# Czech University of Life Sciences Prague

# Faculty of Economics and Management

# Department of Economics



# Diploma Thesis

# Oil and Energy Production Analysis

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## DIPLOMA THESIS ASSIGNMENT

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Business Administration

Thesis title

## Oil and Energy Production Analysis

### Objectives of thesis

The primary objective of this research paper is to assess the OPEC, IEA and non-OPEC, non-IEA states. The researcher will seek to determine the impact of OPEC on the pricing of oil in the international market, evaluate the reliance of IEA organization and non-IEA countries on OPEC to make production cuts. Then, the researcher will try to discover how much does OPEC's production cuts impact prices, and the behavior of OPEC – Cartel or competitive – and build a framework for finding out the practice of competitor organizations.

### Methodology

-Linear regression model

-Quantitative Method

-Qualitative Method

-Deductive approach

-Time trend analysis

This research paper adopts the quantitative design and uses data collected from BP, OPEC, IEA and EIA organizations. Linear regression issued to analyse the data where variables such as a daily average of production output, change in production and oil prices are used.

**The proposed extent of the thesis**

60 – 80 pages

**Keywords**

OPEC, IEA, NON-IEA countries, Oil, Oil-policy, Energy policies.

**Recommended information sources**

Alhajji, A. and Huettner D. (2000). OPEC and the World Oil Markets from 1973 to 1994: Cartel, Oligopoly or Competitive? ISBN 978-1-907555-67-1

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Dean

Prague on 28.11.2019

**Declaration**

I declare that I have worked on my diploma thesis titled "Oil and Energy production analyses" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on                    _____30.11.2019_____

# Oil and Energy production analyses

## Abstract

The purpose of this research paper is to evaluate and assess the theoretical claim that non-OPEC organizations and states rely on OPEC to make production cuts. The concept is based on the relationship between supply and demand in the oil market where it is believed the production cuts on a large scale of producers can fluctuate in oil prices. Energy policies put forward by policy organizations such as IEA, OPEC and also national policy makers depend on this theory to create policies and thus put forward political and economic agendas for their national interest. Therefore it is important to find out if this theory is correct and to which organization does it apply. Also, the behaviour of OPEC must be known to build future policies based on the practice of this powerful organization; cartel is the consensus of behaviour for this organization.

**Keywords**: OPEC, IEA, NON-IEA countries, Oil, Oil-policy, Energy policies, production cuts.

# Analýzy produkce ropy a energie

## Abstrakt

Účelem této výzkumné práce je zhodnotit a posoudit teoretické tvrzení, že organizace a státy, které nejsou členy OPEC, spoléhají na OPEC při snižování výroby. Koncept je založen na vztahu mezi nabídkou a poptávkou na trhu s ropou, kde se věří, že výrobní škrty ve velkém měřítku producentů mohou kolísat v cenách ropy. Energetické politiky předkládané politickými organizacemi, jako jsou IEA, OPEC a také tvůrci národních politik, závisí na této teorii při vytváření politik, a proto předkládají politické a hospodářské programy pro svůj národní zájem. Proto je důležité zjistit, zda je tato teorie správná a na kterou organizaci se vztahuje. Rovněž je třeba vědět, jak se chová OPEC k vytváření budoucích politik založených na praxi této mocné organizace; kartel je shodou chování této organizace.

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# 1    Introduction

Nowadays, oil policies are considered strategic plans in every government due to the importance that this commodity has gained. Public administrators are attempting to incorporate their oil policies into their social, political, and most importantly, their economic objectives (Rabin, 2003). This applies to oil-exporting and importing countries; countries that export want stable high prices and importing countries don't mind volatility as long as prices are dragged every while downwards. By definition, public administration is the implementation of government policy, and from that regard, the implementation of national oil policy falls within the field of public administration (Carey, 2015). But nowadays, many industries rely on oil in the form of raw oil for energy production or for petrochemicals, which are an essential raw material for producing a lot of consumer goods, heavy manufacturing products, and industries. Thus the importance of oil has become high on the government's agendas that both oil-exporting and importing countries are developing oil policies to control the present and create a sustainable outlook for the future. OPEC is a powerful organization that was created in 1960 in Baghdad, Iraq, to function as an intergovernmental organization to deal with the interest of oil-exporting countries and preserve their economic and political importance. The organization has 14 members with Iran, Saudi Arabia, Nigeria, and Venezuela being the leading players and highest producers among the members (Castree et al., 2013). The International Energy Agency is another international energy organization that was built as a reaction to OPEC, and it includes countries only from the OECD, countries such as the UK, US, France and Japan. Moreover, some countries are observer countries that are not in OPEC and not in IEA, such as Russia, China, and Brazil.

The rise of oil as a political commodity has been a strategic resource that was incorporated into specific energy policies. Public administrators in governments have formed alliances in the form of intergovernmental organizations such as OPEC and IEA, and others remained as observers (Smith, 2001). But these energy policies are often complex and are concentrated on a particular objective. Some countries like net exporters from the Middle East focused on increasing their revenues from oil sales because their GDP and government expenditures rely on that (Colgen, 2004).

Other countries such as the IEA members in Scandinavian Europe have energy policies that rely on investing in alternative energy resources, energy efficiency and limiting the impact on the environment. These are the cornerstone strategies and objectives of the IEA: energy security, economic developing and environmental impact (IEA, 2016). These policies are not shared by OPEC members because the internal national situation of each member differs from the OECD members and so does the situation in non-OPEC non–IEA members who are mainly large producers (Russia) and also large consumers with large populations like China (OPEC Annual reports, 2015).

The rationale behind this research paper is in analysing two issues about energy policies among states and their members in their relevant organizations: reliance on production cuts and behaviour of policy. The issue of reliance among organisation regarding production cuts has been mentioned in the literature or energy policies, especially by Fattough and Sen (2015), Tutt and Clitch (2015), Almugeura (2007), Gulen (1996) and Alhajji (2015). The main theory regarding reliance is presented by Fattouh and Sen (2015), who argues that non-OPEC countries rely on OPEC to make production cuts. This is the theoretical puzzle that the researcher wants to assess and study in this paper. In other words, do non-OPEC countries rely on OPEC to make production cuts?

The relevance of production cuts in energy policies is in their impact on oil pricing. Organizations attempt to manipulate supply on a large scale, hoping to influence prices up or down depending on their energy policy. This relationship is studied in this paper about OPEC; the researcher wants to find out if OPEC can impact prices and if OPEC behaves like a cartel (taking the interest of everyone in the organization by acting as a cohesive front and thus impacting oil prices).

Moreover, previous literature has not separated between the non-OPEC states, and these include countries with various resources and huge differences in energy policies (IEA General Energy Policies, 2016; IEF, 2016). Also, members among the same organization have minor differences in policies; Norway is a net exporter of oil and also a member of IEA which has 85% of net importers. But Norway has similar energy policies on alternative energy resources, energy efficiency, and environmental impact. These policies are not shared with Russia for example, which is also a non-OPEC member.

Therefore, this paper will analyse the issue of dependence on production cuts between OPEC and two different non-OPEC groups: IEA and non-IEA.

These policies are essential to analyse, and their analysis is related to researchers in the field of Energy Policy, they are connected to officials in the OPEC organization, IEA organization, and detective countries. The conclusions of this paper can be beneficial for developing energy policies by these organizations and can also be used for a foundation for further research in this field. That's because this field can hinder accurate examination because of the incompetence to obtain information would be clear out the official data. Thus, researchers that might be able to gain better data form internal resources via various methodological technique can rely on the results of this paper which analyses theoretical aspect in energy policy in order to earn broader insight about the interactions of generating energy policies among OPEC, IEA, and non-OPEC non-IEA states.

# 2     Objectives and Methodology

## 2.1    Objectives

The primary objective of this research paper is to assess the OPEC, IEA and non-OPEC, non-IEA states. The researcher will seek to determine the impact of OPEC on the pricing of oil in the international market. I will evaluate the reliance of IEA organization and non-IEA countries on OPEC to make production cuts. Then, I will try to discover how much does OPEC's production cuts impact prices, and the behavior of OPEC – Cartel or competitive – and build a framework for finding out the practice of competitor organizations. Furthermore, the paper will describe the policies of OPEC, IEA, and remaining countries and recommend further improvements for their systems and will analyse the foloowing questions:

1)What is the relationship between OPEC production and IEA (OECD) production?

2)What is the relationship between OPEC production and non-OPEC (and non-OECD) countries (such as China, Russia, and Brazil)?

3)What is the relationship between change in production and oil prices? Is OPEC a cartel?

## 2.2    Methodology

The methodology is an essential part of the research paper because it gives the reader a clear idea about the logical flow of the article. The methodology is considered the blueprint of any research paper and thus is an integral part, which is often criticized if it was not consistent. The research finding's credibility can be tested and questioned if the research methodology is inconsistent or does not follow a logical flow. The research onion presented by Saunders et al. (2009) is a good roadmap for the decisions to be made in the methodology.

The research philosophy is a methodological judgment concerned with the origin of knowledge or in another expression: how is education achieved and admitted? There are various research philosophies, such as positivism, realism, interpretivism, and pragmatism (McNabb, 2002). Further, the research philosophy is divided into three separated areas: the ontology, epistemology, and axiology.

The most relevant philosophy analysis is concerned with the research epistemology, which is concerned with the source of acceptable knowledge (Saunders, 2009). The continuum of the epistemological question is between positivism on one end of the spectrum and realism on the other end.
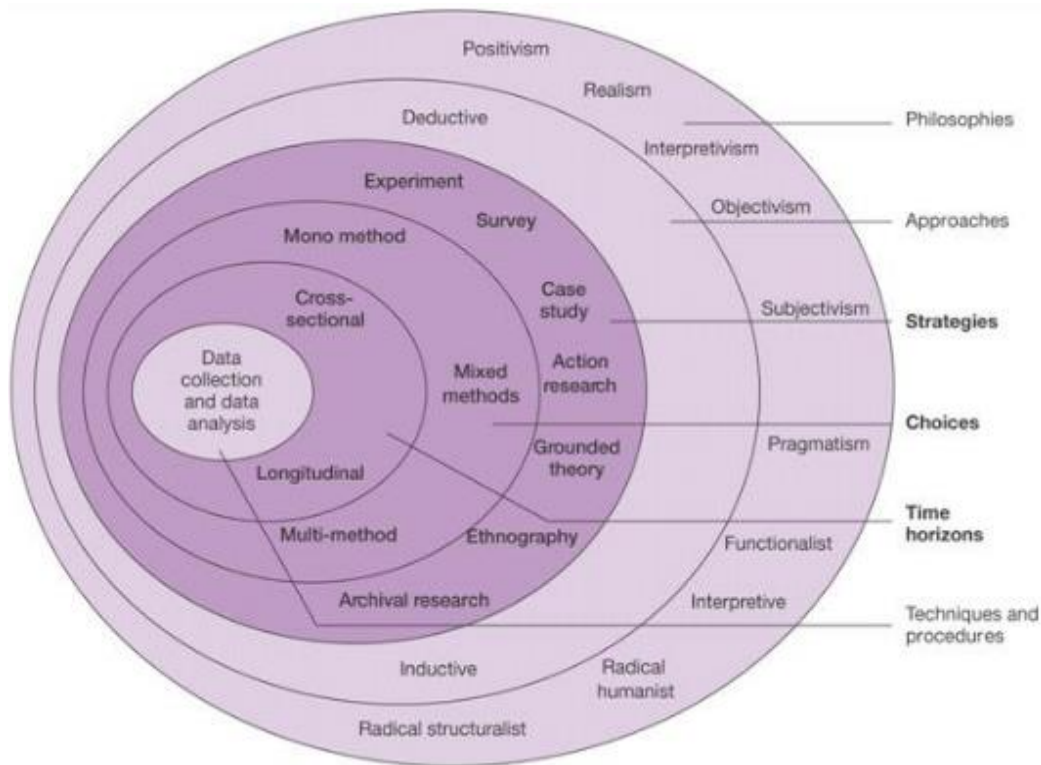


Figure 1. Research Onion (Saunders et al., 2009)

The positivist philosophy argues that acceptable knowledge is knowledge that is objective and external. In other words, it is the observations and reality that is considered true knowledge. On the other hand, realism argues that knowledge is socially constructed and that it is subjective and that means that knowledge depends on the viewer rather than concrete facts (Zikmund et al., 2013). So, from a positivist point of view there is a high emphasis on facts, data and searching for causality, but in the realism, the researcher will focus on the social construct, social behaviour of actors involved, and focus on the meaning of data (Suanders, 2009). In the center of the continuum lies what is acknowledged as interpretivism: which is a school of thought that belief in finding causality and objectivity yet maintains that the observer is part of the observed phenomenon and that social actors and the social world plays a vital role that is complex enough to affect the relationship between variables. In other words, facts themselves are not enough to account to explain

the relation in any particular phenomenon. The epistemological option in research philosophy of this analysis is positivism.

The purpose positivism philosophy was preferred over realism is obvious, and that is because firstly the researcher wants to be as objective as possible and as far away from putting specific conclusions or insight towards the research outcomes. In order to achieve optimum credibility for the results of the data analysis and overall outcome, the positivist philosophy maintains a reasonable distance between the researcher and the decisions. Moreover, the realism philosophy is not relevant for research in public administration and primarily policies about oil and overall macroeconomic decisions. That's because social communications, even though they might play a little role, won't play an imperative role. Therefore, realism was out of the proposal; instead of interpretivism seemed more probable than realism.

Why researcher choice was positivism because it is more in accordance with a quantitative approach, also want to maintain full objectivity and lastly because I believe that social interactions will not have a significant influence on forming oil policies. Because it is more linked to the wellbeing of all countries involved therefore, personal connections would cease to make any effect. Riccucci (2010) argues that both interpretivism and positivism have played a significant role in building a research database in public administration.

