A MODEL TO FORECAST WTI OIL PRICES

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ABSTRACT

This paper aims at forecasting the evolution of the oil prices in the short and medium term. In order to accomplish that, we rely on historical data as well as possible variables that may have influence on the price. With all the important variables defined, we are going to focus on choosing the econometric model that will help us in forecasting. After that, we are going to see how the current market situation is mainly due to the United States and the OPEC production increase. Once we have estimated the model, we will draw different conclusions, first seeing the impact of the different variables and second linking the price estimated with the one-year future contract.

Keywords: oil prices, forecast, OPEC, World Texas Intermediate, fracking.

JEL Codes: C54, C32.

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LISTING, TABLES AND GRAPHS LIST

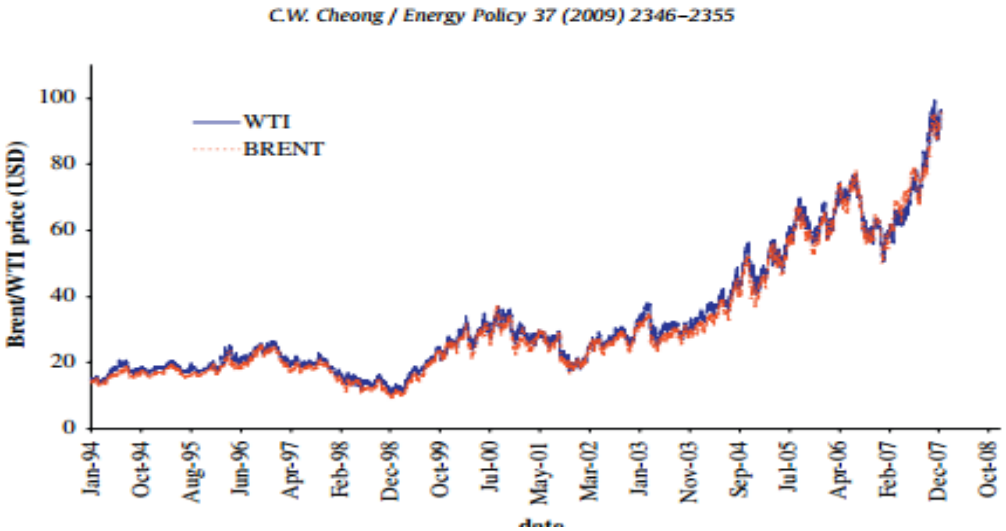
1 INTRODUCTION

The oil impact on the economy of both producing and consuming countries, as well as in international relations, has become increasingly large; as the countries are developing economically, greater is its energy consumption and, therefore they will have greater dependence in oil and its derivatives. Although it is true they haven't had much weight historically in energy production, renewable resources are becoming more relevant lately, such as photovoltaic, hydraulic and mainly wind. However, these types of energy are more typical in developed countries since they require an investment which will not be recovered in short term. In General, we are in a context where developed countries act as consumers and the exporting ones, are those in developing, depending mostly on the oil for this development.

In view of the importance of this commodity in economy, many analysts have tried to predict its price in order to reduce the possible shocks in the economy that could produce the volatility of prices. However, many difficulties are found in making their forecasts due to their non-observable variables such as relationships between exporting and importing countries, relations between the countries or even the appearance of a new way to extract the oil, and make the prices go down sharply, as the fracking. For this reason, oil long term prediction models are less precise since they are more prone to impacts caused by factors hardly observable or predictable. Thus, this work will mainly focus on short and medium term.

We must take several things into account before we proceed with the study. First, in the oil market there are basically two large markets where the barrel price is referenced: World Texas Intermediate (WTI) in the U.S. and the barrel of Brent in Europe. Both barrels have 159 litres each, but the oil's composition from each one is slightly different so the price is valued in each market. However, you can see that there is a strong correlation between the Brent barrel's price and WTI, so, although diversions will always be present , predicting the WTI barrel's price can be used to get an idea of the Brent barrel's price, and vice versa. So, for convenience, the price that we are going to use in this work will be World Texas Intermediate.

Graph 1 Brent vs WTI oil prices



Source: C.W. Cheong elaboration, Energy Policy 37 (2009)

2 RELATED LITERATURE

Given the importance of the barrel's price level in economy, many analysts have try to explain how they will evolve in order to anticipate possible short-term problems caused by this price level. So, the literature is extensive but varied at the same time due to the difficulty to explain the volatility of oil prices.

In the same way is the historical literature, related to the most influential oil prices ups and downs in the past 45 years. Starting with the first great moment of inflection in prices studied in this work, Greg Myre (2013) explains and summarizes the main causes for which the price has developed as we should see later. The main reason was due to an embargo by OPEC, although there were other causes such as the dollar devaluation. Six years later, there was another massive increase in prices, mainly due to OPEC's strategy and the wars, indicated by Philip K. Verleger and J. Phillips (1979). Just one year later, in 1980 these prices went down sharply on account of an overproduction. In addition, there is no shortage of authors who found similarities between the state of the market in 1980 and the current one, as for example Russell Gold, Senior Energy Reporter for the Wall Street Journal (2016). From 1980 to 2003 prices did not vary too much, but starting from 2003,we can notice a great increase in the demand for this commodity, produced in large part due to the growth of economies that so far had relatively not much impact as for China (above all), India and Southeast Asia (Fan Ying and Jin-Hua Xu, 2011). Regarding the current market situation there is no a large literature as the above mentioned papers, there is rather a lot of journals that we have based on. It must be have in mind that despite having an extensive literature of different prices studies, its causes and its consequences in the past, this work is based on future prices, so we only got key points from the above literature. Though, it is true that these key points have helped us to a better understanding of the current market situation, as we can notice finding certain similarities in the current market and the 1980.

Focusing on the future prices prediction, there is also a lot of work done with this end. However, there is a great difficulty (and hence controversy) when choosing a model that allows us to choose the analysis of future prices. According to Bill Gilmer, director of the Institute for Regional Forecasting at the University of Houston (2016): "*Why are all the forecasts so poor? "It is because the world will not stand still. All of the evaluations of crude futures markets assume that on a particular day the market takes past prices, inventory data and other fundamentals to produce a set of spot and futures*

prices." However, there are several specific ways to estimate models such as the models of temporal-series, econometric models, or financial models. All of them, or at least the most important ones and those that have more prestige are gathered in the Research Review entitled "Crude Oil Price Forecasting techniques" by N. Bashiri and J. Pirés. It is worth mentioning that despite having read a lot of papers about how the described models have been estimated, many of them do not appear in the literature since they have not been relevant when it comes to work. Although they have been determinant at the moment of choosing the model that fits us the best. Among them, we must highlight the work of Kaufmann, R.K. (2004). "*Does OPEC Matter? An Econometric Analysis of Oil Prices*." In which the author proposes the following equation to discern if the OPEC actions have importance in barrel prices:

$$Price_t = a + \beta_1 Days_t + \beta_2 Quota_t + \beta_3 Cheat_t + \beta_4 Caputil_t + \beta_5 Q1_t + \beta_6 Q2_t + \beta_7 Q3_t + \beta_8 War_t + \mu$$

This will be the model in which we will base on to predict the future price, adding other variables as well that may be relevant today like the production of USA due to fracking (A. Rowell, 2015).

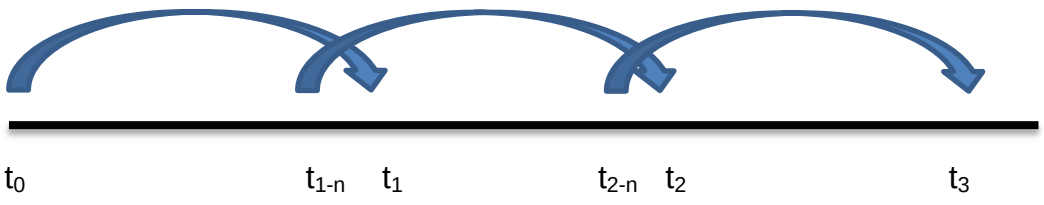
3 FORWARD AND SPOT MARKET

We call spot market to all those sets of transactions that have the purchase or sale immediately. On the other hand, in the forward market, purchases or sales take place at a future date, although both the transaction and the date are set in the present.

The oil market is a clear example of forward. According to Financial Times (2015) “In the first five months in 2015, average daily volume in WTI totaled 1M contracts on CME and ICE combined. Combined volume in Brent had 876,000 contracts a day, up 35 per cent from the same period a year before.” Resources such as electricity, gas or oil, are almost impossible to store for a running person or even for many institutions. This is one of the main reasons why the forward market is the main focus of transactions. So, invest in future market is the main way for good. Investors have mainly these pathways of profitability:

The first one is just the spot price. Basically, if the barrel has risen from 90$ to 100$ the investor will have obtained profit by selling.

The other one is the "roll-cost". As we said before, a person and even entities cannot simply store the oil, so it will have to be sold before the ETF expiry date (Exchange-traded funds). The investor will have to do a "roll" of a contract to another before the end of the first one. Therefore, the expiry date will become a very important factor since "ordinary" investors should sell it before. If T + 1 month price is higher than the price of the month T, and successively, we are in a contango situation, otherwise we call it backwardation. We will see it better with the following graph:



Due to the before described property of the oil market of not be able to store oil, users should close the future contract until it expires. For example, if it expires in t_1 they need to close contract on $t_{1\text{-}n}$. On that date, user will renew the contract to one that ends in t_2, having to close it before expires too. This is what we mean with "roll". The "cost" or "yield" is the profit or loss that will mean the investor different tradings of future contracts.

It may seem that the contango situation will always be beneficial for investors. However, let's say for example that an ETF have a price set for $90 at month X. Before maturity, the investor has to sell such ETF and buy future contracts in x + 1 month price of $ 91. This is a loss for investors in the short term. Therefore a situation of "backwardation" can also mean a win situation for the investor.

4 OIL PRICES – HISTORICAL VIEW

Once we know the difference between spot and forward markets, the study's objective is to predict the short or medium term oil forward prices in the most accurate way. Knowing how the price has evolved over the past years, can help us for this purpose, as we could find similarities on the past market states with the current situations and helps us to know at what point we are, too. We will just focus on the factors that made the oil price fluctuate to a great extent. We will not center on the economy consequences of the price alteration, as we have mentioned before, this is not the objective of the work. However, we will talk about the causes that will help us to know the reason for the fluctuations in the price. Finally, all the listed prices will be real, not nominal. That is, although we talk about the price of 1980 for example, it will be the current inflation-adjusted price to make easier and more reliable with actual comparison.

