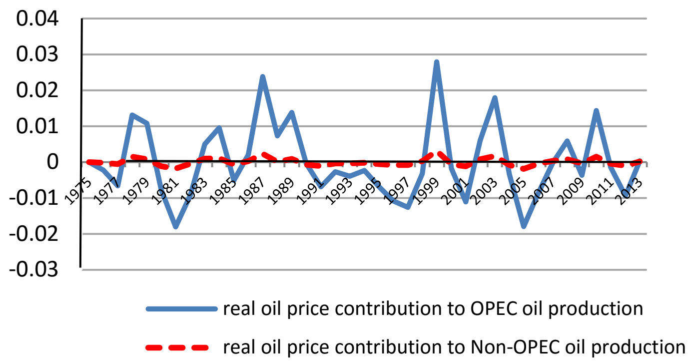

Figure 8: Cumulative Effects of Structural Shocks to Oil Price on OPEC and Non-OPEC Oil Production

Cumulative effects of structural shocks to OPEC oil production on non-OPEC oil production as well as Cumulative effect of structural shocks to non-OPEC oil production on OPEC oil production are described in figure 9. According to figure 9, cumulative effects of structural shocks to OPEC oil production on non-OPEC oil production are relatively smaller than cumulative effect of structural shocks to non-OPEC oil production on OPEC oil production.

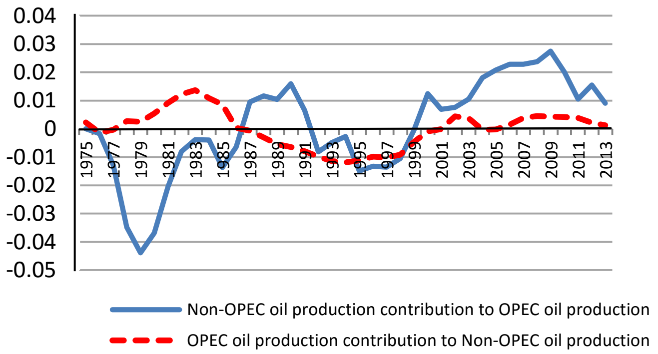

Figure 9: Cumulative Effects of Structural Shocks to OPEC Oil Production on Non-OPEC Oil Production and vice versa

Cumulative effects of structural shocks to OPEC and non-OPEC oil production and real oil price on global oil consumption are described in figure 10. Cumulative effects of structural shocks to OPEC oil production on global oil consumption are relatively greater than cumulative effects of structural shocks to non-OPEC oil production on global oil consumption and cumulative effects of structural shocks to oil price on global oil consumption.

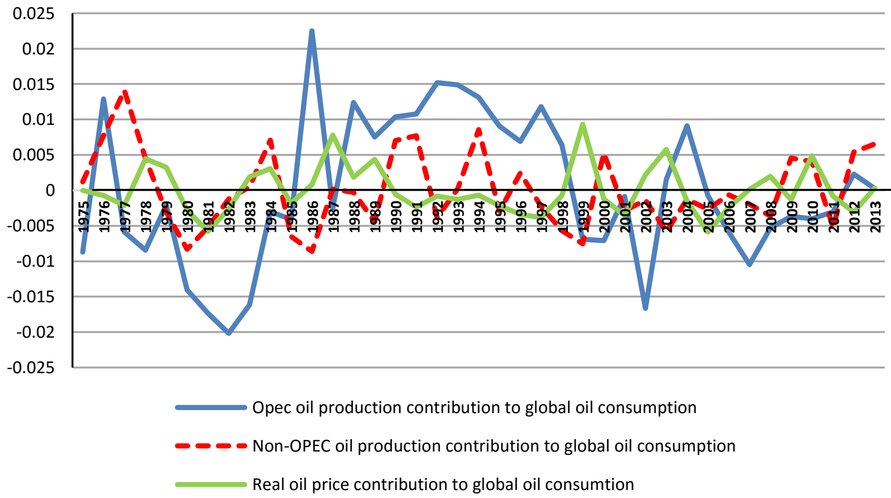

Figure 10: Cumulative Effects of Structural Shocks to OPEC and non-OPEC Oil Production and Real Oil Price on Global Oil Consumption

5.3 Analysis of Variance Decomposition

Forecast Error Variance Decompositions (FEVD$_s$) for OPEC and non-OPEC oil production are presented in table 6, the results of which are obtained from model (1) estimation. Variance decomposition provides a general insight about impact rate of structural shocks in the global oil market on OPEC and non-OPEC oil production growth.