When the researcher first explains the research, they are stating the theory might be understandable from the beginning and must be questioned, or the theory must be created at the end of the study by analysing the observations (McNabb, 2002). There are two primary education approaches deduction and induction and a third approach that is the combination of both and is called abduction (Saunders et al., 2009). In the deductive approach there is a clear logic from between the premise and the conclusion, if all the assumptions are correct, then the conclusion is accurate, and thus the theory is proved. In the inductive approach, there is a gap between the premises and result and the outcome can only be supported by observations. Moreover, the issue of generalizability is apparent between deduction and induction, and this is an important deciding factor for the researcher; deductive approach makes generalizations from general to specific, and its objective is to falsify or verify theory but in the inductive approach, the generalization is from particular to general, and the purpose is to create theory.

The criteria for choosing between deductive and inductive are explained clearly by Saunders et al., (2009) below:

- If the researcher first builds a theory form reading the academic literature and then the researcher designs a method to analyse this theory then the deductive approach is being used.

- If the researcher collects data, explore the phenomenon and then arrives at the theory then the inductive approach is being used.

In this thesis research worker choosed deductive approach.

In this paper the researcher found the deductive approach to be more accurate because by reading the literature the research found a clear theory that describes the relationship between OPEC and non-OPEC oil policies and that it is: the non-OPEC countries rely on the OPEC organization to make production cuts. Of course, the relevance of this theory is that, based on the supply and demand relationship, by decrease supply the prices of the commodity will shift upwards and thus increase the cost. This theory has been argued by Fattouh and Sen (2015: 21) from the Oxford Institute for Energy Studies; "non-OPEC countries leave it to OPEC to implement cuts." This has also been supported by Mabro (1998), but Shojai (1992) says that as non-OPEC relies on OPEC to make the production cuts, there is always conflict among OPEC members also about who is going to hold the burden to cutting. Tutt and Clinch (2014) in an interview with Alison Madueke, CEO of OPEC, he said that "non-OPEC oil generators had to "share the burden" of any further cut in production." Where he means that non-OPEC usually avoid cutting and waits for OPEC to do the same.

There are several other sources that presented the same theory, which seems to be the tradition or the general policy adopted. Hence as seen the theory is already performed and the need to generalize from the general to specific is needed, and therefore the deductive approach was chosen in order to analyse the oil policies of these organizations. The strategy of this thesis is regarding the choice of the tool of data collection as well as the method in which the research will be conducted (Saunders et al., 2009). There are several strategies such as experiment, case study, ethnography, survey, interview, focus groups, grounded theory, and desk research (document review) (McNabb, 2002). In this paper, the research strategy is desk research or document review because the researcher

will analyse existing data of OPEC and non-OPEC oil producers in order to assess their oil policies.

In this paper the researcher will work on and analyse three question which written below:

**1)** What is the relationship between OPEC production and IEA (OECD) production?

This is the first research question and it is regarding the analysis of the relationship between OPEC total annual average daily analysis and total OECD countries production. The variables (Appendix 1 contains the data used for this research question):

- The independent variable (X) in the linear regression is OPEC average daily output per year since 1965 to 2017

- The Dependent variable (Y) in the linear regression is IEA countries average daily production per year since 1965 to 2017

The data for the IEA member states have been retrieved from BP statistics and they are counted as the OECD total production (BP Annual Statistical Review, 2018).

The reason OPEC's production is considered as the dependent variable is that the researcher is interested in knowing if non-OPEC countries behave differently when OPEC change their production. That means if non-OPEC countries, IEA organization members, act differently then the correlation must be negative and that means that IEA countries do not rely on OPEC to make cuts. On the other hand, a positive correlation would mean that IEA countries wait keep on producing regardless of OPEC's production and thus there is reliance by IEA countries.

**2)** What is the relationship between OPEC production and non-OPEC (and non-OECD) countries (such as China, Russia, and Brazil)?

This research paper separates non-OPEC countries into the IEA organization which is mainly contains OECD members and the second non-OECD countries which are not in the IEA organization such as China, India, Russia and Brazil (mainly BRICS). These are countries that are also mainly importers but some are also large exporters such as Russia. The variables for this question are:

- The X variable in the linear regression is OPEC average daily output per year since 1965 to 2017

- The Y variable in the linear regression is non-OPEC and non-OECD countries average daily production per year since 1965 to 2017; these are calculated by subtracting

the total OECD production from the total non-OPEC production and the remainder must be the countries that are non-OPEC   and at the same time non OECD.

**3)** What is the relationship between change in production and oil prices? Is OPEC a cartel?

The importance of research question is that it will give the reader an ability to know if the reliance of non OPEC non IEA countries such as Russia and Brazil are correct in relying on OPEC to make production cuts. In other words, is it worth it to rely on OPEC to make production cuts? This question is important because if OPEC has no ability to influence prices – to go up – then relying on OPEC is useless. Moreover, if OPEC is behaving like a cartel and it is realized the IEA countries (OECD) are not in a head to head competition with OPEC, on the contrary they make cuts at the same time and in a similar rate; then can this lead to the conclusion that the IEA is also a cartel but for developing countries which are interested in average prices and stable prices?

The variables:

- The X variable is the change in production: daily average and annual. Note that the percentage change has been calculated by this formula: 1966 annual production – 1965 annual production 1965 annual production. It must be noted that for the purpose of getting accurate analysis the results of the change in production is multiplied by -1 because the production cuts here (which are calculated as negative numbers) actually have a positive influence.  This has been proposed by Almuguara (2007); Ratti and Vespagnani (2015).

- The Y variable is the Brent oil prices (in dollars) since 1965; the data is collected from two sources (Fred Economic Data; McMahon, 2015).

As noticed before, one of the chief reasons that survey or interview was not used as a strategy is that inability to conduct interviews or distribute questionnaires. As mentioned, lower rank officials had to authority to give interviews or disseminate any information, and higher rank officials were hard to reach. There were also technical difficulties and absence of resources in order to achieve a survey or interview research strategy.

The conceptual framework of research paper is shown below, after analysing and evaluating these connections, the results will be added and discussed.
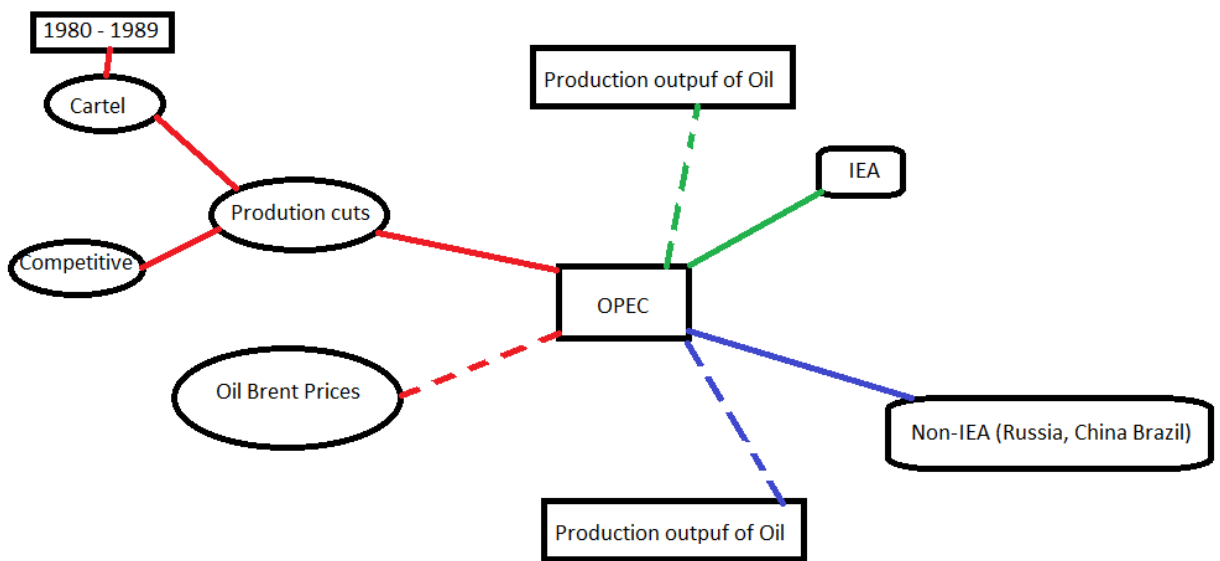
Figure 2. The conceptual framework of thesis

Data collection describes the method that the researcher used to collect the data used for analysis. In this case, there was a problem in accessing primary data (McNabb, 2002). The primary reason is that such data is considered sensitive and interview or surveys won't be successful in attaining any new information. The researcher attempted to book interviews in Azerbaijan for example to collect data regarding the relationship with OPEC, but officials rejected to take part in this interview.

The consensus was that they had no authority to share any information that is not already published either by the government or by OPEC itself. There was another problem in collecting primary data, and that is finding the correct contacts in international oil production consortium of countries such as OPEC or IEA. Finding these contacts and creating a connection with them would be very challenging and time taking as well as expensive due to travelling arrangements that must be done.

In any case, there were no indications that interviews would be granted by lower rank officials and higher rank officials were very hard to get in contact with. Thus primary data was hard to understand and also there were indications that anyway in interviews no report other than official information would be given regarding the relationship among countries or about the current oil policy undergone. The researcher's interest is oil policies, and this happens to be a bit challenging to define clearly, or at least to be surely honest about, by government officials or organization officials.

In this case, in order to evaluate the theory of oil policies between OPEC and non-OPEC organization the use of secondary data from official websites of OPEC and non-OPEC organization such as EIA was necessary and to some extent similar to the information that would be collected in case of an interview. Even though in the additional interview information could be obtained, it was not any way possible.

Thus data was collected from the official publications of:

OPEC regarding annual oil production; Source (OPEC Database Library, 2019)

BP Statistical Review; Source (BP Statistical Review, 2018).

The data analysis tool that will be used in this paper is an inferential statistical tool called linear regression. The data analysis tool has been chosen because it is in accordance with the deductive approach which must use technological tools in order to reach conclusions rather than the use of individual observations of the researcher (Ghauri et al., 1995). Consequently, the use of technical statistical tools is vital to maintain the integrity, reliability and credibility. The device that will be used to implement linear regression analysis is Microsoft Excel by using the Data Analysis function.

The linear regression equation is:

$$\widehat{Y}_i = b_0 + b_1 X_i$$

Formula 1. Linear regression formula (Ryan et al., 2013)

$Y_i$ - is estimated (or predicted )Y value for observation i

$b_0$ - is estimate of the regression intercept

$b_1$ - is estimate of the regression slope

$X_i$ - is value of X observation i

In the equation above the betas are the coefficients. These coefficients are crucials in order to make predictions.

The formula, used to find the coefficients is shown below:

$$\beta_1 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sum_{i=1}^{n}(x_i - \overline{x})^2}$$

Formula 2. Linear regression coefficients formula

$$\boldsymbol{\beta_0} = \overline{\boldsymbol{y}} - \boldsymbol{\beta_1}\overline{\boldsymbol{x}}$$

Formula 3. Linear regression Beta formula

Beta is equal the covariance between x and y by the variance of x.

And it is obvious that the linear model is not indicates all data accurately, which means actual value differs from the prediction. The error is calculated with:

$$\boldsymbol{e_i} = \boldsymbol{y_i} - \widehat{\boldsymbol{y}}_i$$

Formula 4. Linear regression Error (e) formula

The use of linear regression in public administration research has been documented and encouraged by several researchers such as Yang (2008) and Groeneveld et al., (2010) who argued that even though qualitative research remains popular the number of quantitative research is increasing via regression. "Results show that whereas qualitative methods are still predominant compared to quantitative methods (56% versus 44%), the field is becoming increasingly quantitative."

Lastly as i tis noticed The linear regression model will be use in this thesis, the researcher doesn't observe the values of $\beta_0$ and $\beta_1$ but it is possible to make inferences about these using the values of $b_0$ and $b_1$ from the sample where:

$Y_i = \widehat{Y}_i + e_i = b_0 + b_1 X_i + e_i$.

From the given data, the intercept and slope can be found for the simple linear regression line. The main goal here is to evaluate coefficients in the population. The values of $b_0$ and $b_1$ will be used to calculate the values of $\beta_0$ $and$ $\beta_1$. The hypothesis tests and confidence intervals can be conducted on our coefficients from a random sample of data. The visualization of the process looks like:
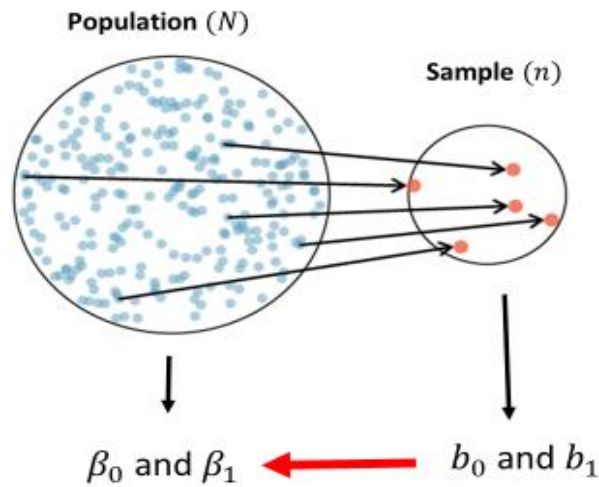
Figure 3. Visual concept of hypothesis testing.