Graph 2 Historical real oil prices

Source: Macrotrending

4.1 1973 Petroleum crisis

We will begin studying the 1973 oil crisis as it is the first great turning point in prices where we have a very pronounced growth of the same history. It began in October 1973, when OPEC agreed a reduction of its oil production, also known as embargo. The embargo ended in March 1974, but then, the barrel price had already risen from $ 18 to $ 53. The reason for the embargo by OPEC was mainly due to major countries within this poster, such as Syria and Saudi Arabia, had a war with Israel, known as the Yom Kippur war. Countries such as United States, United Kingdom or France, gave their support to Israel and OPEC used the oil production as a "war weapon".

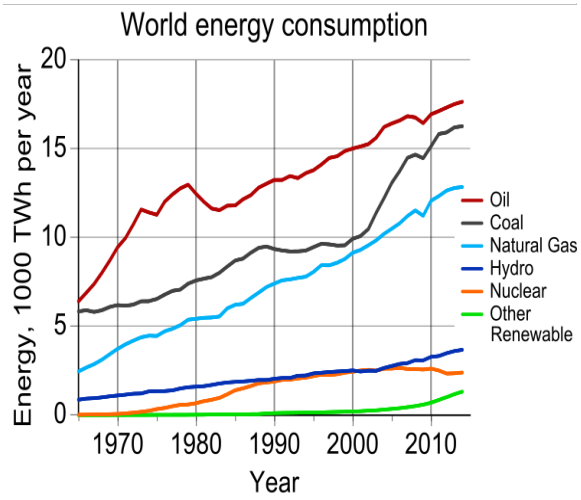
Another main reason for the oil increase prices was the devaluation of the dollar. Oil barrel is bought in dollars so it is very susceptible to such currency fluctuations. At that time United States abandoned the gold standard and suffered two devaluations, in 1971 and 1973. After a devaluation of the dollar, the barrel price may not be the same. Let's say for example that this devaluation barrel after remains to some hypothetical 50$ / barrel. With those 50$ after the devaluation we can 'buy less goods' in the international market, so it is equivalent to say that the real barrel price has diminished. Therefore, to keep the real barrel price in dollars has increased after a devaluation, and vice versa.

4.2 1979 Oil Shock

We are already in 1979 with the second great raise of the oil barrel price , as main protagonists OPEC and the war again. As a result of the war between Iran and Iraq, the barrels production of both countries declined sharply. Although Iran was the most affected. In addition, Iran was the fourth largest barrels' producer in the world, reaching approximately 20% of OPEC total production. However, when it comes to the real world production only decreased by 4% since many cartel countries offset the decline in production of both countries to increase their own. However, here there is a new element that later we will see which is very important in determining the barrel price: speculation. Helped by the announcement the 20th of January in 1979 in Saudi Arabia which indicated that they would drastically reduce its production (not only did not reduce it, as did not increase it later), spread some panic in international stock causing to rise the price more than had been expected under normal conditions.

4.3 1980 Oil Glut

Graph 3 World Energy Consumption



We are going to see for the first time a significant drop in the barrel price. The reasons are diverse. First, during those years the change of the dollar to other major currencies rose around 50%. The reason of the relationship between the change of the dollar and the barrel already explained it in the "shock" in 1973, but this time with the opposite effect. On the other hand, the successive crises in the 70's made the demand resent. Attached to that until 1980 oil offer followed an upward trend, we are to principles of 1980 with an excess of supply. Although we have previously said that the demand for oil is almost inelastic, this time we have to add some shade: energy demand is inelastic. OPEC, which until then had relied on the inelasticity of oil demand to control the price, underestimated the capacity of other sources of energy to know the need of energy consumption to some extent. As you can see in the graph, while oil demand fell, other renewable sources were increasing theirs, thus compensating possible from energy shortages of the fall in oil consumption. We are in this case therefore another factor to take into account that it had not appeared on previous occasions; alternative energies, these basically being coal, natural gas, the nuclear power plant, and the renewable, which as we can see, from the middle of the 2000s is gaining importance.

4.4 From 1980 to 2014

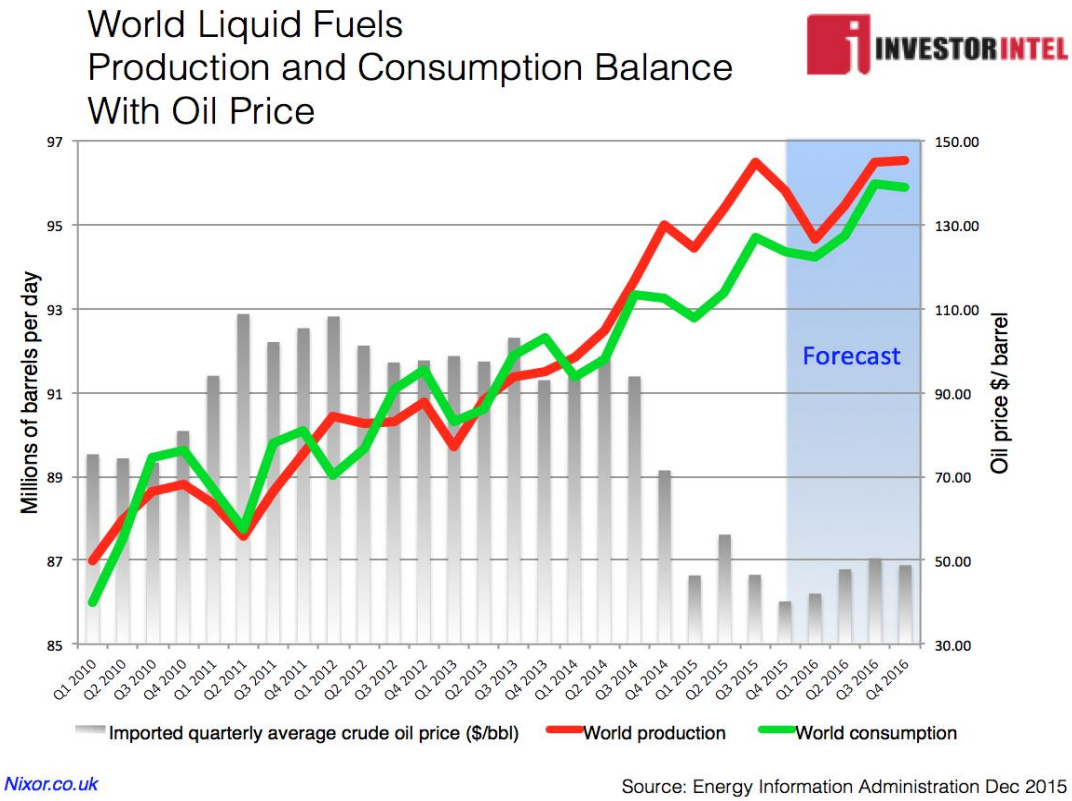
After the glut oil previously studied, prices have been fluctuating with certain stability except for a peak in 1990. This peak was due to the Iraqi invasion of Kuwait, both major oil exporters. This, added to threats in cut production of Saudi Arabia, caused the increase in price that was quickly back to normal.

From 1980 to 2007 annual oil consumption has increased at a rate 1.1% per year, from 33.1 million barrels to 85.8 billion in 2007. However, in the period 2003-2007 this increase was 1.9%, almost double. In 2003 there is a boom in commodities, which greatly increase the demand of those, related mostly to enormous industrial growth of China, India and Southeast Asia.

4.5 Current market state

We are currently experiencing a drop in price since June 2014 where the barrel price came to be over $ 100 each. As we have already seen in previous precedents in history, OPEC will always be a factor to consider when analyzing prices. The demand for oil is inelastic in short term, is a good with an almost fixed demand, and in the case of expanding or shrinking it will do it in a very limited way. Therefore, what largely determines the oil price is the offer. Indeed, current barrel prices go down, to a minimum of 35$ / u, has been due to an oversupply as we can see in the chart below:

Graph 4 World production and Consumption Balance



Before 2014 the supply and demand alternated between them making the stock of barrels were minimal, resulting in a relatively stable price level. However from the beginning of 2014 so far, there is no point in which demand exceeds supply, assuming this barrel prices down to the $ 35/u at the end of 2015. This excess supply has two main protagonists, OPEC and United States.

In United States, the fracking boom has doubled its production of barrels from 2008 to 2014, surpassing Saudi Arabia as maximum global producer of crude with 11.6 million barrels. It seems clear that by this increase in production, there is an excess of supply. What is not so evident is the reason for which this excess supply has not stabilized so that end up keeping a balance with the demand, as it would have to occur in a normal scenario. But that's where the OPEC comes. Their response, with Saudi Arabia at the head of the strategic decisions, has been the further increase of oil production, currently a 32.7 per cent of the world total production. The result of this aggressive production strategy has been that in United States, according to the consulting firm

Baker Hughes published by CNBC, the number of oil rigs has gone from 1.366 at the end of 2014 to 515 now. Thanks to this, it seems logical that during 2016 will be a turn down in the production of oil barrels. However appears a third protagonist, Iran. Currently Iran, which is in confrontation with Saudi Arabia, suffers an embargo by the US problems priori with nuclear issues, declining export since about 2 million barrels a day in 2012 up to 1.1 today. However in mid-January of this year was announced the end of this embargo to fulfill a series of agreements that will be "an increase of 500,000 barrels of crude per day once the sanctions are officially withdrawn", as confirmed according to the general director of the State oil company, RoknoddinJavadi.

Thus, broadly speaking, on the one hand have a contraction of the offer by the US because of the closure of approximately 60% of its oil platforms, and a significant increase of half a million barrels a day from Iran, what makes us think that the offer must not vary too much. However contraction due to the fall in US production will also see their response in a drop in OPEC's total production in 2016. In particular, according to Reuters, the cartel expected a drop of 660,000 barrels per day through 2016.

5 VARIABLES THAT COULD HAVE AN EFFECT ON OIL PRICES

5.1 Demand-related variables

1. The China situation, a country in which signs of recession are beginning to see although its Government is making great efforts to curb it. China is the second country that consumes millions of barrels per day, 9.4.
2. The future ability to cope with more demand for energy by alternative energies as they become more efficient and, therefore, more profitable.
3. United States production. The US is the country that consumes millions of barrels per day in the world, 19.15. While it is true that production is also linked to the offer, a reduced U.S. production would increase demand since it has to cope with high oil consumption which currently has.

5.2 Supply-related variables

1) As we have seen in the important turning points in the history of barrel prices, OPEC had a very important role in them. They have a high capacity to influence the price.
2) United States. With the current fracking revolution, USA became the largest producer of oil. However, margins were lower than the OPEC, since each country has different operating costs. Therefore as soon as the price has dropped many U.S. refineries have had to close as we have seen previously.