Table 6: Variance Decomposition for OPEC and Non-OPEC Oil Production

		1973-1996				1997-2013			
		oil price	global oil consumption	Non-OPEC oil production	OPEC oil production	Oil price	global oil consumption	Non-OPEC oil production	OPEC oil production
OPEC oil production	1	0	0	0	100	0	0	0	100
	2	3.93	34.4	3.33	58	1.298	24.51	1.59	72.59
Non-OPEC oil production	1	1.59×10^{-29}	6.09×10^{-29}	88.90	11.09	6.93×10^{-30}	9.4×10^{-30}	98.28	1.717
	2	0.1124	1.94	83.98	13.96	0.0197	2.97	84.6	12.37

Resource: Research Findings

Global oil consumptions shocks during 1973-1996 and 1997-2013 forecast 34.4% and 24.51% of changes in OPEC production growth for a one-year and two-year period, respectively. $FEDV_s$ results confirm that OPEC oil production growth during two periods of 1974-1996 and 1997-2013 has been more affected by changes in global oil consumption.

Based on a one-year and a two-year period, OPEC oil production growth indicates statistically significant changes in non-OPEC oil production growth for 1973-1996 (11.09% and 13.96%) and 1997-2013 (12.37%). Non-OPEC oil production has been more affected by changes in OPEC oil production.

Forecast Error Variance Decompositions ($FEVD_s$) for oil price and oil consumption, during 1973-1996 and 1997-2013, are presented in table 7.

Table 7: Variance Decomposition for Oil Price and Global Oil Consumption Growth

		1973-1996				1997-2013			
		Oil price	**global oil consumption**	**Non-OPEC oil production**	**OPEC oil production**	**Oil price**	**global oil consumption**	**Non-OPEC oil production**	**OPEC oil production**
oil price	1	63.95	3.33	0.017	32.69	82.8	12.95	2.38	1.88
	2	60.19	3.16	1.79	34.84	51.81	36.4	9.49	2.26
global oil cosumption	1	3×10^{-29}	46.78	21.98	31.23	1×10^{-30}	81.6	3.94	14.38
	2	2.64	69.21	11.35	16.78	3.35	73.33	8.86	14.45

Resource: Research Findings

OPEC oil production growth during 1973-1996 foretells 32.69% and 34.84% of changes in oil price growth for a one-year and two-year period, respectively. Global oil consumption growth during 1997-2012 fortells 12.95% and 36.4% of changes in oil price growth for a one-year and two-year period, respectively.

OPEC oil production growth during 1973-1996 foretells 31.23% and 16.78% of changes in global oil consumption growth for a one-year and two-year period, respectively. OPEC oil production growth during 1997- 2013 foretells 14.38% and 14.45% of changes in global oil consumption growth for a one-year and two-year period, respectively.

6. Conclusion

Hamilton (2013) defined five major periods during which significant changes in oil price have occurred: (1899-1859), (1945-1900), (1972-1946), (1996-1973), and (2010-1997). In this paper, the the behavior of the real oil price and OPEC and non-OPEC oil production during 1973-2013 are modelled. To do so, global oil consumption is considered in the modelling. Interactions among OPEC, non-OPEC oil production, global oil consumption, and the real price of crude oil are estimated using a structural VAR model (SVAR). After providing evidence for the structural breaks in oil price in 1996, the results indicate that, according to variance decomposition analysis, during the two periods of 1996-1973 and 2013-1997, OPEC's oil production responded significantly to positive shocks of global oil consumption and non-OPEC oil production responded significantly to shocks of OPEC oil production. Accordingly, we expected non-OPEC oil production responds to the global oil consumption shocks; however, analysis of variance and impulse response function did not confirm our expectation. During the OPEC era (1973-1996), oil price responded significantly to positive shocks of OPEC oil production and during the new industrial age (1997-2013) responded significantly to shocks of global oil consumption. According to historical decomposition analysis of oil price, cumulative effects of structural shocks of non-OPEC oil production and price on OPEC oil production are greater than cumulative effects of structural shocks of OPEC oil production and real oil price on non-OPEC oil production. Also, cumulative effects of structural shocks of OPEC oil production on real oil price are greater than cumulative effects of structural shocks of non-OPEC oil production on real oil price**.**

References

Alquist, R., & Gervais, O. (2013). The Role of Financial Speculation in Driving the Price of Crude Oil. *The Energy Journal*, *34*(3), 7-40.

Almoguera, A., Douglas, C., & Herrera, M. (2011). Testing for the Cartel in OPEC: Non-Cooperative Collusion or just Non-Cooperative? *Oxford Review of Economic Policy*, *27*, 144-168.

Dées, S., Karadeloglou, P., Kaufmann, R. K., & Sánchez, M. (2007). Modelling the World Oil Market: Assessment of a Quarterly Econometric Model. *Energy Policy*, *35*, 178-191.

Fattouh, B., Kilian, L., & Mahadeva, L. (2013). The Role of Speculation in Oil Markets: What Have We Learned so far? *The Energy Journal*, *34*(3), 7-40.

Gately, D. (2007). What Oil Export Levels Should We Expect from OPEC? *The Energy Journal*, *28*(2), 151-173.

Gately, D., Al-Yousef, N., & Al-Sheikh, Hamad, M. H. (2013). The Rapid Growth of Domestic Oil Consumption in Saudi Arabia and the Opportunity Cost of Oil Exports Foregone. *Energy Policy*, *47*, 57-68.