The null and alternative hypothesis will be stated in terms of $H_0$ or $H_a$ and significance level $\alpha$ will be calculated. Then computing the test statistic $t$ (which will be used in statistical software) and assuming the null is true and making a decision by: a) Comparing **the test statistic** $t$ with the critical value or values or b) Comparing **the p-value** with the significance level $\alpha$. And lastly stating conclusion. It should be considered that the thesis has two separate hypothesis tests and inferences: one for the intercept and another for the slope and therefore, it is useful to specify some notation to keep track of these coefficients. Each coefficient will be indexed using $j = 0, \ldots, k$, where $k$ is the total number of predictor or input variables in our model. With simple linear regression, $k=1$ and we have $\beta_{j=0}$ and $\beta_{j=1}$. When working with regression coefficients, the most common setup is a two-sided test with the null equal to zero for each regression coefficients. If the slope or intercept are truly equal to zero, then they don't even need to be included in the regression model. The null is that the coefficient $j$ in the population is zero: $H_0 : \beta_j = 0$ and the alternative is the coefficient $j$ in the population is not zero: $H_a : \beta_j \neq 0$. Researchers typically use $\alpha=0.05$ as the criterion for "statistical significance". With regression coefficients, output from

statistical software usually includes a range of $\alpha$ levels for interpreting the results. The test statistics will be computed. The test statistic for each regression coefficient is a t-test statistic with the following form:

$$t = \frac{b_j - 0}{SE_{b_j}} = \frac{b_j}{SE_{b_j}}$$

Formula 5. T test statistic formula

This is sometimes called a **t test statistic**, **t-value**, or **t-ratio**. Since $k = 1$, the t-ratio lies on a t-distribution with degrees of freedom $(df)$ equal to $n - k - 1 = n - 2$. The t-ratio tells us how far the sample coefficient is from the null hypothesis of a population coefficient equal to zero. The statistical software will be used to obtain the t-ratio and find the standard error $SE_{b_j}$. Next, it is vital to compare the Test Statistic with a Critical Value (or Values). The critical value or values is based on the significance level $\alpha$. Since a two-sided test are being conducted,

where $H_a: \beta_j \neq 0$:

If $|t| \geq t_{\left(\frac{\alpha}{2}\right)}$, then $H_0: \beta_j = 0$ is rejected. After using statistical software critical values will be obtained. The P-value will be compared with the Significance Level $\alpha$. Knowing that the p-value is the probability of obtaining a test statistic as or more extreme than it is actually obtained, for a two-sided test

where $H_a: \beta_j \neq 0: p - value = 2 \times P(T \geq |t|)$.

 If the p-value $\leq \alpha$ which means the null is rejected. The statistical software will be used to obtain the p-values as well. In conclusion, for the intercept, rejecting the null leads to the conclusion that the intercept in the population is not zero. Typically inferences about the intercept aren't that substantively interesting. For the slope, rejecting the null leads to the conclusion that the slope in the population is not zero. That is, the researcher concludes

that the linear relationship between the predictor or input variable and the outcome is "statistically significant" at the $\alpha$ level.

# 3     **Literature Review**

The literature review is one of the main sections of research and it describes the theoretical aspects of the research objective as well as presenting the reader with an idea about past research that has uncovered similar or relevant research to this research topic. The goal of the literature review is firstly to gain an insight about the topic under discussion in a way that the reader is introduced to the themes that will follow (Hart, 1998). Moreover, the purpose of the literature review is to establish a theoretical framework about the research area, define critical theories and concepts, discuss the previous research that supports the theory provided in the research at hand, and to establish the field of research (RMIT, 2016); in this case public administration and specifically oil policies. In addition, the literature review is also an opportunity to reveal the research methodologies used by previous researchers regarding similar topics and analyse the similarities and differences in the methodology and how such discrepancies can limit the conclusion or improve it (Labaree, 2009).

There are several types of literature review, such as argumentative, theoretical, methodological, systemic, historical and integrative. In this paper, the researcher will use the systemic review (as well as accommodating the discussion regarding the methodological choices of researchers). Moreover, the method in which the topics will be described is thematic in nature (Labaree, 2009). That means that each theme that defines the variables, as well as the main title of the research, will be discussed. Lastly, the literature review will in two separate sections: the first section will preview the theoretical concepts and ideas that are necessary for the understanding of oil polices in general and the second section is concerned with presenting and analysing previous studies and literature.

## 3.1  OPEC

OPEC is an organization that combines a dozen oil exporting countries. The acronym stands for Organization of Petroleum Exporting Countries. There are a dozen state members in the OPEC organization that have entered into the organization in different time frames. OPEC is an intergovernmental organization that was founded in 1960 in Iraq and later in 1965 the organization was moved to Vienna, Austria (OPEC Report, 2015). The organization has 14 member states which account to more than 70% of the world's oil proven reserves and produces around 40% of total oil production in the oil market today. The state members of OPEC are Saudi Arabia, Venezuela, Iraq, Iran, Qatar, Nigeria, Kuwait, Libya, Gabon, Indonesia, Algeria, Angola, United Arab Emirates and Ecuador. As it can be seen from the list aforementioned, most of the member states are from the Middle East and the Persian region. Thus it can be concluded that many of the decisions that this organization take can be influenced by regional conflict and regional political interests of the primary member states such as Saudi Arabia, Iran and Iraq (OPEC History, 2016).

| | 1960 | 1970 | 1980 | 1990 | 2000 | 2014 |
|---|---|---|---|---|---|---|
| Algeria | 181.1 | 1,029.1 | 1,019.9 | 783.5 | 796.0 | 1,192.8 |
| Angola | 1.1 | 83.9 | 150.0 | 473.8 | 736.1 | 1,653.7 |
| Ecuador | 7.5 | 4.1 | 204.1 | 286.1 | 392.2 | 556.6 |
| IR Iran | 1,067.7 | 3,829.0 | 1,467.4 | 3,135.3 | 3,661.3 | 3,117.1 |
| Iraq | 972.2 | 1,548.6 | 2,646.4 | 2,112.6 | 2,810.0 | 3,110.5 |
| Kuwait[1] | 1,691.8 | 2,989.6 | 1,663.7 | 858.6 | 1,996.1 | 2,866.8 |
| Libya | – | 3,318.0 | 1,831.6 | 1,389.1 | 1,347.2 | 479.9 |
| Nigeria | 17.4 | 1,083.1 | 2,058.0 | 1,726.7 | 2,053.6 | 1,807.0 |
| Qatar | 174.6 | 362.4 | 471.4 | 405.6 | 648.2 | 709.2 |
| Saudi Arabia[1] | 1,313.5 | 3,799.1 | 9,900.5 | 6,412.5 | 8,094.5 | 9,712.7 |
| United Arab Emirates | – | 779.6 | 1,701.9 | 1,762.6 | 2,174.7 | 2,794.0 |
| Venezuela | 2,846.1 | 3,708.0 | 2,165.0 | 2,135.2 | 2,891.0 | 2,682.6 |
| **OPEC** | **8,273.0** | **22,534.5** | **25,279.9** | **21,481.6** | **27,600.8** | **30,682.9** |

Figure 4. OPEC members daily production as a function of time (OPEC report, 2015) (in barrels) 1*Figures include share of production from Neutral Zone.

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The primary purpose of the OPEC organization is to dominate the oil market and more clearly to control the prices of oil traded in the international market. However, reviewing the history of OPEC, it can be seen that it was chiefly affected by politics and even managed by politics many times rather than by pure economic measures. For instance, the Oil Embargo in 1973-1974 that made an insufficiency in oil resources throughout the world especially in the US and UK and any country that supported Israel in the Yom Kippur war. Another situation was the hostage crisis in Vienna, where the oil ministers of Iran and Saudi Arabia were taken hostage to be executed by a group that supported the Palestinian cause; in any case, the organization has seen the pinnacle of its power since its inception and up to 1980s. The organization had a gigantic ability to manipulate oil prices; it also had the largest oil reserves and also the organization account to half of the world's oil production consistently since its inception up to this day. These factors have given much power to the OPEC organization. The source of this power is that many of the non-OPEC oil producers are net oil importers and thus they need more than they produce (Maxwell, 2013).

However, the internal situation of OPEC was not always satisfying; the organization has rarely been able to create a unionized front and there was still internal conflict regarding several issues especially the burden of cuts; another point is cheating among its members regarding the accepted quotas. That is because OPEC members agree on production quotas among each other, but it seems that from a national perspective there were several cases, there is empirical evidence, where countries changed their oil policies and secretly increased their production output.

There have been various research papers that examine the issue of internal conflict in OPEC and also analysing the behaviour of a cartel in the organization, but this will be discussed in more details in the second section of this paper. However, it is important to note the works of some researchers who proved that inside OPEC there are violations regarding the accepted quotas. Of course, the importance of this is that the proof of violations means that the negative impact on oil prices might not always be the relationship between OPEC and non-OPEC relationship regarding production cuts but also regarding the internal conflict in OPEC regarding production cuts.

Phillips (2014) argues that and it is clear that there is cheating in OPEC during 2014 because it seemed that the oil price demand by these countries and their production levels do not match. In other words, countries want higher prices yet they keep increasing their

production. Griffin and Xiong (1997) say that there is clear empirical evidence that supports the fact that OPEC state members have the incentive to cheat in order to increase their profits and gain from increased prices. They argue that what happens in that when prices are high, state members want to produce more on the account that other countries are respecting their quotas which will allow the prices to stay high. The chart below compares the OPEC quota with the actual production (in million barrels per day). Opec-12 includes Iraq while Opec-11 does not. Even without Iraq, and with Libya constrained, the production is significant.
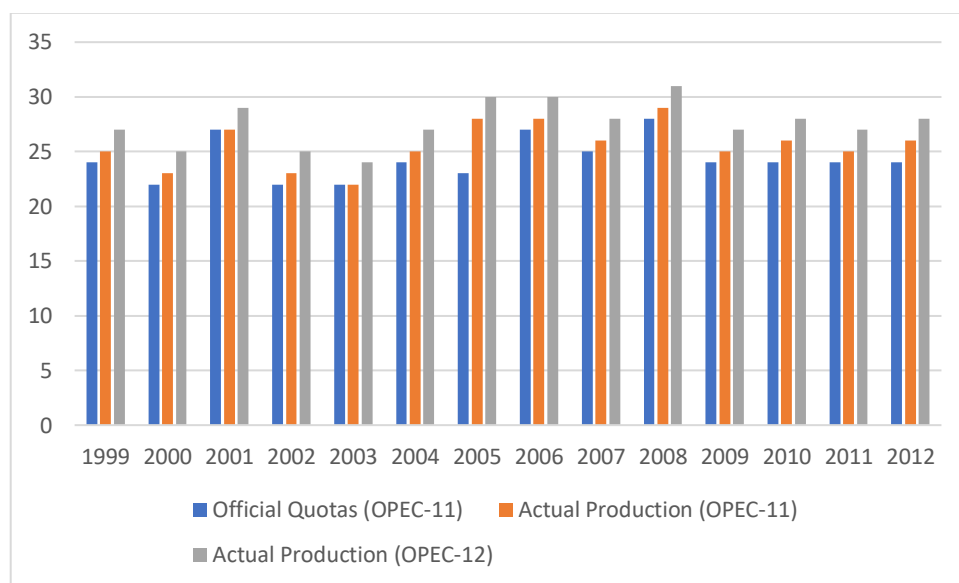


Figure 5. Total OPEC violations of quota (Bloomberg, 2014; as cited in SoberLook, 2015) (in million barrels per day)

However, when several state members behave this way a sudden increase in supply will appear which will cause the value to decrease. Griffin and Xiong (1997) argued that evidence suggests that OPEC is no longer a cartel but has become a Cournot competing organization.
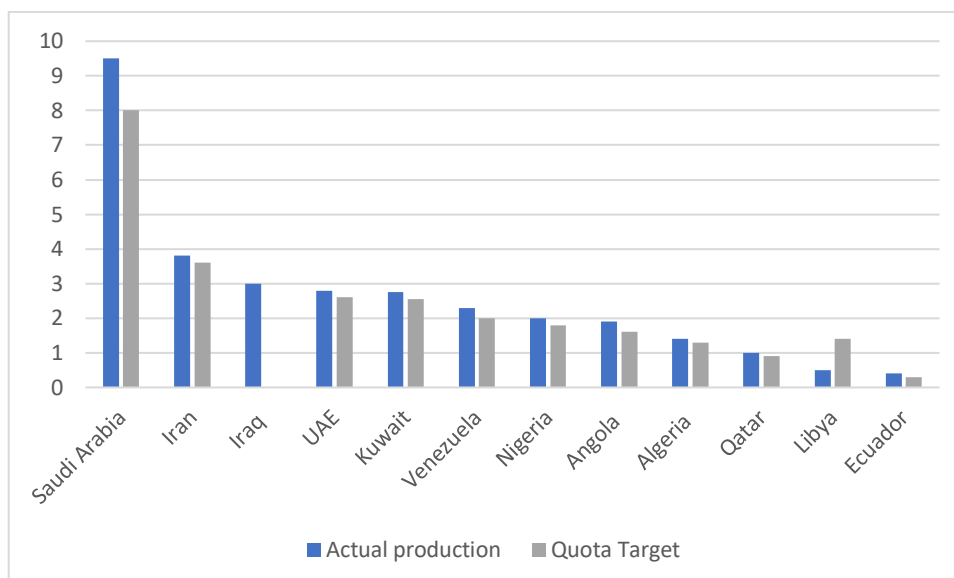
Figure 6. Production violations by country
(Bloomberg, 2014; as cited in SoberLook, 2015, in million barrels per day)

The Figure 9 is the overage by country. Iraq currently does not have a quota because of their "transition phase". Libya is clearly having "technical" difficulties meeting their quota.

## 3.2    **Non-OPEC countries and organization**

Though OPEC is an organization with a clear history of forming, and that is to control oil prices, the non-OPEC countries are basically all the other oil exporting countries. But of course it is not a coincidence that all of the remaining oil exporting countries is net importing countries (Maxwell, 2013). These are the countries which are mainly in the OECD (Organization for Economic Cooperation and Development). These countries have a varying capability of production, ranging from US which has a high production capability to Turkey and some other European countries which have insignificant production capability that can barely suffice for internal use (Lantzke, 1975). As seen in the figure below, all the countries in the top ten net oil importers are from the OECD and members of the IEA. Net imports = total imports – total exports.

As mentioned before, in 1973-1974 there was an oil embargo that took place by OPEC on several countries such as US, UK and France due to their support to Israel. This oil embargo had a powerful effect on the economics of these countries and they suffered in terms of energy. The oil policies of these countries have been altered to include political unrest. Oil

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always had a specific link to politics as a commodity like no other (Backus and Crucini, 2000).