5.3 Other variables

On the other hand, there is a factor that must be taken into account as it is important in determining the price, speculation. The CEO of Exxon-Mobil, Rex Tillerson, states in a Senate hearing last year: "*Speculation was driving up the price of a barrel of oil by as much as 40%*".Furthermore, according to the general counsel of Delta Airlines, Ben Hirst, and the experts at Goldman Sachs "*Excessive speculation is causing oil prices to spike by up to 40%*". Even Saudi Arabia, the largest exporter of oil in the world, told the Bush administration back in 2008, during the last major spike in oil prices, that speculation was responsible for about $40 of a barrel of oil. (Reuters, 2016)

6 ECONOMETRIC MODELS

In view of the importance of the crude oil prices in the dynamics of the global economy, many analysts have tried to create methods that can predict their volatility and the forward price. Due to its difficulty, there are no conclusions that clarify which ones are the most valid. However, we can analyze the most used models, which are basically divided into 2 categories: quantitative and qualitative methods. In this section we are going to do a brief review of the different quantitative methods as they are the most commonly used and, later, we are going to deepen in those which we are interested in.

Quantitative models are focused on explaining the price, especially in the short and medium term, based on past events. We can also divide them in two categories; econometric models and "non-standards models". However, we will focus only on the first as they are the most used and not in the "non-standards models" since them mostly use techniques that are outside our scope as tools of non-linear computational methods. Econometric models are used in trying to know how it will evolve in the future oil prices. We can divide them into: temporal-series models, financial models and structural models.

6.1 Temporal-series models

These models are used when; the data exhibit a systematic pattern, such as autocorrelation; the number of potential explanatory variables is large and their interactions suggest a highly complex structural model; or when the prognosis of the dependent variable requires the prediction of the explanatory variables. All of these conditions seem that they apply to oil prices.

The studies' results show that temporary models are suitable for the forecast of the prices of oil in a short term, but limited at the time of forecast in the long term. These time series models have demonstrated accurate forecasts of volatility in the oil price, but there is no single model that encompasses the various reasons why this volatility may be in the price. Finally, they show how such prices and their volatility have an important non-linearity; small shocks to the economy could be large and unpredictable consequences for the prices of oil and its volatility.

6.2 Financial Models

Financial models are suitable to estimate the relationship between spot prices and future and discuss whether futures contract prices are unbiased predictors of future spot prices, and whether they are efficient based on the hypothesis of market efficiency. The results of these financial models such as de Bopp y Lady (1991), Serletis (1991), Zeng y Swanson (1998) or the most recent Nomikos (2011) show that the close relationship between the future price and the spot future price are robust, while this relationship varies over time and is difficult to explain with accuracy by existing models. While financial models predict the presence of a risk premium into futures prices compared with expected future prices, existing models can not accurately estimate the premium and its dynamics through time.

6.3 Structural Models

The movements of oil prices from these models are constructed through a collection of fundamental variables. They are the explanatory variables that are commonly used to explain the behaviour of oil prices: OPEC, the level of stocks, consumption and production of petroleum and other variables not directly related to oil as the economic activity, the interest rates, exchange rates and other commodities prices. In this context, there are many studies that investigate price movements based on fundamentals. At the same time, we can divide them into models based on the OPEC behaviour of OPEC, in models based on stocks and a combination of both.

6.3.1 OPEC Behaviour Models

The authors state that the OPEC is strongly encouraged to support a floor for oil prices because it is the main source of income for almost all of its members. In addition, OPEC tries to maintain an upper limit on prices because if it is too high, other countries with potential to produce oil would be motivated to do so, taking OPEC market share. Based on this, the authors establish a model prediction of the price based on production quotas, inventory levels and expectations of future market prices determined by the currently available information. Results from these models

demonstrate that they are effective in predicting the price in the event that this be maintained both in the upper or lower limit that it tries to maintain the OPEC. However, it is ineffective in moments where prices have ups and downs.

5.3.2. Inventory Models

Stocks-based models made a short-term forecast of short-term nominal monthly WTI prices in the spot market. In this model, the price of WTI spot is built on the basis of three factors:

(1) Oil inventory level from countries that make up the OECD[1], or expressed another way, deviating from current inventories compared to the normal inventory level (calculated by taking into account seasonality and historical inventories at that date),

(2) Inventories below normal from the OCDE[1], which reflects the skewed price changes in response to change in inventories when the inventory level is below normal vs the change in prices when the stock level is higher than the normal.

(3) Year differences of monthly inventories.

6.3.3 Combination of inventory and OPEC behaviour models

Kaufmann (2004) investiga el impacto del comportamiento de la OPEP sobre los precios reales del petróleo. Los autores examinan la causalidad de Granger entre el uso de la capacidad de la OPEP, las cuotas de la OPEP, los comportamientos engañosos de los miembros de la OPEP y el consumo futuro de los stocks por parte de la OECD. El resultado del test de causalidad de Granger evidenció como existe correlación entre el comportamiento de la OPEP y los precios de crudo, pero no al revés.

Kaufmann (2004) investigates the impact of the OPEC behaviour on the real oil prices. The authors examine the Granger causality between the use of the ability of OPEC, OPEC quotas, misleading the members of OPEC behaviours and future consumption

of stocks by the OECD. The Granger causality test result showed as there is correlation between the OPEC behaviour and crude oil prices, but not the reverse.

7 ECONOMETRIC ESTIMATION

7.1 Chosen Model

To explain the market of oil prices, we have chosen an estimation of temporal-series linking monthly spot prices from 2010:01 until 2016:02 with the value of different variables on the same date. So we used the estimate by ordinary least square (OLS).

The model is linear in the parameters. However it is not linear in variables, since as we will see later we will carry out logarithmic transformations in order to achieve a better estimate. In any case, we can use an OLS model if it is linear in the parameters.

The model in which we have based on is in the estimates by Kaufmann (2004), in which it has in mind both the OPEC production and the different policies used by them. The model in question is as follows:

$$Price_t = \beta_0 + \beta_1 Days_t + \beta_2 Quota_t + \beta_3 Cheat_t + \beta_4 Caputil_t + \beta_5 Q1_t + \beta_6 Q2_t + \beta_7 Q3_t + \beta_8 War_t + \mu$$

Kaufmann relates the price on a date "t" with different variables values that we can find on the right side of the equation. These variables, as himself indicated in his work, are:

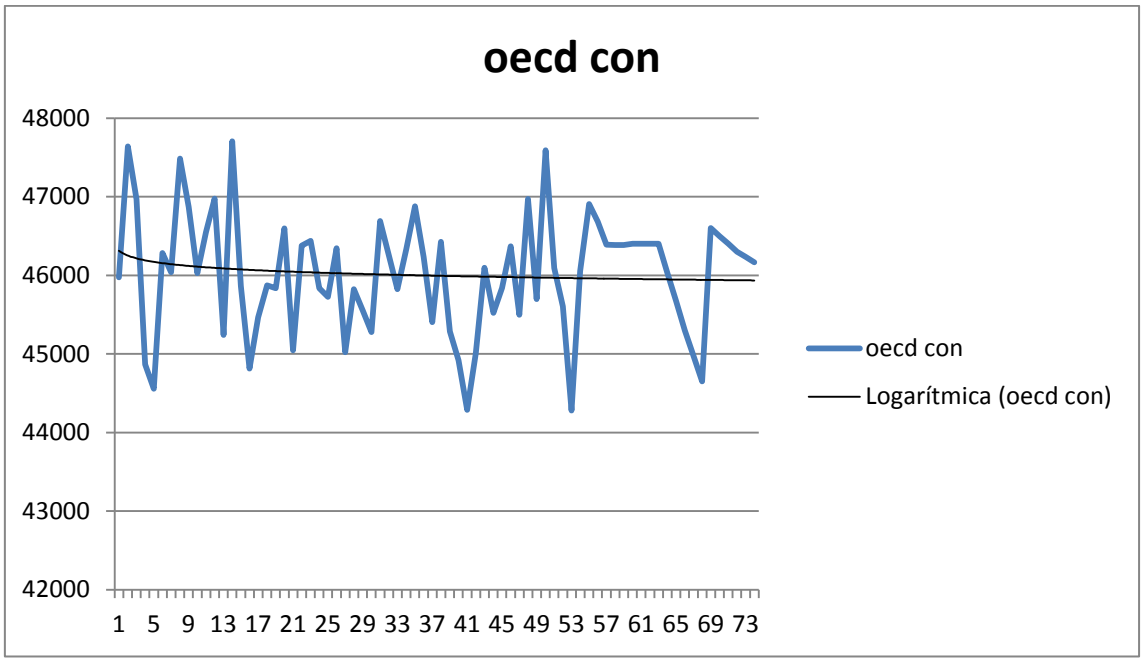
"Days is days of forward consumption of OECD crude oil stocks, which is calculated by dividing OECD crude oil stocks by OECD crude oil demand, Quota is the OPEC production quota (million barrels per day), Cheat is the difference between OPEC crude oil production and OPEC quotas (million barrels per day), Caputil is capacity utilization by OPEC, which is calculated by dividing OPEC production (mbd) by OPEC capacity (mbd), Q1, Q2, and Q3 are dummy variables for quarters I, II, and III, respectively, and War is a dummy variable for the Persian Gulf War (third and fourth quarters of 1990). "

However, we are in a different time from that examined by Kaufmann and, therefore, the conditions are different. As we have seen above, currently the production by OPEC as the U.S .due to racking is so important. For this reason, we have also included U.S. production in the relationship.

For the election of the other variables we have used both those that historically have been crucial in the evolution of prices and those that always have had an impact on them. The chosen variables have been: the real interest type from United States and the strength of the dollar regarding major currencies, both U.S. and OPEC production, a variable that is recently gaining more and more strength: total renewable energy production.

It is possible that we miss some demand-related variables. However the reason why we have not included any variable of this style is because we assume that demand will remain steady in the studied period. To give more force to this assumption, we can observe in the following graph that we have done how the logarithmic trend [2] by the OECD oil consumption has remained relatively constant:

Graph 5 OECD consumption



Source: own elaboration based on U.S Energy Information Administration data

7.2 Model estimation

For the estimation model we have chosen the following variables:

$$LnPrice_t = \beta_0 + \beta_1 LnDolar_t + \beta_2 Real_t + \beta_3 LnUsOpecProd_{t-3} + \beta_4 LnRenProd_t + \mu$$

$LnPrice_t$

Spot price of oil barrel on the specified date, extracted from U.S. Energy Information Administration (Appendix 1).

$LnDolar_t$

The United States dollar value regarding major foreign currencies. These data are collected from the Federal Reserve of St. Louis and its calculation has been used as an index of 100 in 1973. In the event that it appreciates about other currencies, that index increased and vice versa. As we have explained previously, the dollar's status is very important in establishing the oil prices. For instance, imagine that a European user decides to spend $100 in this commodity. Change of 0.9€ / $, that user would cost € 90. However, in the event that in the following month the dollar suffered an appreciation to be 0.95€ / $, would cost it more money to get the same amount of oil. This will affect the oil price in the sense that the market will resent and users would demand less oil and, as a result, the dollar price would decline. Therefore, we have a negative correlation, if the dollar suffers an appreciation, the barrel price will drop, as it reflects our estimate.