Ghoshray, A., & Johanson, B. (2010). Trend in World Energy Prices. *Energy Economics*, *3*, 1147-1156.

Gulen, G. S. (1998). Efficiency in the Crude Oil Futures Market. *Journal of Energy Finance and Development*, *3*, 13-21.

Hamilton, J. D. (2013). Historical Oil Shocks. In R. E. Parker, R. M. Whaples (Eds.), *Routledge Handbook of Major Events in Economic History*. New York: Routledge Taylor and Francis Group.

---------- (2009). Understanding Crude Oil Prices .*The Energy Journal*, *30*(2), 179-206.

Huppmann, D., & Holz, F. (2012). Crude Oil Market Power-a Shift in Recent Years? *Energy Journal*, *33*, 1-22.

Kaufmann, R. K., Bradford, A., Belanger, L. H., Mclaughlin, J. P., & Miki, Y. (2008). Determinants of OPEC Production: Implications for OPEC Behaviour. *Energy Economics*, *30*, 333-351.

Kilian, L. (2009). Not All Oil Prices Shocks Are Alike: Disentangling Demand and Supplyshocks in the Crude Oil Market. *Am. Econ. Rev.*, *99(3)*, 1053-1069.

Kilian, L., & Hicks, B. (2013). Did Unexpectedly Strong Economic Growth Cause the Oil Price Shock of 2003-2008? *J. Forecast, 32,* 385-394.

Kisswani, Kh. M. (2015). Does OPEC Influence Crude Oil Prices? Testing for Cointegration and Causality Effect. *Journal of Economic Research*, *20*, 231-255.

Kolodzeij, M., & Kaufmann, R. K. (2014). Oil Demand Shocks Reconsidered: A Cointegrated Vector Autoregression. *Energy Economics*, *41,* 33-40.

Lee, J. & Strazicich, M. C. (2004). Minimum LM Unit Root Test with One Structural Break. *Working Paper*, Retrieved from http://econ.appstate.edu/RePEc/pdf/wp0417.pdf.

---------- (2003). Minimum Lagrange Multiplier Unit Root Test with Tow Structural Breaks. *Review of Economics and Statistic, 85,* 1082-1090.

Li, R. (2010). The Role of OPEC in the World Oil Market. *International Journal of Business and Economics*, *9*(1), 83-85.

Loutia, A., Mellios, C., & Andriosopoulos, K. (2016). Do OPEC Announcements Influence Oil Prices? *Energy Policy*, *90*, 262-272.

Lumsdiane, R. L., & Pappel, D. H. (1997). Multiple Trend Breaks and the Unit Root Hypothesis. *Review of Economics and Statistics*, *79,* 212-218.

Maslyuk, S., & Smyth, R. (2008). Unit Root Properties of Crude Oil Spot and Futures Prices. *Energy Journal*, *36(7)*, 2591-2600.

Perron, P. (1989). The Great Crash, the Oil Price Shock and the unit Root Hypothesis. *Econometrica*, *57,* 1401-1361.

Pindyck, R. S. (1999). The Long-run Evolution of Energy Prices. *Energy Journal*, *20(2)*, 1-27.

Postail, F., & Picchetti, P. (2006). Geometric Bronian Motion and structural Breaks in Oil Prices: a Quantitative Analysis. *Energy Economics*, *28,* 506-522.

Ramcharran, H. (2001). OPEC's Production under Fluctuating Oil prices: further Test of the Target Revenue Theory. *Energy Economics*, *23*, 667-681.

Ratti, R., A., & Vespegnani, J. L. (2015). OPEC and Non-OPEC Oil Production and the Global Economy. *Energy Economics*, *50*, 364-378.

Rowland, Ch. S., & Mjelde, J. W. (2016). Politics and Petroleum: Unintended Implications of Global Oil Demand Reduction Policies. *Energy Research & Social Science*, *11*, 209-224.

Sadorsky, P. (1999). Oil Price Shocks and Stock Market Activity. *Energy Economics*, *5*, 449-469.

Saikkonen, P., & Lutkepohl, H. (2000). Testing for the Cointegrating Rank of a VAR. *Journal of Business & Economic Statistics*, *18(4)*, 451-464.

Serlites, A. (1992). Unit Root Behavior in Energy Futures Prices. *Energy Journal*, *13(2)*, 119-128.

Simpson, J. L. (2008). The Effect of OPEC Production Allocations on Oil Prices. *Working Paper*, Retrieved from http://ro.uow.edu.au/dubaiwp/6/.

Smith, J. L. (2009). World Oil: Market or Mayhem? *Journal of Economic Prospectives*, *23*(3), 145-64.

Wirl, F. (2008). Why Do Oil Prices Jump (or Fall)? *Energy Policy*, *36*(3), 1029-1043.

Zivot, E., & Andrews, D. W. K. (1992). Further Evidence on the Great Crash, the oil Price Shock, and the Unit Root Hypothsis. *Journal of Business and Economic Statistics*, *10*, 251-270.