That means that national energy policies were not only economic but also political and security oriented in some sort. Therefore, after the embargo was over in 1974 the US led a coalition to create an organization that would face OPEC. The organization was called International Energy Agency (IEA).

The state members of the International Energy Agency are: Japan, United States, United Kingdom, Turkey, Canada, Australia, Sweden, Germany, France and several others (Beilecki, 2002). The total members states in IEA are 24 members and they are only OECD countries; from Europe, North America, and Australia. These states are mainly net imports of oil and they are heavy consumers of oil. For example, the US consumes around 24% of total oil production in the world. The list of countries below in oil consumption reveals that majority of countries in the firs then countries are from the IEA – except for China, Brazil and Russia. Which means the importance of IEA is that it organizes the oil policies of these nation states because they are highly reliant on oil.

| United States | 7,39 |
|---|---|
| Japan | 4,66 |
| China | 4,5 |
| South Korea | 2,24 |
| India | 2,2 |
| Germany | 2,16 |
| France | 1,63 |
| Singapore | 1,31 |
| Italy | 1,16 |
| Spain | 1,16 |

Figure 7. Total net imports of top ten countries in 2012 (in million barrels)
(Energy Information Administration, 2014)

The IEA is an organization that serves as a policy adviser for the nation members. Just like OPEC, the organization has its oil polices and energy policies and it serves as a hub for countries to interact and create oil policies which will help these countries survive.

Therefore, it seems that OPEC and IEA are adversary organization; one which has the highest reserves and does not consumer a lot of oil (OPEC) and the other has less reserves and imports oil more than it produces (Beliecki, 2002). The purpose of the IEA is to:

- Advice on energy policies to member states (IEA, 2016)

- Also cooperation with non-member states such as Russia and China because they are somewhat in the same position but they are not in the OECD (Smith, 1985)

- Develop energy policies

- Assess energy security

- Create economic development

- And environmental protection

- Lastly, create a constant stockpile available in each member state which is equivalent to 90 day of last year's net imports; this policy is created to avoid impact of embargos (Willrich and Conant, 1977).

| Rank Country | Consumption |
|---|---|
| 1 United States | 18,961 |
| 2 China | 10,480 |
| 3 Japan | 4,557 |
| 4 India | 3,660 |
| 5 Russian Federation | 3,493 |
| 6 Brazil | 3,003 |
| 7 Saudi Arabia | 2,961 |
| 8 Germany | 2,435 |
| 9 Canada | 2,374 |
| 10 Korea | 2,328 |
| 11 Mexico | 2,090 |
| 12 Iran | 1,885 |
| 13 Indonesia | 1,718 |
| 14 France | 1,713 |
| 15 United Kingdom | 1,502 |
| 16 Italy | 1,260 |
| 17 Singapore | 1,240 |
| 18 Spain | 1,208 |
| 19 Thailand | 1,171 |
| 20 Australia | 1,080 |

Figure 8. Highest oil consumers in the world (Index Mundi, 2016)

The figure above shows ranking of the countries for consumption of oil, million barrels per day.

## 3.3    **Oil policy and its determinants**

This section of the literature review can be considered one of the most important because it defines the meaning of an energy policy, the meaning of policy in public administration, and also the framework in which OPEC and IEA works within in terms their policies. Moreover, the determinants of an oil policy are determined which is also essential for revealing to the reader the way that this research paper has been constructed in a  way to deal and assess the determinants of the oil policies of these organizations. Since the objective of this paper is to assess the relationship between IEA and OPEC then the definition of the frameworks for their policies is essential.

Energy Policy is a peer reviewed journal that defines the term Energy Policy as the behaviour (or manner) of which a state or a group states in which they would address issues of energy production, distribution, transportation, development and security (Dincer, 2002). For each of the above discussed organization there is a specific set of energy determinants that would define the framework in which the organization creates its policy. Note that Dincer (2002) argued that energy policies are rarely clearly defined. Also Marriet and Decalles (2009) argued that energy polices in the OECD as well as in OPEC member states have usually been confusing and obscure and only headlines are provided regarding the plans they have. Moreover, Marriet and Decalles (2009) say that in order to gain better insight about the organization's energy policies then the national policies of powerful state members must be analysed because they are often the representative strategy. This is also supported by the issues that rose from the IEA regarding delaying the announcement of Peak Oil in order not to push prices up and damage United States energy budgets (Said, 2015).

## 3.4    **The International Energy Agency Policies**

It must be noted that since the non-OPEC members are considered in the IEA it is clear that not all non-OPEC players are IEA members; the exceptions re China and Russia. Russia is a main exporter yet it is not a member of any organization and China is a main importer and is also not a member of both organization. Therefore, when considering non-OPEC countries the policies of IEA members can differ from Russia's and China's. This differentiation is important due to the issue of oil pricing; that's because some IEA

countries which are mainly net importers might be interested in lower prices on the international market while Russia for example will be interested in higher oil prices. Thus among the IEA members only Denmark, Norway and Canada are net exporters and all the other countries are net importers. Therefore, the issue of pricing here would differ for each member state (IEA Imports, 2016)

By analysing the IEA General Energy Policies outlook the policies that are revealed in terms of oil and gas are shown below (IEA General Policies, 2015)

Norway: "Norway supports increasing production of oil"

Japan: "In the light of changing gas markets, Japan is examining ways to increase its power as a buyer."

Italy: "Italy reviews its gas market mechanisms and infrastructure, hoping to keep rising gas prices in check"

General Policies:

Canada: "Canada is modernising and streamlining its regulatory procedures for reviewing projects for the development of natural resources"

USA: "The United States has recently published a Climate Action Plan for steady, responsible national and international action to reduce GHGs"

Sweden: "Sweden is working towards its long-term priority of a vehicle fleet independent of fossil fuels by 2030. Sweden has long and successful experience using high taxation on energy"

Therefore as it can be seen from the above policies the countries which are known to be net importers have different concentration than countries which are net exporters. It can be concluded that net exporters such as Norway and Canada are interested in higher pricing, better infrastructure and more investment in energy sectors. But other countries such as Sweden, US and UK are interested in less dependency on oil and gas and are more into taxing these commodities and concentrating on renewables.

## 3.5 OPEC policies

On the other hand, OPEC is also an organization which is concerned with forming cohesive oil policies for its member states (OPEC, 2016). Note that OPEC members have 70% of the world's oil proven reserves and they are all net oil exporters. Even though there is growth in their national markets, they remain to have a significant difference in their

national need and their export capacity which gives them the upper hand over other exporting countries. Moreover, production costs in most of the OPEC countries are meager because energy policies there are built on subsidies, tax cuts and low infrastructure costs. In addition to that technical issues such as well area and different petroleum industry technicalities such as well depth play a role in the price of oil production which is significantly low in OPEC countries. The table below sums the proposed issue clearly and shows how OPEC countries have a little cost of production which IEA countries have significant costs of production. For instance, the cost of production of oil barrel in the UK costs as much as the total amount for OPEC to produce one barrel (Statistica, 2016).
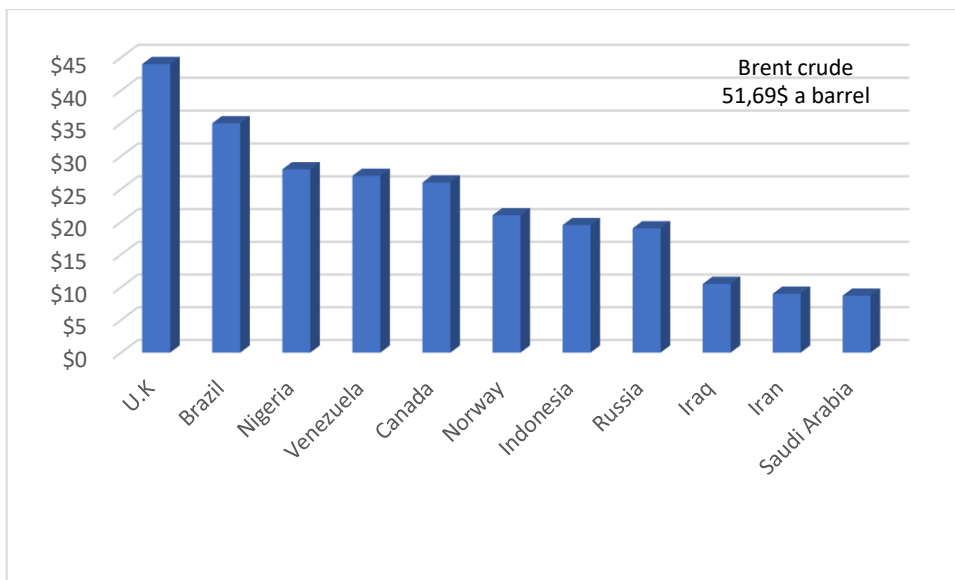


Figure 9. Cost of producing a barrel of oil (Wall Street Journal, 2016)

And the table below shows how much US dollars oil production costs to countries. Comparing table 11 and table 12 we can recognize gross margin for each country. For instance cost of producing a barrel of oil in UK is approximately 44$ and production cost about 17$, so gross profit is 44-17=27 in US dollars.
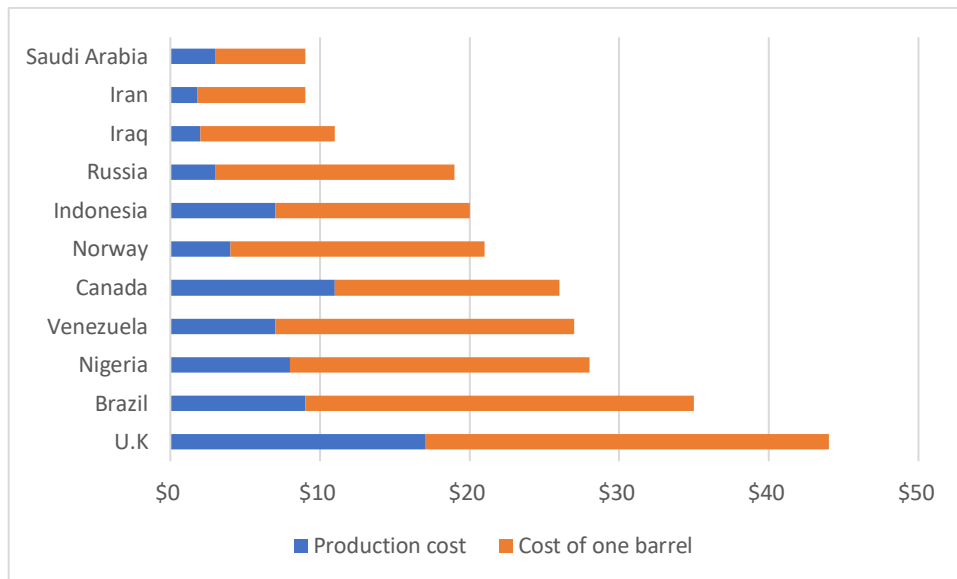
Figure 10. Cost of oil production in each country (Wall Street Journal, 2016)

Finally, the OPEC statute (mission) is summarized in the OPEC reports below (OPEC Statute, 2016):

- "harmonise the petroleum policies of its Member Countries as part of its efforts to safeguard their interests"

- "the Organization shall work together to ensure stable oil price"

- "secure fair returns to producing countries and investors in the oil industry"

- "Provide a steady petroleum supply to consumers."

Policy determinants as summarized by (Geri and McNabb, 2011; McGowan, 2012; IEA General Policies, 2016) :

- Prices

- Production

- Supply

- Demand

- Renewable energy

- Proven reserves

- Import/Export Relationship

- GHG

- Transportation

- Political influence

- Energy Dependency

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- Social Impacts and human development

- Energy Efficiency

- Environmental Impact – Climate Change Act

Thus in light of this research paper the policy determinants that will eb considered are: prices, imports exports, supply and demand, and production.

## 3.6 Evidence for reliance in oil policies

This section of the literature review will discuss the theoretical and empirical evidence that supports the theory which is provided by the research paper and that is that non-OPEC countries rely on OPEC to make production cuts. Note that non-OPEC countries here are represented by two separate states such as Russia and China and also by IEA which represents the interest of OECD countries which created this organization to look after the interest of these countries in reaction to the 1973 oil embargo.

In contemporary energy policies there seems to be a theory supported by literature that non-OPEC countries rely on OPEC to make production cuts. There are several reasons why production cuts are made and the main reason, maintains good prices of oil in the international market. But the question remains: which country must cut its production ?

It is understood why countries are reluctant to make production cuts, and that's because cuts means less revenues and other countries will make higher revenues. How the cuts are shared and by which organizations is the essence of the presented theory.

Fattouh and Sen (2015) argued that non-OPEC countries rely on OPEC to make production cuts and hold the burden of cuts. "It has long been the case that non-OPEC countries leave it to OPEC to implement cuts" (Fattouh and Sen: 13). In that research paper, the researcher used qualitative methods as well as quantitative methods to analyse the relationship between OPEC and non-OPC members. Though the main purpose of the research paper was to analyse the energy policy Saudi Arabia, one of the conclusions was the reliance of non-OPEC countries on OPEC to decrease production. Moreover, another conclusion was that among OPEC members there is often disagreement onto who should shoulder the production cut burden. Furthermore, Tutt and Clinch (2015) also said that OPEC's director believes that non-OPEC must also share the burden of oil production cuts "Diezani Alison-Madueke, said that non-OPEC oil producers had to "share the burden" of any future cut in production." This clearly insinuates that non-OPEC usually relies on OPEC to make cuts.

Almuguera et al., (2007) presented a research paper that used the exact similar methodology in order to test a similar concept pertaining to the behaviour of the OPEC in face of non-OPEC countries. Note that the issue of behaviour is similar and overlapping with the concept of this paper. In other word, in the conclusion of this paper a point will be made in terms of the behaviour of OPEC, non-OPEC and IEA. That's because from the behaviour of the organization in terms of production in could be concluded whether the organization is acting as a carter or as competitive fringe.