$LnUsOpecProd_{t-3}$

Before explaining in what we have based on to implement this variable, we will start with how we have come to it. First of all, we had included the "DSDiff" variable, i.e., the difference between production and world oil consumption, measured as production - consumption. Therefore a high value had shown that there was a supply excess while conversely a low value means an excess of demand. The more excess supply exist (higher value) the lower the price is.

However, to make the ordinary least squares with this variable, out that it was not a sign that was not appropriate and meaningful. This had been able to be since the difference between consumed and produced in a specific month, did not reflect the stock. For example, if in 1 month there has been a surplus of production of 5000 barrels, and in the following month there is a deficit of - 2000, does not mean that on the second month there is deficit of - 2000 since 5000 barrels produced in the previous period do not disappear. In fact, it would have an excess of production in the second month of 5000 - 2000 = 3000u. Therefore, the total accumulated with respect to prior periods may have been estimated in this variable. When you estimate the total accumulated, the variable gives us the pertinent sign. The more difference between produced and consumed, the more the barrel price will lower. However, even so the variable was still not very significant with a very high p-value. For this reason, we decided to eliminate the part of demand as we already discussed above and leave only the supply part.

A partir de los datos observados en la U.S Energy Information Administration, también hemos podido observar como el principal aumento de producto venía dado por la situación de EEUU y por la consecuente respuesta de la OPEC traduciéndose en un posterior aumento de la producción. Así pues, en un primer momento se introdujo las variables UsProd y OPECprod, es decir la producción de US y la OPEC respectivamente en el periodo estimado. Sin embargo, existía correlación entre ambas variables, por lo que finalmente se optó por unirlas y hacer una variable que incluya la producción conjunta.

From the observed data in the U.S. Energy Information Administration, we also have seen as the main increase of product was given by the US situation and consistent response from OPEC resulting in a further increase in production. Thus, we initially entered the variables UsProd and OPECprod, i.e. the US and OPEC production respectively the estimated period. However, there was a strong correlation between both variables, so finally it was decided to join them and make a variable that includes the joint production.

But, again, it came out that the variable has a positive sign, when it should be clearly negative. I.e., the estimated model reflected that an increase in production resulted in an increase of prices, which is obviously wrong. To fix this, we opted to include a delay of 3 months. This delay was included under the assumption that the production does not have its immediate effect on the market, because since that occurs until is supplied

passes “t” time. In addition, countries have reserves that even faced with an increase in production, at specific moments may opt to increase their reserves. Once filled these reservations, it would be a collapse in the price. Therefore, in this work we will assume that an increase or decrease in oil production will have its effect on the market in the next quarter.

$\mathbf{Real_t}$

It measures the real monthly interest rate in the United States. Since it has been impossible to find monthly data on U.S. real interest rates, it has been calculated based on the monthly nominal interest rate and monthly inflation rates using the following macro-economic equation:

$$(1+i_N) = (1+i_R)(1+\pi), \qquad \Rightarrow \quad i_R = \frac{1+i_N}{1+\pi} - 1 \approx i_N - \pi$$

A high real interest rate affects the oil prices reducing them for various reasons:

1. By increasing the incentive for oil extraction today in contrast to the future extraction.
2. Encouraging investors to invest in Treasury bonds before that in the commodities market as it increases their profitability.
3. A high real interest rate also made the national currency to appreciate, and to appreciate the dollar lowers price.

Finally, we should bear in mind that we have not done a logarithmic transformation in this variable since the United States economy has presented during certain specific moments a negative real interest rate, so in the event that we would have made it a logarithm, such negative samples had been overlooked.

$LnRenProd_t$

Logarithmic transformation in production of renewable energy in a given period. Obviously this variable does not appear in older models, since renewable energies have relatively little time to age and importance. However, we thought that it might be significant. The most logical thing would be that this variable should submit a negative correlation with the barrel price. An increase in production of renewable energy would decrease the price of these energies. Therefore, there would be demand in energy that would displace from the oil market to the renewable market. As we shall see, we have not added any delay to this variable. The reason is that it seems logical to think that the energy produced by renewable sources has a cost and difficulty much higher with respect to the barrels of oil storage. It is a power that must be used after produced by what in this case that would have immediate effect on prices. As aim to reinforce this theory, even gave the case the past day, May 11, 2016, in which Germany paid to consumers so that they consume energy due to the surplus that produced the renewable, as it points the DailyMail (2016): "Germany hit a new high in renewable energy production at the weekend thanks to sunny and windy weather. The excess power generated meant it sent power prices into the negative for some consumers."

Before moving on model estimations, we will check if the correlation between the independent and the dependent variables are negative as we had estimated in all the previous cases:

Graph 6 Correlations between variables

Coeficientes de correlación, usando las observaciones 2010:01 - 2016:02
valor crítico al 5% (a dos colas) = 0.2287 para n = 74

spotprices	REAL	Dolar	RenProd	usopecprod	
1.0000	**-0.5106**	**-0.8651**	**-0.5609**	**-0.5292**	**spotprices**
	1.0000	0.6185	0.4115	0.2374	REAL
		1.0000	0.8394	0.7741	Dolar
			1.0000	0.8957	RenProd
				1.0000	usopecprod

Effectively, we can see how the correlations between the dependent variable and the others are negative. With [1] being a perfect direct correlation, [0] does not exist any kind of correlation and [- 1] a perfect inverse correlation. A priori, the variables that have more correlation are, in this order: dollar, production of renewable energy, combined production of OPEC and US and us real interest rate. And, as we have said, all have a negative correlation.

7.3 Model results

Table 7 Ordinary Least Square

Modelo 23: MCO, usando las observaciones 2010:04-2016:02 (T = 71)
Variable dependiente: l_spotprices

	Coeficiente	*Desv. Típica*	*Estadístico t*	*Valor p*	
const	33.3639	5.26747	6.3339	<0.0001	***
l_vsmajorcurrencies	−4.99592	0.318184	−15.7013	<0.0001	***
l_usopecprod_3	−1.02904	0.712721	−1.4438	0.1535	
l_RenProd	0.345633	0.0534498	6.4665	<0.0001	***
REAL	0.0789859	0.0171265	4.6119	<0.0001	***

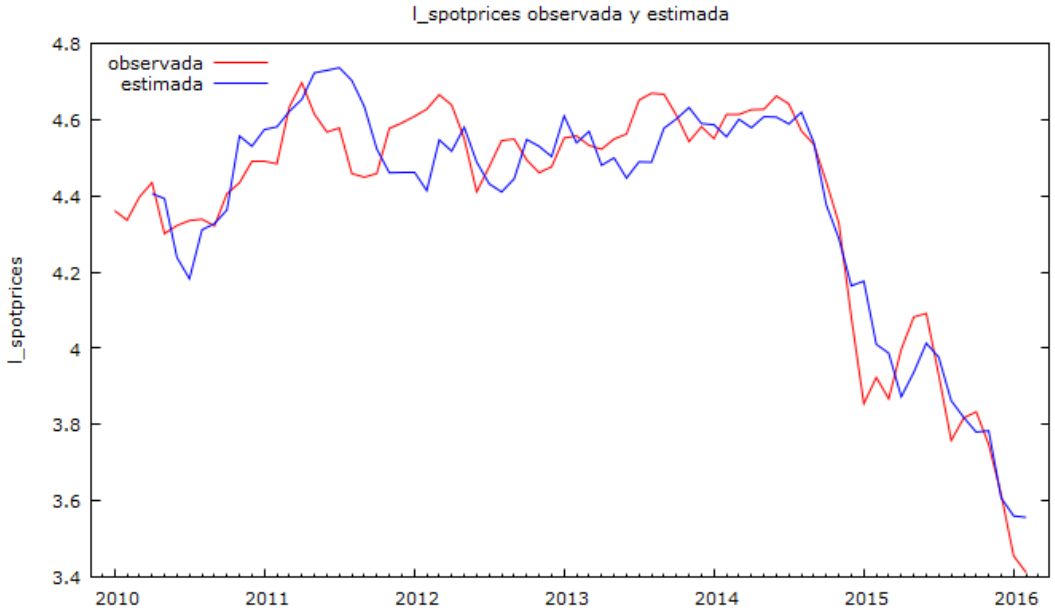
Media de la vble. dep.	4.382175	D.T. de la vble. dep.	0.315423
Suma de cuad. residuos	0.753114	D.T. de la regresión	0.106821
R-cuadrado	0.891863	R-cuadrado corregido	0.885309
F(4, 66)	136.0835	Valor p (de F)	4.02e-31
Log-verosimilitud	60.64614	Criterio de Akaike	−111 2923
Criterio de Schwarz	−99.97889	Crit. de Hannan-Quinn	−106.7933

The equation that below model give us is as follows:

$LnPrice_t = 33.3639 - 4.99592LnDolar_t + 0.07898Real_t - 1.02904LnUsOpecProd_{t-3} + 0.3456LnRenProd_t$

From what we can see, it seems that fixed R-square fixed quite something (0.8853) from what we can guess that the above estimated variables have a high relationship with those observed. To see it in a more graphic way, we can create a chart in which we will compare the spot prices over time estimated variable with the observed one:

Graph 8 Estimated vs observed



We will now delve into the specific variables. Taking into account above results that has yielded us estimated by ordinary least squares model, all variables are significant except for the variable l_UsOpecProd_3. However, the p - value is relatively low. We will now move on explaining all the variable results, sorted by significance, in other words, sorted by importance when it comes to explain SpotPrices dependent variable:

LnDolar$_t$: clearly significant with p-value less than 0.0001. As we had planned, the relationship is negative. A 1% increase in the variable that reflects the strength of the dollar, will result in a decrease of the 4.99% in barrel prices

LnRenProd$_t$: An increase in total renewable production translates into a price increase. At the beginning, it would make no sense since the oil and renewable energies are substitute goods in some way, by which a reduction of the price of one would be also that on the other. In this case the estimates get us a 1% increase in the production of renewable energy would result in an increase of the 0.07898% spot price.

LnUsOpecProd$_{t-3}$: The relationship comes out negative as we had planned. A 1% increase in OPEC production translates into a decrease of 1.029% in forward prices in the next quarter.

Real$_t$: In this case the relationship between America's real interest rate and the barrel price comes out positive. Contrary to what we had planned. An increase of 1 point (since it is not logarithmic) in the real interest rate, will result in an increase of 0.079% in barrel prices.

8 FORECASTING

8.1 Forecasting independent variables

In this section we will simply replace the future variables given in the previous estimation made by ordinary least squares. We are not going to make a prognosis of the variables themselves, what we are going to do is to take the data forecasted by different reliable sources. The period that we are going to compare are spot prices on June 1, 2016, with the forward from June 1, 2017 and prices estimated for June 1, 2017. Remembering the estimate that our Ordinary Least Squares Model has yielded:

$LnPrice_t = 33.3639 - 4.99592LnDolar_t + 0.07898Real_t - 1.02904LnUsOpecProd_{t-3} + 0.3456LnRenProd_t$

Then we replace independent variables for the following expected data in June 2017:

β_1 Log Dólar $_{june2017}$:

Graph 9 Dolar Index Forecast

Contract	Last	Change
DXY00 (Cash)	93.529s	-0.187
DXU16 (Sep '16)	93.527s	-0.231
DXZ16 (Dec '16)	93.577s	-0.226
DXH17 (Mar '17)	93.632s	-0.226
DXM17 (Jun '17)	93.697s	-0.216

Open Interest is for the previous day's trading session.

The data collected by Barchart indicates that dollar rate according to other currencies will be **95.862** in the month in which we want to focus for the estimation.

β_2 Real $_{june2017}$:

Graph 10 Nominal interest forecast

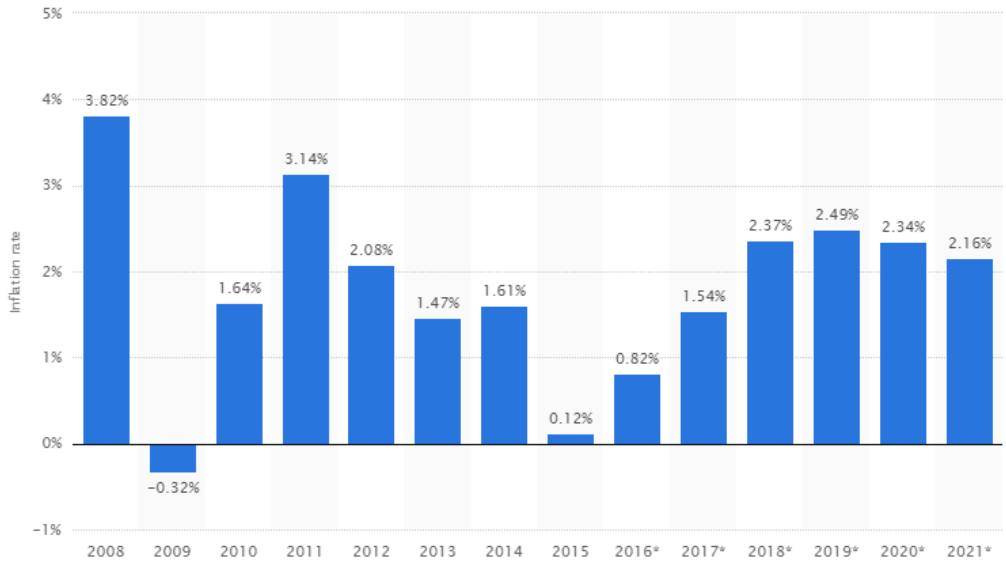
United States Money	Last	Q2/16	Q3/16	Q4/16	Q1/17	2020
Interest Rate	0.5	0.5	0.5	1	1	2.25

Source: http://www.tradingeconomics.com/united-states/interest-rate/forecast

According to Trading Economics, U.S interest rate will increase about 0.5 per cent in the next quarter and up to 1% in 2017. This would give us a nominal interest rate 1% higher from here 12 months.

However, it must take into account that we have to subtract inflation to extract the real interest rate. Average expected inflation according to Statista website for 2017 is 1.54%:

Graph 11: Inflation forecast



Therefore the expected real interest rate of interest expected in June 2017 would be 0.78 + 1 - 1.54 = **0.24%.**

β_3 Log UsOpecProd march2017:

This is by far the most difficult part to predict, due to it will be based on internal policies from United States and OPEC that we didn't know anything. Therefore, we only can trust in what they both say about ir. So, according to US energy information administration (EIA) " *US production – which plateaued last year – to fall to 8.6 million bpd this year from an average of 9.4 million bpd last year, or 100,000 bpd lower than its previous forecast* " Therefore it is expected that US production will turn down to 8.6 million barrels per day.

By OPEC side, it is rather more difficult to predict the future production quotas given the closed nature of this cartel. However, the own OPEC states that "*An oversupply of oil, which has led to a steep decline in the price of the commodity in recent years, could*

ease soon" according to IbTimes (2016). The big question is how much will decrease OPEC production. As there is no data of any official source and as we have seen that the OPEC policy has been influenced in recent years by what has made US, we can assume that it will lower its production quotas in the same way in which US will do it. According to the EIA, United States will decrease its share of production from 9.4 million to 8.6 million, 9.30%. However, we cannot assume that OPEC will also lower its quotas by 9.30%. First, because they are not in the same situation, and second because a reduction of 9.3% of the OPEC share would be excessive taking into account the large number of barrels produced per day. Therefore we are going to assume that it will decrease its production by 2%, a share that seems reasonable. It should be noted that, indeed, that 2% is a completely arbitrary number and that it is still a subjective logic. The reason for not been able to indicate an exact fee is the lack of data due to the closed nature which we mentioned before.

Therefore, assuming that the US will reduce its production 9.3% and OPEC will do so by 2%, the total production of both, would be around **3577 thousand barrels per day.**

β_4 Log RenProd $_{june2017}$:

According to EIA "*expects total renewables used in the electric power sector to increase by 13.0% in 2016 and by 3.3% in 2017*" therefore, following the previous case, the production of renewables would be a total of: 50,757 * 1.033 = **52,431 tWh**

8.2 Forecasting dependent variable

Now, we have only to replace the variables in the estimated model:

$LnPrice_t = 33{,}3639 - 4{,}99592ln(93{,}697) + 0{,}07898(0{,}24) - 1{,}02904Ln(3577) + 0.3456Ln(52{,}431)$

The result shows that the dependent variable will be: **3,969366892**. That, transformed to absolute terms give us a value of $ **52,93**. Thus, there is an expected prices rise $47,64 as of June. As we can see, the estimate has not given us any unreasonable results. However, the best way to see if the model has given a good result, is comparing the estimated price with future contract in the same date, i.e. June 2017:

Graph 12 Crude Oil WTI Futures prices

Crude Oil WTI Futures Prices Fri, Jun 24th, 2016

Current Prices | End-of-Day Prices | Options Quotes

Contract	Last	Change	Open	High	Low
CLY00 (Cash)	47.60s	-2.52	0.00	47.60	47.60
CLQ16 (Aug '16)	47.64s	-2.47	50.30	50.45	46.70
CLU16 (Sep '16)	48.31s	-2.45	50.89	51.08	47.39
CLV16 (Oct '16)	48.82s	-2.43	51.48	51.53	47.93
CLX16 (Nov '16)	49.29s	-2.42	52.00	52.00	48.49
CLZ16 (Dec '16)	49.72s	-2.40	52.27	52.40	48.86
CLF17 (Jan '17)	50.05s	-2.40	52.58	52.58	49.28
CLG17 (Feb '17)	50.31s	-2.39	52.13	52.13	49.67
CLH17 (Mar '17)	50.53s	-2.38	52.51	52.51	49.83
CLJ17 (Apr '17)	50.72s	-2.35	53.06	53.06	50.37
CLK17 (May '17)	50.87s	-2.33	52.62	52.62	50.30
CLM17 (Jun '17)	51.01s	-2.30	52.70	52.72	50.27
CLN17 (Jul '17)	51.11s	-2.26	51.20	51.74	51.11
CLQ17 (Aug '17)	51.19s	-2.24	0.00	51.19	51.19
CLU17 (Sep '17)	51.27s	-2.22	51.76	51.76	51.27
CLV17 (Oct '17)	51.37s	-2.20	51.40	51.40	51.25
CLX17 (Nov '17)	51.49s	-2.18	0.00	51.49	51.49
CLZ17 (Dec '17)	51.62s	-2.17	53.99	54.00	50.84
CLF18 (Jan '18)	51.67s	-2.15	0.00	51.67	51.67
CLG18 (Feb '18)	51.71s	-2.14	52.50	52.50	51.71

Source: BarChart.com

In addition, we can also observe as the difference is minimal with respect to future contract price: $ 52,93 front $ 51,01, just two dollars. With these results, if we trust entirely from the estimated model, we could even get an investment strategy. In this case the strategy would be to buy future contracts from July of the coming year to $51.11 now and sell them to spot price in June for $ 52,93.

9 CONCLUSSION

The model estimation seems to be satisfactory although some variables do not have the expected sign. Probably since the other variables with negative sign accumulate a big weight when it comes to explaining the dependent variable. So, that can partly 'absorb' the negative effect of the other variables. But, although the estimate gives a priori coherent results, it not should be forgotten that the predictions of oil prices are something that turned upside down many analysts who use more advanced techniques and yet remain unable to predict it accurately.

This must be borne in mind that despite the results, to carry out this work we found a double limitation. First, the first limitation comes when modelling since the ordinary least squares estimation is rather simple for something as complex and convoluted as the price of the barrel. Second, at the time of the data collection, there were certain disagreements, although minimal, according to the sources consulted. This is basically because it is difficult to control the world oil market and even more if there are organizations such as OPEC which are so obscure when it comes to show data, inform about the strategies used, futures fees, production, etc.

For this reason, this work should not be taken as a perfect model in order to make a forecast on the barrel price; it should rather be taken as a first step easily expandable and improvable due to the extensive quantity and quality of various techniques existing for this purpose. In addition, this works also let us to know the convoluted world faced by analysts of this sector and how difficult is for them to have to come up with accurate predictions.