Alumgeura et al., (2007) concluded that OPEC behaves in cournot competitive method and not in a cartel as the literature suggests while the non OPEC are also clearly in a competition with OPEC." Cournot competition is defines as "an industry structure in which competing firms that make the same homogeneous and undifferentiated product choose a quantity to produce independently and simultaneously. The Cournot Competition model makes a number of assumptions – the firms cannot collude or form a cartel, and they seek to maximize profit based on their competitors' decisions" (Investopedia, 2016).

Ratti and Vespignani (2015) also made a research paper that analysed the relationship between oil production of OPEC and non-OPEC countries. The model of Ratti and Vespignani's research is very much similar to the research made by the author of this paper. The tool used for data analyses I linear regression and thus the research design is quantitative. Moreover the research conceptual framework is similar; Ratti and Vespignani analysed the relationship between oil production as well as the change in oil prices in the international oil market. The tables below summarize the results of their research. The sample period is from 1974:Q1 to 2012:Q4. The study uses quarterly data so as to make use of a broad indicator of global economic activity provided by a proxy for global GDP which can be constructed at this frequency.11 A proxy variable for global GDP ($GGDP$)$t$ is provided by the aggregated purchase power parity GDP in U.S. dollars for the U.S., the European Union countries, Australia, Canada, China, Ireland, Japan, Korea, Mexico, New Zealand, Norway and Turkey.12 Oil price ($OPt$) is the spot price of Western Texas Intermediate (WTI) oil from the U.S. Department of Energy. These countries account for more than 80% of global GDP for most of the data period. The starting date is dictated by the availability of oil price data.

**OPEC oil production**

| Age of OPEC (1974–1996) | | | | | New industrial age (1997–2012) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Quarters | OPEC | Non-OPEC | Global GDP | Oil prices | Quarters | OPEC | Non-OPEC | Global GDP | Oil prices |
| 2 | 81.60 | 13.40 | 4.11 | 0.90 | 2 | 81.21 | 0.07 | 1.17 | 17.53 |
| 4 | 78.94 | 12.96 | 6.01 | 2.08 | 4 | 72.86 | 0.22 | 5.72 | 21.18 |
| 8 | 78.72 | 12.92 | 6.26 | 2.08 | 8 | 72.71 | 0.23 | 5.93 | 21.13 |

**Non-OPEC oil production**

| Age of OPEC (1973–1996) | | | | | New industrial age (1997–2012) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Quarters | OPEC | Non-OPEC | Global GDP | Oil prices | Quarters | OPEC | Non-OPEC | Global GDP | Oil prices |
| 2 | 7.10 | 86.81 | 0.10 | 5.97 | 2 | 0.39 | 97.09 | 2.23 | 0.27 |
| 4 | 7.04 | 85.44 | 1.42 | 6.08 | 4 | 0.42 | 93.92 | 2.26 | 0.40 |
| 8 | 7.03 | 85.12 | 1.76 | 6.07 | 8 | 0.42 | 96.90 | 2.27 | 0.40 |

Figure 11. Variance decomposition of growth in OPEC and non-OPEC oil production (Ratti and Vespignani, 2015, data in millions of barrels)

The OPEC oil production (*OOPt*) and non-OPEC oil production (*NOOPt*) data in millions of barrels average pumped per day from the U.S. Department of Energy. Real variables are nominal variables deflated by the U.S. CPI from the Federal Reserve Bank of St. Louis.

Moreover, the figure below shows the change in oil production variance between oil production in OPEC and non-OPEC countries.

Ratti and Vespignani (2015) used Hamilton's (2013) model in research to check for the strength of OPEC to change prices during five different periods. Moreover, as in Hamilton the correlation between OPEC production and non-OPEC production is positive at 0.35 which is positive but not very strong.

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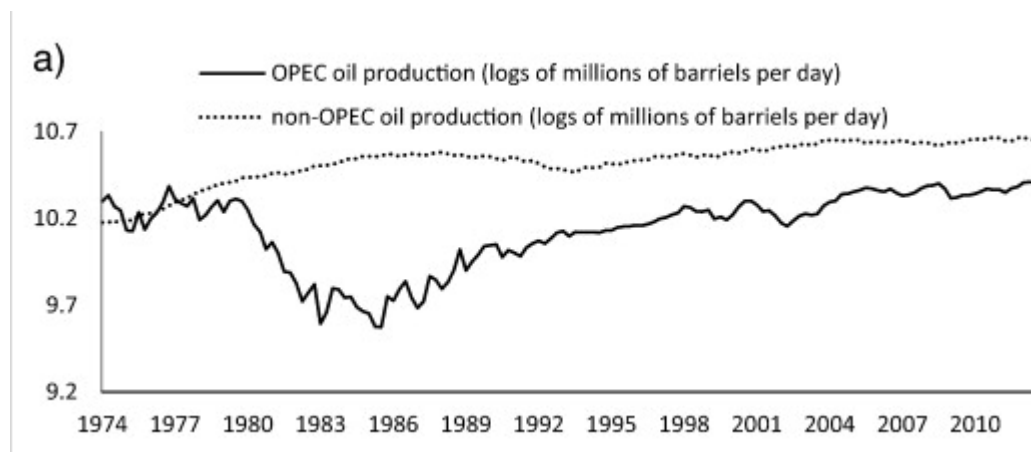
Figure 12. Difference between OPEC and non-OPEC production (Ratti and Vespegnani, 2015)

But Ratti and Vespignani (2015) found that only in the "industrial age" (1980 to 1995) period this correlation existed. As Hamilton argued, positive correlation would indicate reliance among the organization; Hamilton (2013) says that a positive correlation means that both organizations are increasing their production based on each other's increase. This supports Fattouh and Sen's (2015) theory of oil production cuts reliance. Note that an importance difference between this research paper and Hamilton's is that this one takes into consideration the relationship and reliance of oil production among OPEC, IEA members and non-OPEC countries excluding the OECD countries.

Gulen (1996) also analysed the relationship between oil production between OPEC and non-OPEC countries by using a quantitative method but not via linear regression. "These implications of cartel behaviour are tested via co-integration and causality tests." It can also be seen that there is a link between the relationship between oil production and the behaviour of organization; such as Cartel or Cournut competitiveness. "This is also the only period in which the causality from OPEC production to the price of oil is statistically significant. Overall, the evidence suggests that OPEC did act as a cartel in the 1980's in order to maintain prices, while it simply took advantage of market conditions in the 1970's and did not have to restrain output." That means the research of Gulen (1996) also found that OPEC acted as a cartel in 1980's in order to raise prices. This allows the conclusion, by the author of this paper, that OPEC somewhat acted in a way that made other states to rely on OPEC to make production cuts. That means that when OPEC acted as a cartel in order to increase prices it made other countries rely on OPEC to cut production.

Griffin (1985) found that OPEC acts as a cartel especially in the 1980s period; via linear regression and unit root tests he found that the oil production between OPEC and non-OPEC has been positive. Moreover, Griffin (1985) found that OPEC's behaviour as a cartel means that OPEC has the ability to influence prices in that paper. on the other hand, Spilimbergo (2001) and Gulen (1996) found not relationship between the production output of OPEC and non-OPEC; the consensus of these papers is that OPEC is not a cohesive cartel and it has to impact on prices.

Finally, the latest research by Alhajji and Heutner (2000) found that "neither OPEC nor the OPEC core can be considered as dominant producer" and that means that there is no relationship between production of OPEC and non-OPEC and also no influence on prices. This research is very convincing because it is supported by Smith (2002) who argued that there are several other factors that play a role in the creation of pricing in the oil market and organization such as OPEC and also non-OPEC organization has so much internal conflict and other factors that precludes the ability to create influence on the international markets. Alhajji and Heuter (2000) also indicated that political wars and instability can cause price structural breaks.
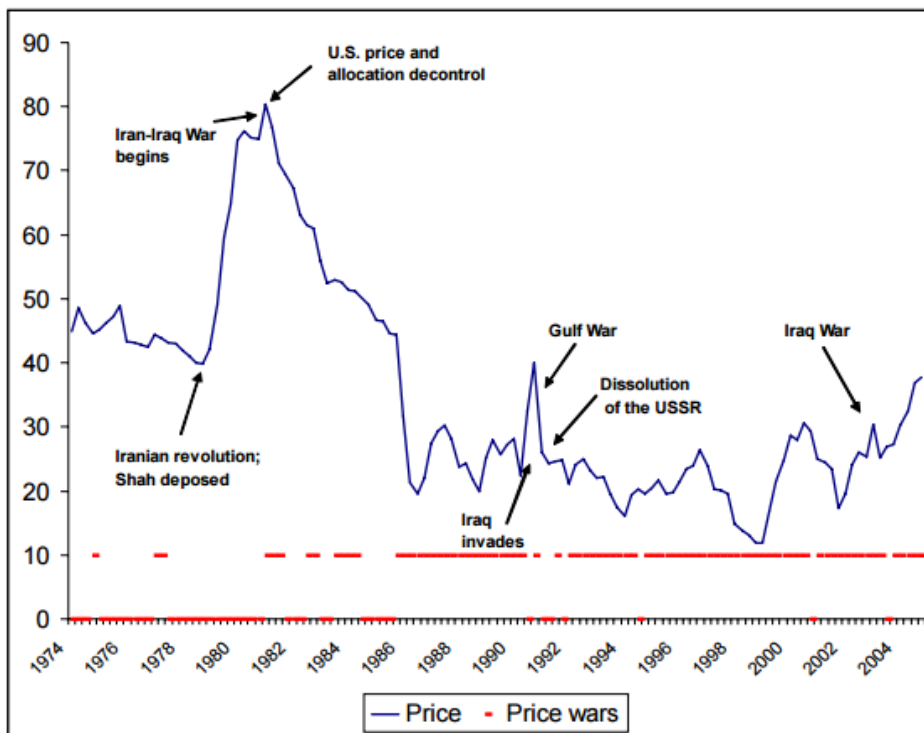


Figure 13. Price wars (Gulen, 1996)
Note: Prices are measured in dollars per barrel of December 2002.

Lastly the literature review regarding the supply and demand relationship is also important for this paper because it shows in detail the interplay between supply and demand which is necessary for the understanding of the need of production cuts. The law of demand states that whenever the price of a good increases the demand for this good decreases. As to the law of supply it states that if the price of a good increase the supply for it increases. But the interplay among the supply and demand brings in the equilibrium prices which are the price at which the supply and demand intersects. In addition, it is known that when the supply for a commodity increases the price of the commodity decreases and when the price decreases the demand increases (Tucker, 2008). Therefore, it can be seen why oversupplying the oil market is not favourable for oil exporting countries because it will decrease the selling price. But this interplay in the oil market is important. For example, during high prices of oil, consumers rely more on oil efficiency and avoid using cars with high fuel consumption due to their high cost of usage. Thus the demand will eventually decrease from the consumers' side; this is also the issue for manufacturing process that cannot decrease their production but will increase their cost. On the other hand, on the supply side, an increased price means more R&D in oil, more oil projects, more jobs in the oil sector and increasing consumer purchasing power for citizens of oil exporting countries (Smith 2015). The Economist (2014) reveals this interplay with supply and prices quite clearly in figure below.

This graph below shows that at low oil prices, $50 dollars per barrel in during 2016, only OPEC countries can make profit during low prices which shows a very complex situation and from the graph it understandable how oil prices affect OPEC and non-OPEC production and viability.
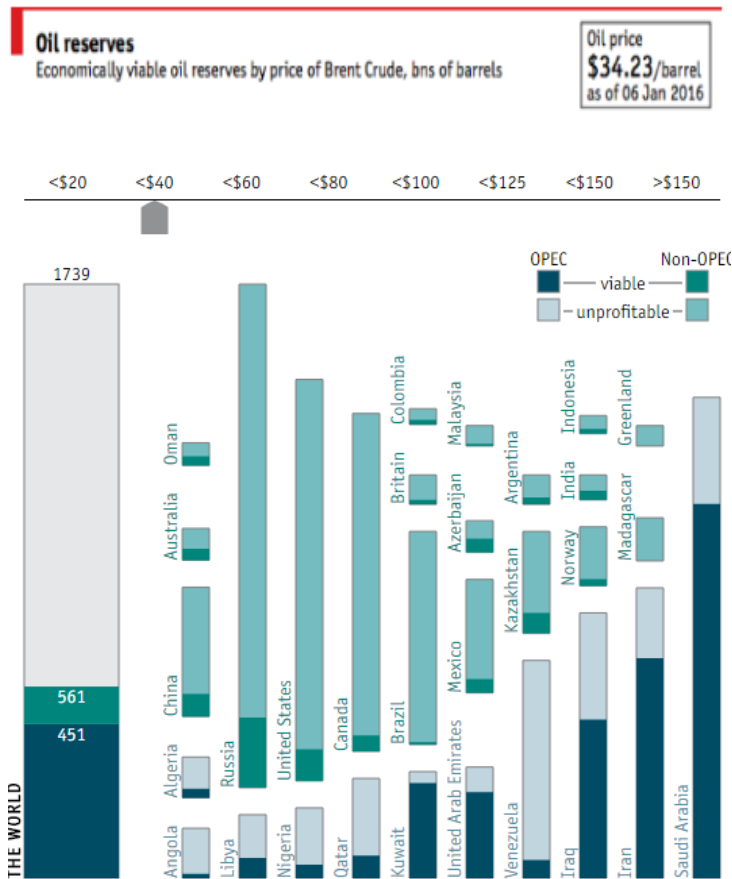
Figure 14. Interactive graph regarding oil production viability (Economist, 2014)

Table which shown below describes, how the WTI oil price and World Oil supply changes year by year and it is seen that the lines moves opposite each other which means when supply of products increases, oil price goes down.



Figure 15. Relationship between supply and prices (Economist, 2014)

OPEC countries want high oil prices to have higher governmental revenue because their GDP's depends highly on oil exports. On the other hand, non-OPEC countries, and especially IEA organization and the OECD countries want lower oil prices because they are mainly net importers, note that inside each organization there are different policies that drive their interests. Yet, with low prices, as seen from the figure above, they are no longer able to produce their own oil because they have high cost of production which means that there is a trade-off between low prices and high prices for OECD countries.