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11 APPENDICES

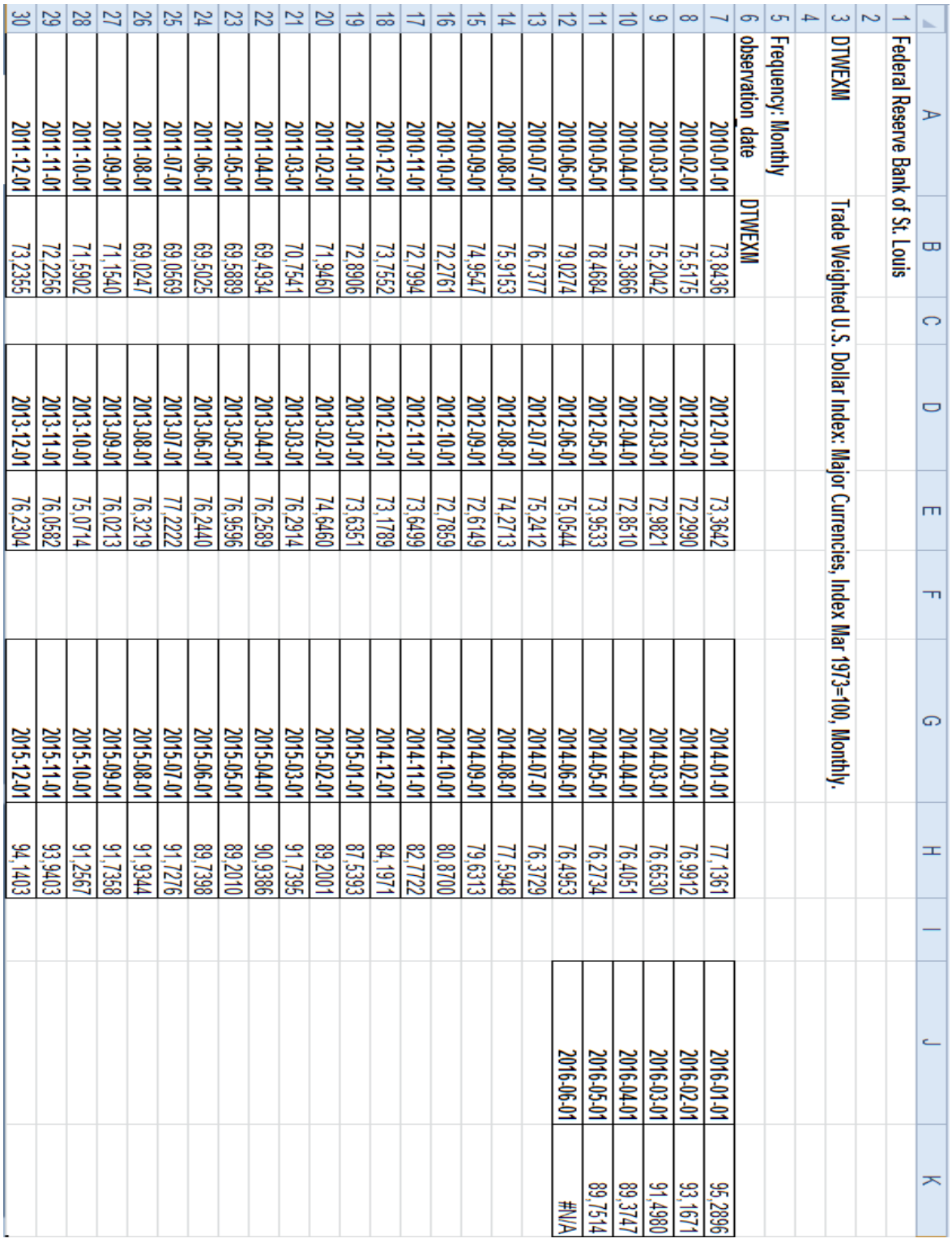
APPENDIX 1: WTI MONTHLY SPOT PRICES

Cushing, OK WTI Spot Price FOB (Dollars per Barrel)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	22.93	15.46	12.61	12.84	15.38	13.43	11.59	15.10	14.87	14.90	15.22	16.11
1987	18.65	17.75	18.30	18.68	19.44	20.07	21.34	20.31	19.53	19.86	18.85	17.28
1988	17.13	16.80	16.20	17.86	17.42	16.53	15.50	15.52	14.54	13.77	14.14	16.38
1989	18.02	17.94	19.48	21.07	20.12	20.05	19.78	18.58	19.59	20.10	19.86	21.10
1990	22.86	22.11	20.39	18.43	18.20	16.70	18.45	27.31	33.51	36.04	32.33	27.28
1991	25.23	20.48	19.90	20.83	21.23	20.19	21.40	21.69	21.89	23.23	22.46	19.50
1992	18.79	19.01	18.92	20.23	20.98	22.39	21.78	21.34	21.88	21.69	20.34	19.41
1993	19.03	20.09	20.32	20.25	19.95	19.09	17.89	18.01	17.50	18.15	16.61	14.52
1994	15.03	14.78	14.68	16.42	17.89	19.06	19.66	18.38	17.45	17.72	18.07	17.16
1995	18.04	18.57	18.54	19.90	19.74	18.45	17.33	18.02	18.23	17.43	17.99	19.03
1996	18.86	19.09	21.33	23.50	21.17	20.42	21.30	21.90	23.97	24.88	23.71	25.23
1997	25.13	22.18	20.97	19.70	20.82	19.26	19.66	19.95	19.80	21.33	20.19	18.33
1998	16.72	16.06	15.12	15.35	14.91	13.72	14.17	13.47	15.03	14.46	13.00	11.35
1999	12.52	12.01	14.68	17.31	17.72	17.92	20.10	21.28	23.80	22.69	25.00	26.10
2000	27.26	29.37	29.84	25.72	28.79	31.82	29.70	31.26	33.88	33.11	34.42	28.44
2001	29.59	29.61	27.25	27.49	28.63	27.60	26.43	27.37	26.20	22.17	19.64	19.39
2002	19.72	20.72	24.53	26.18	27.04	25.52	26.97	28.39	29.66	28.84	26.35	29.46
2003	32.95	35.83	33.51	28.17	28.11	30.66	30.76	31.57	28.31	30.34	31.11	32.13
2004	34.31	34.69	36.74	36.75	40.28	38.03	40.78	44.90	45.94	53.28	48.47	43.15
2005	46.84	48.15	54.19	52.98	49.83	56.35	59.00	64.99	65.59	62.26	58.32	59.41
2006	65.49	61.63	62.69	69.44	70.84	70.95	74.41	73.04	63.80	58.89	59.08	61.96
2007	54.51	59.28	60.44	63.98	63.46	67.49	74.12	72.36	79.92	85.80	94.77	91.69
2008	92.97	95.39	105.45	112.58	125.40	133.88	133.37	116.67	104.11	76.61	57.31	41.12
2009	41.71	39.09	47.94	49.65	59.03	69.64	64.15	71.05	69.41	75.72	77.99	74.47
2010	78.33	76.39	81.20	84.29	73.74	75.34	76.32	76.60	75.24	81.89	84.25	89.15
2011	89.17	88.58	102.86	109.53	100.90	96.26	97.30	86.33	85.52	86.32	97.16	98.56
2012	100.27	102.20	106.16	103.32	94.66	82.30	87.90	94.13	94.51	89.49	86.53	87.86
2013	94.76	95.31	92.94	92.02	94.51	95.77	104.67	106.57	106.29	100.54	93.86	97.63
2014	94.62	100.82	100.80	102.07	102.18	105.79	103.59	96.54	93.21	84.40	75.79	59.29
2015	47.22	50.58	47.82	54.45	59.27	59.82	50.90	42.87	45.48	46.22	42.44	37.19
2016	31.68	30.32	37.55	40.75	46.83							

Source: U.S Energy Information Administration

APPENDIX 2: TRADE WEIGHTED U.S. DOLLAR: MAJOR CURRENCIES.



	A	B	C	D	E	F	G	H	I	J	K
1	Federal Reserve Bank of St. Louis										
2											
3	DTWEXM	Trade Weighted U.S. Dollar Index: Major Currencies, Index Mar 1973=100, Monthly.									
4											
5	Frequency: Monthly										
6	observation_date	DTWEXM		2012-01-01	73,3642		2014-01-01	77,1361		2016-01-01	95,2896
7	2010-01-01	73,8436									
8	2010-02-01	75,5175		2012-02-01	72,2990		2014-02-01	76,9912		2016-02-01	93,1671
9	2010-03-01	75,2042		2012-03-01	72,9821		2014-03-01	76,6530		2016-03-01	91,4980
10	2010-04-01	75,3866		2012-04-01	72,8510		2014-04-01	76,4051		2016-04-01	89,3747
11	2010-05-01	78,4684		2012-05-01	73,9533		2014-05-01	76,2734		2016-05-01	89,7514
12	2010-06-01	79,0274		2012-06-01	75,0544		2014-06-01	76,4953		2016-06-01	#N/A
13	2010-07-01	76,7377		2012-07-01	75,2412		2014-07-01	76,3729			
14	2010-08-01	75,9153		2012-08-01	74,2713		2014-08-01	77,5948			
15	2010-09-01	74,9547		2012-09-01	72,6149		2014-09-01	79,6313			
16	2010-10-01	72,2761		2012-10-01	72,7859		2014-10-01	80,8700			
17	2010-11-01	72,7994		2012-11-01	73,6499		2014-11-01	82,7722			
18	2010-12-01	73,7552		2012-12-01	73,1789		2014-12-01	84,1971			
19	2011-01-01	72,8906		2013-01-01	73,6351		2015-01-01	87,5393			
20	2011-02-01	71,9460		2013-02-01	74,6460		2015-02-01	89,2001			
21	2011-03-01	70,7541		2013-03-01	76,2914		2015-03-01	91,7395			
22	2011-04-01	69,4934		2013-04-01	76,2589		2015-04-01	90,9386			
23	2011-05-01	69,5889		2013-05-01	76,9596		2015-05-01	89,2010			
24	2011-06-01	69,5025		2013-06-01	76,2440		2015-06-01	89,7398			
25	2011-07-01	69,0569		2013-07-01	77,2222		2015-07-01	91,7276			
26	2011-08-01	69,0247		2013-08-01	76,3219		2015-08-01	91,9344			
27	2011-09-01	71,1540		2013-09-01	76,0213		2015-09-01	91,7358			
28	2011-10-01	71,5902		2013-10-01	75,0714		2015-10-01	91,2567			
29	2011-11-01	72,2256		2013-11-01	76,0582		2015-11-01	93,9403			
30	2011-12-01	73,2355		2013-12-01	76,2304		2015-12-01	94,1403			