# 4 Results, discussion and analysis

## 4.1 What is the relationship between OPEC production and IEA (OECD) production?

The importance of this relationship is that it analyses the relationship between OPEC and specific non-OPEC countries. Previous research has discussed the relationship between OPEC and non-OPEC countries but non-OPEC countries vary a lot, especially the OECD countries which are represented by the International Energy Agency and other non-OPEC such as Russia and China.

That's because IEA countries are producers but they are mainly importers but Russian and Russia are somewhat both; they consume large amounts of oil and in the case of Russia they produce a lot of it. Moreover, Russia as a non-OPEC country is not in both organizations, OPEC and IEA, is that they have totally different interests. Thus the importance of the separation of the non-OPEC countries; this separation is evident in the first and second research questions.

The results of the regression are shown in the table below.

As seen from the figure the Pearson Correlation is 0.37 which means that if the correlation is positive must not very strong. On the other hand, the R squared is not very good; it was 14 % which means that this correlation explains only 14 % of the movement in data. Even though the R-squared is not used to accept or reject the null hypothesis (Yan, 2009), it is considered a good indicator about the significance and strength of the relationship between the variables (Seber and Lee, 2012).

This weak measurement, 14 %, means that Alhajji (2001) might have been correct in the estimation that the relationship between OPEC and non-OPEC is not bound by production rules and that there is no correlative behaviour between them. Even though, empirically there is a clear correlation between these variables in this paper, the weak r-squared means that the movement in OPEC's production output is not very much linked to the action in the IEA member state change in production.

| Regression Statistics | | | | | |
|---|---|---|---|---|---|
| Multiple R | 0.377209738 | | | | |
| R Square | 0.142287187 | | | | |
| Adjusted R Square | 0.125469288 | | | | |
| Standard Error | 3063.816158 | | | | |
| Observations | 53 | | | | |
| ANOVA | | | | | |
| | df | SS | MS | F | Significance F |
| Regression | 1 | 79418097 | 79418096.67 | 8.460461824 | 0.066364117 |
| Residual | 51 | 4.79E+08 | 9386969.45 | | |
| Total | 52 | 5.58E+08 | | | |
| | Coefficients | Standard Error | t Stat | P-value | Lower 95% |
| Intercept | 13337.16819 | 1762.615 | 7.566694958 | 6.9494E-10 | 9798.571409 |
| X Variable | 0.196891997 | 0.067691 | 2.908687303 | 0.005364117 | 0.060996613 |

Figure 16. Regression results for research question 1

For this particular data, $b_0 \approx 13337.16$ and $b_1 \approx 0.197$ are found.

The line is thus expressed as: $\hat{Y}_i = b_0 + b_1 X_i = 13337.16 + 0.197(X_i)$.

Interpretation of the test statistics:

For the intercept $(j = 0)$, $t = \frac{b_0}{SE_{b_0}} = \frac{13337.16}{1762.61} \approx 7.56$.

For the slope $(j = 1)$, $t = \frac{b_1}{SE_{b_1}} = \frac{0.197}{0.067} \approx 2.91$.

These each lie on a t-distribution with $n - k - 1 = 53 - 1 - 1 = 51$ degrees of freedom. For the intercept, the probability of obtaining a test statistic as or more extreme than the one observed under the assumption that the null is true is $p - value = 6.9494E - 10$. The corresponding p-value for the slope is $p - value = 0.005364117$.

Moreover, two measures of overall model fit are also given. Firstly, we're given the residual standard error, or the root mean square error (RMSE). Conceptually it tells the size of our average residual. It is computed by taking the square root of the $SS$ divided by the

degrees of freedom $(df = n - k - 1)$: $RMSE = \sqrt{\frac{SS}{df}} = \sqrt{\frac{SS}{n-k-1}} = \sqrt{MS_{Residual}}$.

Furthermore, the output also gives us the $R^2$ or the coefficient of determination. It is the proportion of variation in the outcome accounted for or explained by our regression model. Adjusted $R^2$ is a version of $R^2$ that adds a penalty for including a noisy input variable in the model. Lastly, another inferential test is also given which is based on an F test statistic. In the context of simple linear regression, the F test can be viewed as an alternative to the t-test for the slope with $H_0: \beta_1 = 0$ versus $H_a: \beta_1 \neq 0$. The F test statistic lies on the F

distribution with $df_{Regression} = k$ and $df_{Residuals} = n - k - 1$, where $k$ is the number of predictor or input variables. In simple linear regression $k = 1$.

The p-value of this regression is 0.063 which is above the needed 0.05 for the rejection of the null hypothesis. This means that the null hypothesis cannot be rejected. This also means that the alternative hypothesis (that there is no relationship between the behaviour of OPEC and IEA members) cannot be rejected and is possible; in this case the possibility of occurrence of such hypothesis is 6.3 %. This means that the positive relationship found between production levels of OPEC and the IEA is not accepted.

 According to the analysis made by the statistical software, R square is 0.14, which indicates that there is an inferior proportion of the variance between the independent variable (OPEC average daily output per year) and the dependent variable (IEA average daily production annually).

This result is considered extremely important in the field of oil market and that means that's that Alhaji (2000) as well as Smith (2001) who found no relationship between OPEC behaviour and non-OPEC behaviour could be the closest to reality because they assumed that other actors are more influential regarding the relationship between organization and that simple interactions regarding production is not enough. For deeper analysis the graph of oil production of OPEC and IEA countries is presented in the graph below.
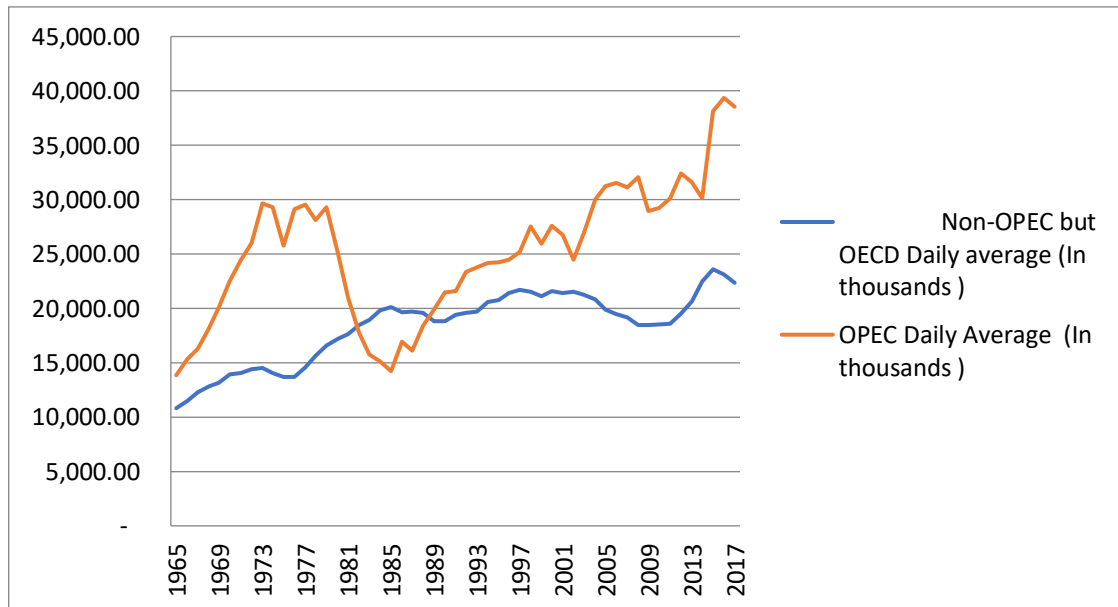


Figure 17. Relationship between OPEC and IEA members

As seen from the figure above, the positive correlation could be realized but it can also be realized that the reliance of IEA members on OPEC is not so strong. Only between 1980 and 1989 OPEC decreased its prices but in this period IEA countries did not increase their production a lot. The IEA non-OPEC production has been a steady increase since the beginning and between 2007 and 2010 there was a certain decrease in both organizations. This means that the hypothesis that argues that non-OPEC countries rely on OPEC to make cuts does not include OECD countries which are part of the IEA organization. Therefore, even though the IEA and OPEC seem to be in a head to head rivalry they have a common interest: steady prices and this relationship will be studied further in the last research question.

Further analysis also support this conclusion; by analysing the change in production output per year for both IEA and OPEC it is seen that in 18 observations (18 years) OPEC made production cuts; the highest production cut occurred in 1981 which was

17 % of OPEC production.

Also IEA made 16 observed cuts during the same period and 6 out of these cuts coincided with OPEC and that means that 37.5 % of times IEA made cuts at the same time OPEC made cuts and that clearly means that there is no reliance between those organization especially between IEA and OPEC. The graph below shows the instances where the cuts coincided. The graph reveals that percentage increase or decrease of oil production; generally negative values represent oil production cuts and the instances where the production cuts coincided are the instances where the negative bars coincide.
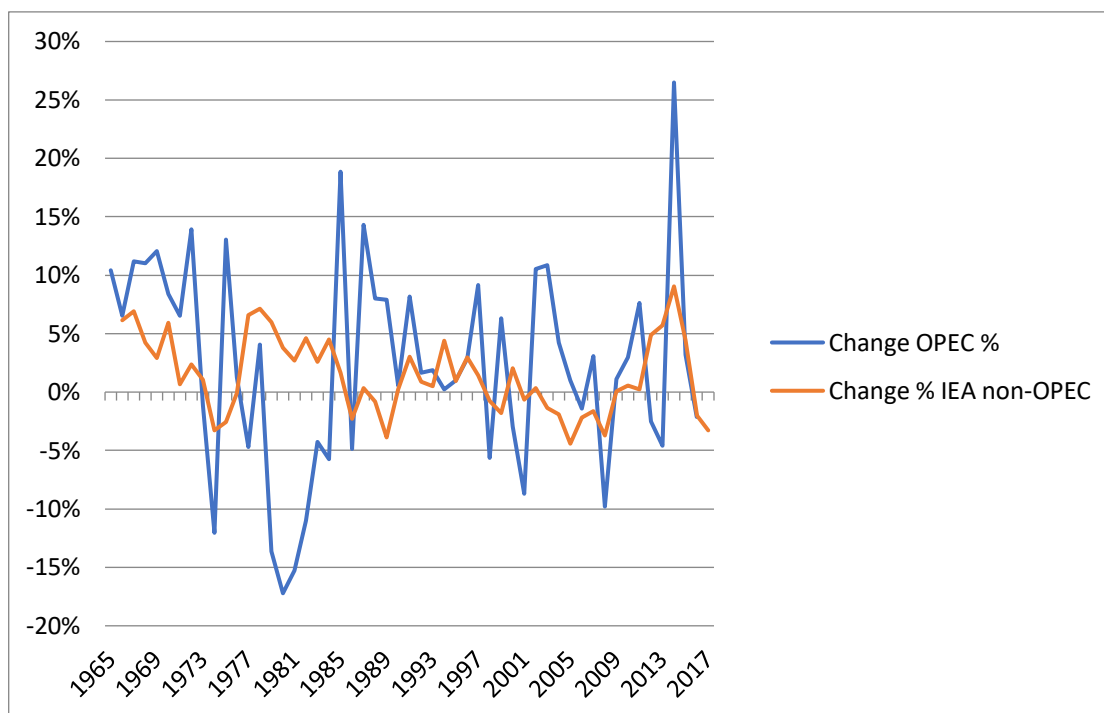
Figure 18. Comparison Between change in percents of OPEC's Production and change in percents of IEA production

## 4.2 What is the relationship between OPEC production and non-OPEC (and non-OECD) countries (such as China, Russia, and Brazil)?

The second research question analyses the relationship between OPEC production and between non-OPEC producers, of course there is a difference between the first non-OPEC relationship and the second one.

It is important to make a difference between these non-OPEC countries because their behaviour is different. For example, there is a consensus about the cartel behaviour of OPEC but the consensus regarding the competitiveness of the non-OPEC countries is not clear because these countries vary in needs and behaviour. Some of them are part of the OECD which have energy policies including environmental policies and concentration on alternative energy resources. Moreover, OECD countries are more interested in energy efficiency policies rather than importing more oil; on the other hand, there are other countries which are interested in higher oil prices such as Russia and Brazil.

As seen from the table below it is clear that there is a very strong positive relationship between OPEC production levels and non-OPEC and non-OECD (not IEA organization). As mentioned before in the literature review Griffin (1985) found that there is a positive

relationship between non-OPEC countries and OPEC production and thus supporting the idea that there is reliance of non-OPEC countries on OPEC for production cuts.

The Pearson correlation rate for the measured relationship here is 0.54 which is considered strongly positive. Moreover, the p-value for this relationship is extremely low at 2.1E (numerically, the E refers to scientific notation which means 10 zero) which is extremely low and way below the required 0.05 level (Yan, 2009). That means that based on these results the null hypothesis can be rejected and that means that the relationship between OPEC and non-OPEC (non-IEA) production levels are accepted and there is a significant level of correlation among the data.

The interpretation of the strong positive correlation between the production of OPEC and non-OPEC (non-IEA) is that there is reliance between these organizations. That means that non-OPEC countries which are also non-IEA (not in the OECD) such as Russia, China and Brazil actually rely on OPEC to cut production in order to improve prices. The interpretation logic is that if the correlation is positive this means that when OPEC increases its production non-OPEC countries such as Russia and China also increase their production. That means that even if the prices are low non-OPEC countries keep on increasing their production output depending on the production of OPEC.

Of course the analysis is not over, and analysing the percentage changes of production allows a clearer insight towards what does these non-OPEC producers do when OPEC cuts its production. Based on the positive correlation, these non-OPEC producers (also non-IEA) must either not decrease their output or actually increase their output. In other words, unlike the no-correlation which was found between OPEC and IEA where production cuts coincided 60 % of the times; in this correlation, there must be no coincides between the data.

Moreover, r-squared is 30 % which is high; the interpretation of the r-squared is that 30 % of the movement in the data in the OPEC's production is explained by the movement in non-OPEC production (Seber and Lee, 2012).

The analysis made by the statistical software indicates that R square is 0.30, which specifies that there is not a strong proportion of the variance between the independent variable (annual OPEC average daily output) and the dependent variable (Non-OPEC and Non-OECD countries average daily production per year).

| Regression Statistics | | | | | |
|---|---|---|---|---|---|
| Multiple R | 0.548448055 | | | | |
| R Square | 0.300795269 | | | | |
| Adjusted R Square | 0.287085373 | | | | |
| Standard Error | 7777.029502 | | | | |
| Observations | 53 | | | | |

| ANOVA | | | | | |
|---|---|---|---|---|---|
| | df | SS | MS | F | Significance F |
| Regression | 1 | 1.33E+09 | 1326979803 | 21.94000995 | 2.12293E-05 |
| Residual | 51 | 3.08E+09 | 60482187.87 | | |
| Total | 52 | 4.41E+09 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% |
|---|---|---|---|---|---|
| Intercept | 19069.45431 | 4474.128 | 4.262160693 | 8.73963E-05 | 10087.2667 |
| X Variable | 0.804823191 | 0.171823 | 4.684016433 | 2.12293E-05 | 0.45987351 |

Figure 19. Regression results for the second research question

For this particular data, $b_0 \approx 19069$ and $b_1 \approx 0.80$ are found

In the second question the line is can be considered as:

$$\hat{Y}_i = b_0 + b_1 X_i = 19069 + 0.80(X_i)$$

Interpretation of the test statistics:

For the intercept $(j = 0)$, $t = \frac{b_0}{SE_{b_0}} \approx 4.26$.

For the slope $(j = 1)$, $t = \frac{b_1}{SE_{b_1}} \approx 4.68$.

In regard to intercept, the probability of obtaining a test statistic as or more extreme than the one observed it is assumed that the null is true is $p - value = 8.73963E - 05$. The corresponding p-value for the slope is $p - value = 2.12293E - 05$.

On top of that, two calculations of overall model fit are also given. At first, there is the residual standard error, or it is also known as root mean square error (RMSE). As per the concept it shows the size of the average residual. Furthermore, the output also gives the coefficient of determination which is $R^2$. It is the proportion of variation in the outcome that is calculated by our regression model. The changed $R^2$ is a version of $R^2$ that adds a penalty for including a noisy input variable in the model.

Finally, in relation to simple linear regression, it is possible to see the F test as an alternative to the t-test for the slope with $H_0: \beta_1 = 0$ versus $H_a: \beta_1 \neq 0$.

The analysis of the data of percent changes of the non-OPEC countries (non IEA) it can be seen that only 3 times did they make production cuts worth 1 % (2 observations) and 2 % (one observation) which are extremely low; on the other hand, OPEC made 14 production cuts with an average of 12 %. That means that it is clear that the non-OPEC countries have often relied on OPEC to make the production cuts. The figure below reveals the above analysis in more detail.
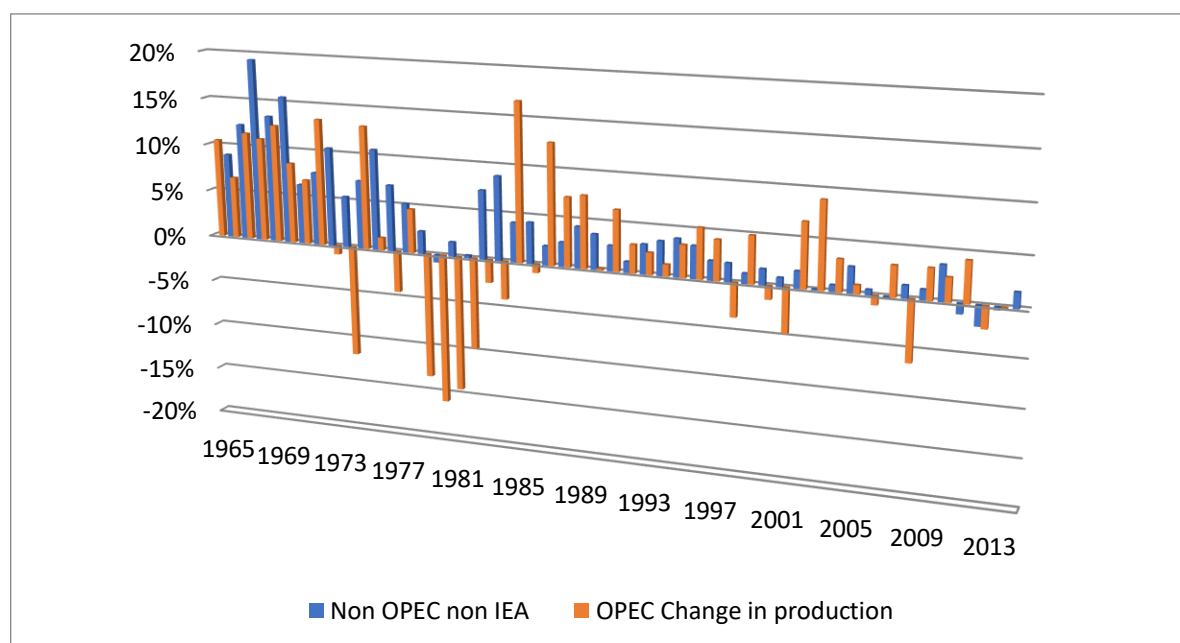


Figure 20. Relation between percent change in production between OPEC and non-OPEC non-IEA countries.

## 4.3 What is the relationship between change in production and change in oil prices? Is OPEC a cartel?

The third research question is concerned with finding out whether OPEC is behaving like a cartel. In other words, does OPEC have the influence to change prices? And does it take the interest of all its members by decreasing production in order to increase oil prices and thus improving the GDP of member countries which are mainly net exporting countries. This research was replicated by Gulen (1996) and Sipliminerg (2001) and they have found that in one instance that OPEC was a cartel and in another that it was a Cournut competitor. Note that the cartel behaviour was significant only in some time period and overall the

behaviour was considered to be cournot competitive. The period that Ratti and Vespingnani (2015) argued that between 1980 to 1989 OPEC behaved like a cartel and had the ability to influence prices.

 By analysing the results of the below table it's clear that there is a weak positive correlation with low r-squared value at 2 %. The weak Pearson correlation is at 0.15 but in this regression the null hypothesis cannot be rejected because the p-value is 0.27 which is 27 % and that is higher than the required 5 % and that mean that the null hypothesis cannot be rejected which means that there is no correlation between production changes and prices (Yan, 2009).

| Regression Statistics | | | | | |
|---|---|---|---|---|---|
| Multiple R | 0.152274948 | | | | |
| R Square | 0.02318766 | | | | |
| Adjusted R Square | 0.004034477 | | | | |
| Standard Error | 30.28437304 | | | | |
| Observations | 53 | | | | |
| ANOVA | | | | | |
| | df | SS | MS | F | Significance F |
| Regression | 1 | 1110.333 | 1110.332708 | 1.21064262 | 0.276371346 |
| Residual | 51 | 46774.31 | 917.1432505 | | |
| Total | 52 | 47884.64 | | | |
| | Coefficients | Standard Error | t Stat | P-value | Lower 95% |
| Intercept | 33.95270577 | 4.305617 | 7.885677635 | 2.19342E-10 | 25.30881945 |
| X Variable | -52.61571554 | 47.81977 | -1.100292061 | 0.276371346 | -148.6179137 |

Figure 21. Regression results for research question 3

For this particular data, $b_0 \approx 33.95$ and $b_1 \approx -52.61$

The line is: $\hat{Y}_i = b_0 + b_1 X_i = 33.95 - 52.61(X_i)$

Interpretation of the test statistics:

For the intercept ($j = 0$), $t = \frac{b_0}{SE_{b_0}} \approx 7.88$.

For the slope ($j = 1$), $t = \frac{b_1}{SE_{b_1}} \approx -1.10$.

Regarding to intercept, the chances of obtaining a test statistic as or more extreme than the one viewed it is assumed that the null is true is $p-value = 219342\mathrm{E}-10$. The corresponding p-value for the slope is $p-value = 0.276371346$.

Moving forward, two calculations of overall model fit can also be seen. At first, there is the root mean square (RMSE). The result also gives the coefficient of determination which is $R^2$. It is the proportion of variation in the outcome that is calculated by our regression model.

Finally, for the simple linear regression, it is quite possible to see the F test as an alternative to the t-test for the slope with $H_0: \beta_1 = 0$ versus $H_a: \beta_1 \neq 0$.

According to the analysis made by the statistical software, R square is 0.02, which points out that there is a very poor proportion of the variance between the independent variable (change in oil production) and the dependent variable (oil prices).

The change in production values of OPEC organization are not correlated with prices. That means that according to the literature review, overal the OPEC organization does not behave like a cartel and does not have an influence on oil prices. Yet the research by Ratti and Vespagnani (2015) proposed that between 1980 and 1989, this is also supported by Gulen (1996), Smith (2001) confirmed that OPEC behaved as a cartel and was able to influence prices by decrease its production output. Therefore, the researcher here ought to find out if at that period OPEC had the ability to impact prices. This is important because if it is true that changes in production levels of OPEC in that period caused increase in prices then there is a meaning for the reliance of non-OPEC non-IEA countries to rely on OPEC; but they can rely on OPEC only when OPEC behaves in a cohesive manner; in a Cartel.

In the figure which shown below the line is expressed as:

$$\hat{Y}_i = b_0 + b_1 X_i = 23.1231 + 56.00691(X_i).$$

Interpretation of the test statistics:

For the intercept ($j = 0$), $t = \dfrac{b_0}{SE_{b_0}} \approx 19.21654$.

For the slope ($j = 1$), $t = \dfrac{b_1}{SE_{b_1}} \approx 5.700397$.

| Regression Statistics | | | | | |
|---|---|---|---|---|---|
| Multiple R | 0.907061 | | | | |
| R Square | 0.82276 | | | | |
| Adjusted R Square | 0.79744 | | | | |
| Standard Error | 3.566397 | | | | |
| Observations | 9 | | | | |

| ANOVA | | | | | |
|---|---|---|---|---|---|
| | df | SS | MS | F | Significance F |
| Regression | 1 | 413.3033 | 413.3033 | 32.49447 | 0.000735 |
| Residual | 7 | 89.03433 | 12.71919 | | |
| Total | 8 | 502.3376 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% |
|---|---|---|---|---|---|
| Intercept | 23.1231 | 1.203291 | 19.21654 | 2.57E-07 | 20.27776 |
| X Variable | 56.00691 | 9.825098 | 5.700392 | 0.000735 | 32.77424 |

Figure 22. Regression results for the relationship between production cuts and oil prices between 1980 and 1989

In regard to intercept, the probability of obtaining a test statistic as or more extreme than the one observed it is assumed that the null is true is $p - value = 2.57\text{E} - 07$ The corresponding p-value for the slope is $p - value = 0.000735$. As seen in the above figure the Pearson correlation is 0.9 which is extremely and strongly positive, supported by a low p-value which means that the null hypothesis is rejected and the r-squared is very high at 82 % meaning that the relationship between the data is significant. That clearly shows that the literature review was correct in finding that during 1980 and 1989 OPEC was a cohesive organization that behaved like a cartel and had a huge power to influence prices in a correlation of 0.9. That means at OPEC increased its production cuts (the reason why per cent changes had to be multiplied by -1, to reverse the negative sign) the prices increase.

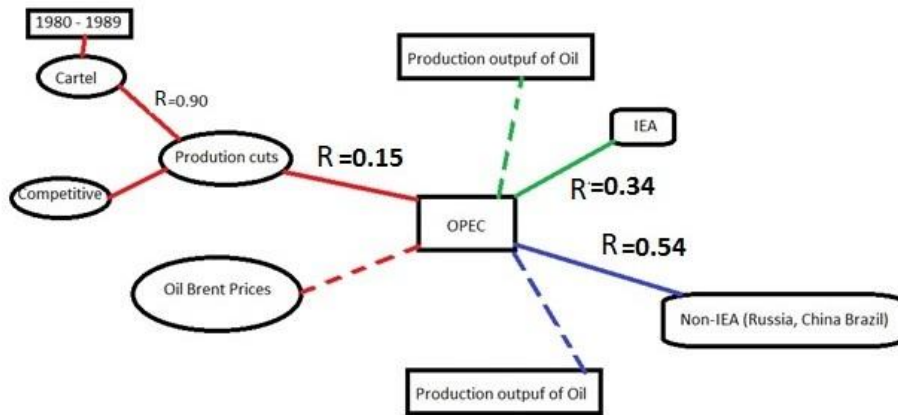In the figure below the conceptual framework with results is shown.



Figure 23. Conceptual framework including results

# 5    Conclusion

In conclusion, the results in some parts of the research questions came as the researcher expected and some came against all expectations. The results of the first research paper revealed that there is no relationship between the production of OPEC and the production of IEA countries (OECD countries such as US, UK and France). There was a positive weak correlation that was not supported by a low p-value which means that the null hypothesis is not rejected.

That means that IEA countries do not rely on OPEC to make production cuts. This is an interesting result that comes against several research papers such as COlgan (2003); Gulen (1996) and Almugeura (2007). As mentioned in the literature review the relationship between supply and demand is very important for the oil international market. In the case of the relationship between OPEC and IEA countries there is an extremely complex situation which Alhajji (2015) for example pointed out by saying that there is no relationship between these organizations in terms of production of oil.

This is clear by analysing the supply and demand relationship also, while OPEC is an organization with mainly Middle Easter countries which have more than 50% of their GDP collected from oil exports, they have a clear objective: keeping oil prices high and stable. This is also supported by the OPEC Statute (OPEC Statute, 2016) which concentrates on making sure OPEC countries have high revenues from selling their oil. Thus it's clear that OPEC would want to have higher prices, yet at the same time it believes that it doesn't always have to shoulder the decrease in production and thus it can befit from high prices and higher sales (high production). On the other hand, the IEA has a more complex situation because at low oil prices these countries cannot produce their national oil due to high costs, for example the cost of UK oil barrel is $46 which means at prices below this, the North Sea oil is non-extractable. At the same time since most of the IEA countries are net importers they are also not interested in high prices because then they will have high budgets to run. This complex situation explains the energy policies by the IEA which is concentrating on alternative energy, energy efficiency and lower prices; except for Norway and Canada because they are net exporters.