Source: Federal Reserve Bank of St Louis

APPENDIX 3: US PRODUCTION RATES (thousand barrels per day)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1973	9,176	9,395	9,272	9,292	9,262	9,214	9,217	9,169	9,065	9,224	9,161	9,063
1974	8,934	9,142	8,965	8,954	8,911	8,780	8,780	8,699	8,443	8,611	8,569	8,527
1975	8,455	8,591	8,493	8,457	8,379	8,421	8,336	8,249	8,280	8,324	8,278	8,254
1976	8,232	8,231	8,232	8,077	8,125	8,094	8,127	8,111	8,150	8,063	8,080	8,061
1977	7,854	8,139	8,090	8,145	8,075	8,102	8,105	8,307	8,480	8,573	8,579	8,487
1978	8,360	8,377	8,720	8,818	8,825	8,832	8,756	8,758	8,800	8,820	8,741	8,662
1979	8,475	8,525	8,601	8,553	8,601	8,432	8,364	8,548	8,523	8,621	8,761	8,615
1980	8,675	8,705	8,698	8,685	8,635	8,554	8,547	8,414	8,619	8,532	8,495	8,606
1981	8,540	8,604	8,613	8,557	8,501	8,629	8,500	8,583	8,604	8,563	8,586	8,585
1982	8,509	8,702	8,667	8,591	8,683	8,646	8,658	8,634	8,701	8,701	8,697	8,598
1983	8,697	8,758	8,700	8,776	8,631	8,667	8,636	8,679	8,784	8,771	8,770	8,397
1984	8,868	8,874	8,672	8,862	8,955	8,852	8,885	8,809	8,993	8,906	8,979	8,897
1985	8,740	9,025	9,095	9,043	9,132	9,022	8,949	8,803	8,954	8,970	8,902	9,030
1986	9,137	9,173	9,013	8,864	8,838	8,623	8,660	8,374	8,328	8,419	8,412	8,352
1987	8,480	8,389	8,464	8,498	8,336	8,279	8,251	8,210	8,205	8,364	8,397	8,318
1988	8,250	8,374	8,374	8,288	8,229	8,170	8,040	8,079	7,895	8,023	8,023	7,942
1989	7,937	7,788	7,575	7,772	7,816	7,624	7,444	7,544	7,548	7,453	7,536	7,337
1990	7,546	7,497	7,433	7,407	7,328	7,106	7,173	7,287	7,224	7,542	7,387	7,338
1991	7,500	7,637	7,546	7,509	7,409	7,320	7,347	7,316	7,368	7,437	7,328	7,299
1992	7,361	7,389	7,348	7,293	7,169	7,167	7,131	6,922	7,030	7,126	7,024	7,103
1993	6,961	6,943	6,974	6,881	6,847	6,795	6,688	6,758	6,712	6,839	6,912	6,858
1994	6,817	6,770	6,746	6,612	6,688	6,611	6,501	6,544	6,609	6,658	6,628	6,760
1995	6,682	6,794	6,600	6,604	6,629	6,579	6,449	6,447	6,416	6,421	6,585	6,530
1996	6,495	6,577	6,571	6,444	6,394	6,458	6,338	6,360	6,482	6,481	6,476	6,506
1997	6,402	6,514	6,452	6,441	6,474	6,442	6,409	6,347	6,486	6,467	6,459	6,531
1998	6,541	6,476	6,408	6,483	6,347	6,267	6,194	6,203	5,789	6,143	6,140	6,043
1999	5,963	5,966	5,883	5,887	5,875	5,760	5,798	5,780	5,804	5,947	5,960	5,959
2000	5,784	5,852	5,918	5,854	5,847	5,823	5,739	5,789	5,758	5,809	5,833	5,855
2001	5,799	5,780	5,880	5,863	5,829	5,766	5,749	5,725	5,709	5,746	5,881	5,887
2002	5,873	5,881	5,886	5,844	5,905	5,884	5,751	5,796	5,411	5,358	5,624	5,722
2003	5,755	5,783	5,803	5,726	5,663	5,659	5,498	5,574	5,609	5,614	5,547	5,571
2004	5,585	5,572	5,617	5,560	5,556	5,407	5,484	5,325	5,081	5,170	5,423	5,510
2005	5,446	5,501	5,601	5,563	5,596	5,442	5,253	5,198	4,214	4,555	4,857	4,988
2006	5,049	5,033	5,028	5,083	5,151	5,164	5,095	5,041	5,030	5,109	5,065	5,187
2007	5,105	5,118	5,120	5,184	5,205	5,073	5,037	4,985	4,902	5,054	5,036	5,109
2008	5,114	5,148	5,193	5,157	5,147	5,137	5,179	5,008	3,980	4,740	5,087	5,113
2009	5,143	5,245	5,217	5,286	5,384	5,274	5,400	5,374	5,562	5,517	5,387	5,453
2010	5,391	5,545	5,503	5,382	5,389	5,379	5,297	5,439	5,608	5,619	5,565	5,598
2011	5,486	5,390	5,601	5,545	5,605	5,569	5,419	5,635	5,562	5,855	5,970	5,991
2012	6,141	6,240	6,224	6,245	6,301	6,259	6,418	6,287	6,556	6,932	7,018	7,079
2013	7,078	7,095	7,161	7,375	7,301	7,264	7,453	7,502	7,727	7,702	7,897	7,873
2014	7,998	8,087	8,244	8,568	8,577	8,678	8,754	8,835	8,959	9,129	9,198	9,423
2015	9,341	9,451	9,648	9,694	9,479	9,315	9,432	9,407	9,453	9,379	9,329	9,246
2016	9,191	9,133	9,127									

Source: U.S Energy Information Administration

APPENDIX 4: US NOMINAL INTEREST RATES

Dataset: Monthly Monetary and Financial Statistics (MEI)

Subject	Long-term interest rates, Per cent per annum														
Unit	Percentage														
Frequency															
Time	Jan-2010	Feb-2010	Mar-2010	Apr-2010	May-2010	Jun-2010	Jul-2010	Aug-2010	Sep-2010	Oct-2010	Nov-2010	Dec-2010			
Country															
United States	3,73	3,69	3,73	3,85	3,42	3,20	3,01	2,70	2,65	2,54	2,76	3,29			
	Jan-2011	Feb-2011	Mar-2011	Apr-2011	May-2011	Jun-2011	Jul-2011	Aug-2011	Sep-2011	Oct-2011	Nov-2011	Dec-2011			
	3,39	3,58	3,41	3,46	3,17	3,00	3,00	2,30	1,98	2,15	2,01	1,98			
	Jan-2012	Feb-2012	Mar-2012	Apr-2012	May-2012	Jun-2012	Jul-2012	Aug-2012	Sep-2012	Oct-2012	Nov-2012	Dec-2012			
	1,97	1,97	2,17	2,05	1,80	1,62	1,53	1,68	1,72	1,75	1,65	1,72			
	Jan-2013	Feb-2013	Mar-2013	Apr-2013	May-2013	Jun-2013	Jul-2013	Aug-2013	Sep-2013	Oct-2013	Nov-2013	Dec-2013			
	1,91	1,98	1,96	1,76	1,93	2,30	2,58	2,74	2,81	2,62	2,72	2,90			
	Jan-2014	Feb-2014	Mar-2014	Apr-2014	May-2014	Jun-2014	Jul-2014	Aug-2014	Sep-2014	Oct-2014	Nov-2014	Dec-2014			
	2,86	2,71	2,72	2,71	2,56	2,60	2,54	2,42	2,53	2,30	2,33	2,21			
	Jan-2015	Feb-2015	Mar-2015	Apr-2015	May-2015	Jun-2015	Jul-2015	Aug-2015	Sep-2015	Oct-2015	Nov-2015	Dec-2015	Jan-2016	Feb-2016	
	1,88	1,98	2,04	1,94	2,20	2,36	2,32	2,17	2,17	2,07	2,26	2,24	2,09	1,78	

Source: Monthly Monetary and Financial Statistics

APPENDIX 4: USA INFLATION RATES

1995	2.8	2.9	2.9	3.1	3.2	3.0	2.8	2.6	2.5	2.8	2.6	2.5	2.8
1996	2.7	2.7	2.8	2.9	2.9	2.8	3.0	2.9	3.0	3.0	3.3	3.3	3.0
1997	3.0	3.0	2.8	2.5	2.2	2.3	2.2	2.2	2.2	2.1	1.8	1.7	2.3
1998	1.6	1.4	1.4	1.4	1.7	1.7	1.7	1.6	1.5	1.5	1.5	1.6	1.6
1999	1.7	1.6	1.7	2.3	2.1	2.0	2.1	2.3	2.6	2.6	2.6	2.7	2.2
2000	2.7	3.2	3.8	3.1	3.2	3.7	3.7	3.4	3.5	3.4	3.4	3.4	3.4
2001	3.7	3.5	2.9	3.3	3.6	3.2	2.7	2.7	2.6	2.1	1.9	1.6	2.8
2002	1.1	1.1	1.5	1.6	1.2	1.1	1.5	1.8	1.5	2.0	2.2	2.4	1.6
2003	2.6	3.0	3.0	2.2	2.1	2.1	2.1	2.2	2.3	2.0	1.8	1.9	2.3
2004	1.9	1.7	1.7	2.3	3.1	3.3	3.0	2.7	2.5	3.2	3.5	3.3	2.7
2005	3.0	3.0	3.1	3.5	2.8	2.5	3.2	3.6	4.7	4.3	3.5	3.4	3.4
2006	4.0	3.6	3.4	3.5	4.2	4.3	4.1	3.8	2.1	1.3	2.0	2.5	3.2
2007	2.1	2.4	2.8	2.6	2.7	2.7	2.4	2.0	2.8	3.5	4.3	4.1	2.8
2008	4.3	4.0	4.0	3.9	4.2	5.0	5.6	5.4	4.9	3.7	1.1	0.1	3.8
2009	0.0	0.2	-0.4	-0.7	-1.3	-1.4	-2.1	-1.5	-1.3	-0.2	1.8	2.7	-0.4
2010	2.6	2.1	2.3	2.2	2.0	1.1	1.2	1.1	1.1	1.2	1.1	1.5	1.6
2011	1.6	2.1	2.7	3.2	3.6	3.6	3.6	3.8	3.9	3.5	3.4	3.0	3.2
2012	2.9	2.9	2.7	2.3	1.7	1.7	1.4	1.7	2.0	2.2	1.8	1.7	2.1
2013	1.6	2.0	1.5	1.1	1.4	1.8	2.0	1.5	1.2	1.0	1.2	1.5	1.5
2014	1.6	1.1	1.5	2.0	2.1	2.1	2.0	1.7	1.7	1.7	1.3	0.8	1.6
2015	-0.1	0.0	-0.1	-0.2	0.0	0.1	0.2	0.2	0.0	0.2	0.5	0.7	0.1
2016	1.4	1.0	0.9	1.1	1.0								