The second research question considered the relationship between OPEC and other non-OPEC countries which are out of the OECD; these countries are like Russia, China and

Brazil. Separating the non-OPEC countries into IEA organization and Russia, China and Brazil (and others) is important because the research conducted before, and was studied in the literature review, considered non-OPEC countries as a whole yet these countries have huge differences in their energy policies. Russia's energy policy does not have a concentration on alternative energy and efficiency which is the core of Germany's and Sweden's energy policy.

Thus when the research treats all non-OPEC countries in one way then the results cannot be generalized. The results of the second research question came to support the literature review and confirmed that the other non-OPEC countries (Russia and Brazil) rely on OPEC organization when it comes to production cuts. This is supported by a strong positive strong correlation supported by a very low p-value which rejects the null hypothesis. That means that the observer countries which are not part of IEA and outside OPEC usually avoid making production cuts and wait for OPEC to make cuts so that they can increase their revenues on a national level.

Thirdly, the last research question the relationship between the change in production level of OPEC and the prices of Brent oil in the international market. The purpose of this research question is to find out if OPEC has the impact to change the prices on the international market and also to check if OPEC acts as a cartel. This research is important in order to know if the IEA organization and the other non-OPEC countries are accurate in relying on OPEC to decrease production; that means does OPEC have the ability to change prices and does the production cuts implemented by OPEC impact the prices or not?

By analysing the data from 1965 to 2014 it is clear that OPEC does not have an impact on prices; the correlation was weak at 0.2 and was not supported by the p-value. On the other hand, OPEC was seen to behave as a cartel with an extremely strong positive correlation at 0.9 between 1980 and 1989. That means only in that period was OPEC able to impact prices.

| Relationships | Theory | Energy Policies (similarities) | Energy Policies (differences) |
| --- | --- | --- | --- |
| OPEC vs. IEA | No reliance from IEA on OPEC for production cuts | Energy policies are similar regarding production levels | Energy policies are different in terms of prices (not clearly known) |
| | | | Energy policies of IEA concentrate on alternative energy, environmental impact and energy efficiency |
| OPEC vs. non OPEC (non-IEA) Russia, China and Brazil | Reliance from non-OPEC on OPEC to make cuts; supports literature review by Fattouh and Sen (2015) | Energy policies similar in wanting higher prices

No concentration on alternative energy, environmental and efficiency | Different in production levels |
| OPEC and Prices | Over 1965 to 2014 no correlation; no impact on prices by OPEC | OPEC behaves as a Cournut competition over the period of 1965 | Non-OPEC (non IEA) should not rely on OPEC to make production cuts because the cuts by OPEC do not have huge impact on prices at the moment |
| | Only from 1980 to 1980 | OPEC's policy as a cartel was only in 1980 to 1980 | |

Figure. Summary of conclusions regarding theories of OPEC and non-OPEC

## 5.1     **Recommendation**

➢      Non-OPEC (non IEA) countries must not concentrate on relying on OPEC to make production cuts because OPEC has no influence to impact prices at the moment; further research must be made in order to analyse the drivers of oil prices which are non-related to the supply and demand relationship.

➢      OPEC must behave like a cartel in order to influence prices; that's because the cartel behaviour can influence other factor than the supply and demand such as the political factors; further research must be done in the area of competitiveness among the OPEC members which is causing conflict among its members which broke down the cartel behaviour of OPEC

➢      Lastly, OPEC must understand the real policy of IEA countries because there is no clear indication about the behaviour of IEA; this paper was not able to conclusively find out the behaviour of IEA when it comes to prices; IEA might not be behaving against OPEC when it comes to production (similar cuts) but might be acting in another area to influences prices according to its interests.

## 5.2     **Limitations**

➢      The first limitation comes in the methodology; the researcher believes that there might be interactions among these organizations beyond the ability of the statistical research to find out. That means that qualitative research mixed with quantitative research might bring in further information regarding the political conflict among OPEC members and bring in answers to why the cartel behaviour is no longer existent

➢      The relationship regarding the reliance of non-OPEC organization such as IEA and non-OPEC is not very clear; non OPEC and non IEA countries rely on OPEC while IEA countries don't rely; this research only find the causality among the relationships but does not give an answer regarding the cause of this behaviour and further research is advised to find the causes, via Multivariate analysis research.

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# Appendix

| Year | Non OPEC all Countries | | | OPEC | | | Non OPEC (OECD countries) | | | Oil Prices |
|---|---|---|---|---|---|---|---|---|---|---|
| | Non-OPEC all Countries daily production | Change in quantity | Change in percentage | OPEC Daily Average (In thousands ) | Change in quantity | Change in percentage | Daily Average (In thousands ) | Change in quantity | Change in percentage | |
| 1965 | 17,876.92 | - | | 13,844.83 | - | | 10,815.18 | | | 3.01 |
| 1966 | 19,182.08 | 1,305.16 | 7% | 15,287.70 | 1,459.72 | 10% | 11,478.43 | 663.24 | 6% | 3.1 |
| 1967 | 20,731.85 | 1,549.77 | 8% | 16,284.47 | 999.54 | 6% | 12,272.86 | 794.44 | 7% | 3.12 |
| 1968 | 22,179.77 | 1,447.92 | 7% | 18,105.58 | 1,869.16 | 11% | 12,795.33 | 522.47 | 4% | 3.18 |
| 1969 | 23,384.08 | 1,204.31 | 5% | 20,104.60 | 1,992.71 | 11% | 13,169.78 | 374.45 | 3% | 3.32 |
| 1970 | 25,293.62 | 1,909.54 | 8% | 22,534.49 | 2,519.31 | 12% | 13,951.96 | 782.18 | 6% | 3.39 |
| 1971 | 26,136.62 | 843.01 | 3% | 24,429.20 | 1,939.59 | 9% | 14,044.76 | 92.80 | 1% | 3.6 |
| 1972 | 27,268.53 | 1,131.91 | 4% | 26,027.35 | 1,691.23 | 7% | 14,376.87 | 332.11 | 2% | 3.6 |
| 1973 | 28,527.12 | 1,258.59 | 5% | 29,652.04 | 3,539.50 | 13% | 14,530.29 | 153.42 | 1% | 4.75 |
| 1974 | 28,947.09 | 419.97 | 1% | 29,321.52 | (265.15) | -1% | 14,055.35 | (474.93) | -3% | 9.35 |
| 1975 | 29,640.64 | 693.55 | 2% | 25,788.08 | (3,486.29) | -12% | 13,698.61 | (356.74) | -3% | 12.21 |
| 1976 | 30,819.50 | 1,178.86 | 4% | 29,146.63 | 3,408.70 | 13% | 13,686.10 | (12.51) | 0% | 13.1 |
| 1977 | 32,732.29 | 1,912.79 | 6% | 29,522.91 | 393.50 | 1% | 14,586.91 | 900.81 | 7% | 14.4 |
| 1978 | 34,661.12 | 1,928.82 | 6% | 28,127.46 | (1,306.11) | -4% | 15,625.29 | 1,038.38 | 7% | 14.95 |
| 1979 | 36,049.32 | 1,388.20 | 4% | 29,271.37 | 1,333.41 | 5% | 16,558.32 | 933.04 | 6% | 25.1 |
| 1980 | 36,930.21 | 880.89 | 2% | 25,279.88 | (3,982.43) | -13% | 17,186.87 | 628.55 | 4% | 37.42 |
| 1981 | 37,651.37 | 721.16 | 2% | 20,927.45 | (4,132.79) | -16% | 17,645.93 | 459.06 | 3% | 35.75 |
| 1982 | 38,556.30 | 904.93 | 2% | 17,733.93 | (3,139.72) | -14% | 18,459.97 | 814.04 | 5% | 31.83 |
| 1983 | 39,671.26 | 1,114.96 | 3% | 15,785.26 | (1,812.42) | -10% | 18,937.76 | 477.79 | 3% | 29.08 |
| 1984 | 41,156.13 | 1,484.88 | 4% | 15,115.72 | (408.28) | -2% | 19,789.66 | 851.90 | 4% | 28.75 |
| 1985 | 41,584.56 | 428.43 | 1% | 14,251.71 | (663.74) | -4% | 20,118.52 | 328.86 | 2% | 26.92 |
| 1986 | 41,911.87 | 327.30 | 1% | 16,942.21 | 2,645.50 | 17% | 19,655.17 | (463.35) | -2% | 14.44 |
| 1987 | 42,387.51 | 475.65 | 1% | 16,122.00 | (165.41) | -1% | 19,726.19 | 71.02 | 0% | 17.75 |
| 1988 | 42,425.68 | 38.17 | 0% | 18,432.78 | 2,327.21 | 13% | 19,565.32 | (160.86) | -1% | 14.91 |
| 1989 | 41,816.57 | (609.11) | -1% | 19,906.89 | 1,501.41 | 7% | 18,804.71 | (760.62) | -4% | 18.23 |
| 1990 | 41,527.06 | (289.51) | -1% | 21,481.64 | 1,677.24 | 8% | 18,844.28 | 39.57 | 0% | 23.76 |
| 1991 | 41,297.66 | (229.40) | -1% | 21,605.47 | 46.72 | 0% | 19,410.73 | 566.45 | 3% | 20.04 |
| 1992 | 40,284.09 | (1,013.57) | -2% | 23,367.01 | 1,523.90 | 6% | 19,589.40 | 178.67 | 1% | 19.32 |
| 1993 | 39,794.77 | (489.32) | -1% | 23,748.15 | 753.80 | 3% | 19,690.92 | 101.52 | 1% | 17.01 |
| 1994 | 40,283.77 | 488.99 | 1% | 24,199.62 | 598.75 | 2% | 20,560.96 | 870.04 | 4% | 15.86 |
| 1995 | 40,874.53 | 590.77 | 1% | 24,260.01 | 328.30 | 1% | 20,757.57 | 196.61 | 1% | 17.02 |
| 1996 | 41,808.17 | 933.64 | 2% | 24,499.60 | 919.31 | 3% | 21,376.28 | 618.71 | 3% | 20.64 |
| 1997 | 42,579.09 | 770.91 | 2% | 25,196.79 | 1,477.79 | 5% | 21,681.30 | 305.01 | 1% | 19.11 |
| 1998 | 42,689.74 | 110.66 | 0% | 27,504.18 | 1,209.68 | 4% | 21,520.36 | (160.94) | -1% | 12.76 |
| 1999 | 42,587.17 | (102.57) | 0% | 25,955.72 | (1,081.18) | -4% | 21,127.63 | (392.73) | -2% | 17.9 |
| 2000 | 43,802.57 | 1,215.40 | 3% | 27,600.76 | 1,497.35 | 5% | 21,536.45 | 408.82 | 2% | 28.66 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2001 | 44,471.00 | 668.42 | 2% | 26,794.14 | (428.12) | -1% | 21,408.46 | (127.99) | -1% | 24.46 |
| 2002 | 45,644.75 | 1,173.76 | 3% | 24,469.89 | (1,386.53) | -5% | 21,486.69 | 78.23 | 0% | 24.99 |
| 2003 | 46,331.54 | 686.78 | 2% | 27,048.21 | 2,027.48 | 7% | 21,197.29 | (289.40) | -1% | 28.85 |
| 2004 | 46,917.39 | 585.85 | 1% | 29,982.41 | 2,750.66 | 9% | 20,800.09 | (397.20) | -2% | 38.26 |
| 2005 | 46,807.02 | (110.37) | 0% | 31,246.44 | 1,006.00 | 3% | 19,883.30 | (916.79) | -4% | 54.57 |
| 2006 | 46,945.05 | 138.03 | 0% | 31,565.62 | 473.32 | 1% | 19,447.39 | (435.91) | -2% | 65.16 |
| 2007 | 47,064.92 | 119.87 | 0% | 31,123.43 | (305.02) | -1% | 19,131.08 | (316.31) | -2% | 72.44 |
| 2008 | 46,591.13 | (473.79) | -1% | 32,075.36 | 1,033.52 | 3% | 18,424.79 | (706.29) | -4% | 96.94 |
| 2009 | 47,224.72 | 633.59 | 1% | 28,927.13 | (2,305.53) | -6% | 18,432.11 | 7.32 | 0% | 61.74 |
| 2010 | 48,165.64 | 940.92 | 2% | 29,249.38 | 1,088.31 | 3% | 18,526.98 | 94.87 | 1% | 79.61 |
| 2011 | 48,038.11 | (127.53) | 0% | 30,121.16 | 902.37 | 3% | 18,574.15 | 47.17 | 0% | 111.26 |
| 2012 | 48,703.38 | 665.28 | 1% | 32,424.70 | 1,492.08 | 4% | 19,482.00 | 907.85 | 5% | 111.57 |
| 2013 | 50,045.30 | 1,341.91 | 3% | 31,603.79 | (919.06) | -2% | 20,635.14 | 1,153.14 | 6% | 108.56 |
| 2014 | 52,253.53 | 2,208.24 | 4% | 30,145.50 | 11.54 | 0% | 22,588.17 | 1,953.03 | 9% | 98.97 |
| 2015 | 53,571.71 | 1,318.18 | 3% | 38,132.55 | 1,560.03 | 4% | 23,596.18 | 1,008.01 | 4% | 62 |
| 2016 | 52,792.17 | (779.54) | -1% | 39,357.90 | 1,225.35 | 3% | 23,121.64 | (474.54) | -2% | 50 |
| 2017 | 52,654.00 | (138.17) | 0% | 38,526.25 | (831.65) | -2% | 22,369.00 | (752.64) | -3% | 58 |

Appendix  1. Data for research question 1