Source: Bureau of Labor Statistics

APPENDIX 5 OPEC PRODUCTION

Data for this Date Range

Feb. 29, 2016	34.07M	Jan. 31, 2014	33.27M
Jan. 31, 2016	34.19M	Dec. 31, 2013	31.87M
Dec. 31, 2015	34.16M	Nov. 30, 2013	31.67M
Nov. 30, 2015	34.40M	Oct. 31, 2013	32.17M
Oct. 31, 2015	34.40M	Sept. 30, 2013	32.12M
Sept. 30, 2015	34.54M	Aug. 31, 2013	32.84M
Aug. 31, 2015	34.47M	July 31, 2013	32.95M
July 31, 2015	34.56M	June 30, 2013	32.79M
June 30, 2015	34.40M	May 31, 2013	33.00M
May 31, 2015	33.86M	April 30, 2013	32.92M
April 30, 2015	33.97M	March 31, 2013	32.48M
March 31, 2015	33.75M	Feb. 28, 2013	32.31M
Feb. 28, 2015	33.16M	Jan. 31, 2013	32.37M
Jan. 31, 2015	33.17M	Dec. 31, 2012	32.59M
Dec. 31, 2014	33.48M	Nov. 30, 2012	32.86M
Nov. 30, 2014	33.32M	Oct. 31, 2012	32.72M
Oct. 31, 2014	33.78M	Sept. 30, 2012	33.22M
Sept. 30, 2014	33.72M	Aug. 31, 2012	33.55M
Aug. 31, 2014	33.32M	July 31, 2012	33.29M
July 31, 2014	33.10M	June 30, 2012	33.39M
June 30, 2014	32.77M	May 31, 2012	33.29M
May 31, 2014	32.77M	April 30, 2012	33.75M
April 30, 2014	32.89M	March 31, 2012	33.49M
March 31, 2014	32.85M	Feb. 29, 2012	33.48M
Feb. 28, 2014	33.41M	Jan. 31, 2012	33.12M

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Data for this Date Range

Dec. 31, 2011	32.80M	Nov. 30, 2009	30.70M
Nov. 30, 2011	32.50M	Oct. 31, 2009	30.76M
Oct. 31, 2011	31.68M	Sept. 30, 2009	30.71M
Sept. 30, 2011	32.05M	Aug. 31, 2009	30.76M
Aug. 31, 2011	32.00M	July 31, 2009	30.62M
July 31, 2011	31.86M	June 30, 2009	30.36M
June 30, 2011	31.61M	May 31, 2009	30.24M
May 31, 2011	30.97M	April 30, 2009	30.19M
April 30, 2011	30.94M	March 31, 2009	30.07M
March 31, 2011	30.81M	Feb. 28, 2009	30.13M
Feb. 28, 2011	31.98M	Jan. 31, 2009	30.15M
Jan. 31, 2011	32.39M	Dec. 31, 2008	31.14M
Dec. 31, 2010	31.81M	Nov. 30, 2008	31.78M
Nov. 30, 2010	31.71M	Oct. 31, 2008	32.52M
Oct. 31, 2010	31.45M	Sept. 30, 2008	32.52M
Sept. 30, 2010	31.88M	Aug. 31, 2008	32.83M
Aug. 31, 2010	31.85M	July 31, 2008	33.02M
July 31, 2010	31.80M	June 30, 2008	32.66M
June 30, 2010	31.78M	May 31, 2008	32.54M
May 31, 2010	31.14M	April 30, 2008	32.24M
April 30, 2010	31.18M	March 31, 2008	32.55M
March 31, 2010	31.00M	Feb. 29, 2008	32.33M
Feb. 28, 2010	30.99M	Jan. 31, 2008	32.23M
Jan. 31, 2010	30.70M	Dec. 31, 2007	32.26M
Dec. 31, 2009	30.60M	Nov. 30, 2007	31.57M

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Source: YCHARTS – Energy Information Administration

APPENDIX 6 DATA USED ON OLS ESTIMATIONS

date	spot price	REAL	$ vs major c	oil suply	oecd con	world con	Diff	Acumulate	acum m/b	RenProd	opec millb	usopec prod
ene-2010	78,33	1,13	73,3039	86498	45973	86329	169	169	1,69	9,785	30,7	3237,13
feb-2010	76,39	1,59	73,8436	87029	47639	89457	-2428	-2259	-22,59	9,071	30,99	3254,27
mar-2010	81,2	1,43	75,5175	87415	46967	88195	-780	-3039	-30,39	10,43	31	3270,59
abr-2010	84,29	1,65	75,2042	87702	44868	84254	3448	409	4,09	10,471	31,18	3279,46
may-2010	73,74	1,42	75,3866	88035	44555	83666	4369	4778	47,78	11,183	31,14	3281,05
jun-2010	75,34	2,10	78,4684	88143	46282	86909	1234	6012	60,12	11,094	31,78	3339,37
jul-2010	76,32	1,81	79,0274	88593	46038	86451	2142	8154	81,54	11,263	31,8	3344,20
ago-2010	76,6	1,60	76,7377	88548	47487	89172	-624	7530	75,30	11,214	31,85	3353,62
sep-2010	75,24	1,55	75,9153	88658	46871	88015	643	8173	81,73	10,718	31,88	3356,24
oct-2010	81,89	1,34	74,9547	88503	46026	86428	2075	10248	102,48	10,424	31,45	3319,18
nov-2010	84,25	1,66	72,2761	88976	46549	87410	1566	11813	118,13	10,125	31,71	3337,95
dic-2010	89,15	1,79	72,7994	88829	46978	88216	613	12426	124,26	10,122	31,81	3354,53
ene-2011	89,17	1,79	73,7552	89398	45241	87970	1428	13854	138,54	13,417	32,39	3409,06
feb-2011	88,58	1,48	72,8906	88319	47706	92763	-4444	9410	94,10	12,598	31,98	3348,92
mar-2011	102,86	0,71	71,9460	87439	45865	89183	-1744	7666	76,66	14,219	30,81	3254,63
abr-2011	109,53	0,26	70,7541	87448	44813	87138	310	7976	79,76	14,204	30,94	3260,35
may-2011	100,9	-0,43	69,4934	87226	45465	88406	-1180	6796	67,96	14,883	30,97	3270,75
jun-2011	96,26	-0,60	69,5889	88143	45874	89201	-1058	5738	57,38	14,775	31,61	3328,07
jul-2011	97,3	-0,60	69,5025	88565	45837	89129	-564	5174	51,74	14,887	31,86	3354,00
ago-2011	86,33	-1,50	69,0569	89087	46598	90609	-1522	3653	36,53	15,257	32,00	3374,68
sep-2011	85,52	-1,92	69,0247	88338	45047	87593	745	4398	43,98	14,415	32,05	3371,85

oct-2011	86,32	-1,35	71,1540	88776	46379	90183	-1407	2991	29,91	14,574	31,68	3349,49
ıov-2011	97,16	-1,39	71,5902	89751	46437	90296	-545	2446	24,46	13,653	32,50	3429,10
dic-2011	98,56	-1,02	72,2256	90152	45836	89127	1025	3471	34,71	14,203	32,80	3465,71
ːne-2012	100,27	-0,93	73,2355	90408	45727	89340	1068	4539	45,39	16,676	33,12	3502,36
feb-2012	102,2	-0,93	73,3642	90809	46343	90544	265	4804	48,04	16,039	33,48	3528,97
ıar-2012	106,16	-0,53	72,2990	90252	45020	87959	2293	7097	70,97	17,969	33,49	3541,93
abr-2012	103,32	-0,25	72,9821	90653	45822	89526	1127	8224	82,24	18,293	33,75	3562,34
ıay-2012	94,66	0,10	72,8510	90234	45552	88998	1236	9460	94,60	20,171	33,29	3524,34
jun-2012	82,3	-0,08	73,9533	90049	45276	88459	1590	11049	110,49	20,276	33,39	3526,78
jul-2012	87,9	0,13	75,0544	90478	46693	91228	-750	10300	103,00	20,618	33,29	3527,96
ıgo-2012	94,13	-0,02	75,2412	90591	46258	90378	213	10513	105,13	20,16	33,55	3549,90
ːep-2012	94,51	-0,28	74,2713	89850	45823	89528	322	10835	108,35	19,62	33,22	3518,68
oct-2012	89,49	-0,45	72,6149	90585	46336	90530	55	10890	108,90	19,875	32,72	3486,88
ıov-2012	86,53	-0,15	72,7859	90981	46879	91591	-610	10279	102,79	18,565	32,86	3496,53
dic-2012	87,86	0,02	73,6499	90818	46233	90329	489	10768	107,68	19,088	32,59	3478,44
ːne-2013	94,76	0,31	73,1789	89858	45402	88199	1659	12427	124,27	21,554	32,37	3456,41
feb-2013	95,31	-0,02	73,6351	89578	46427	90190	-612	11815	118,15	20,926	32,31	3429,66
ıar-2013	92,94	0,46	74,6460	89831	45287	87976	1855	13670	136,70	24,508	32,48	3469,99
abr-2013	92,02	0,66	76,2914	90747	44919	87261	3486	17156	171,56	24,36	32,92	3513,26
ıay-2013	94,51	0,53	76,2589	91002	44286	86031	4971	22127	221,27	25,78	33,00	3526,33
jun-2013	95,77	0,50	76,9596	90988	45009	87436	3552	25679	256,79	26,306	32,79	3496,91

jun-2013	95,77	0,50	76,9596	90988	45009	87436	3552	25679	256,79	26,306	32,79	3496,91
jul-2013	104,67	0,58	76,2440	91823	46097	89549	2274	27953	279,53	26,506	32,95	3526,06
ago-2013	106,57	1,24	77,2222	91650	45523	88434	3216	31169	311,69	27,606	32,84	3516,58
sep-2013	106,29	1,61	76,3219	90983	45840	89050	1933	33102	331,02	27,051	32,12	3443,82
oct-2013	100,54	1,62	76,0213	91313	46369	90078	1235	34337	343,37	28,02	32,17	3455,77
nov-2013	93,86	1,52	75,0714	91671	45498	88386	3285	37622	376,22	25,864	31,67	3403,92
dic-2013	97,63	1,40	76,0582	91719	46974	91253	466	38088	380,88	26,708	31,87	3431,07
ene-2014	94,62	1,26	76,2304	91709	45698	91494	215	38303	383,03	28,531	32,27	3474,93
feb-2014	100,82	1,61	77,1361	92264	47592	95287	-3023	35280	352,80	27,259	32,41	3467,45
mar-2014	100,8	1,22	76,9912	91733	46092	92283	-550	34730	347,30	33,914	32,85	3540,56
abr-2014	102,07	0,71	76,6530	92320	45602	91302	1018	35748	357,48	34,84	32,89	3546,03
may-2014	102,18	0,46	76,4051	92224	44281	88657	3567	39314	393,14	38,027	32,77	3542,90
jun-2014	105,79	0,50	76,2734	93081	46055	92209	872	40186	401,86	38,989	32,77	3537,35
jul-2014	103,59	0,54	76,4953	93288	46908	93917	-629	39557	395,57	38,389	33,10	3581,39
ago-2014	96,54	0,72	76,3729	93620	46683	93467	153	39710	397,10	39,262	33,32	3605,87
sep-2014	93,21	0,83	77,5948	94204	46390	92880	1324	41034	410,34	38,123	33,72	3640,77
oct-2014	84,4	0,60	79,6313	95103	46387	92874	2229	43263	432,63	37,716	33,78	3660,99
nov-2014	75,79	1,03	80,8700	94682	46384	92868	1814	45077	450,77	33,819	33,32	3607,94
dic-2014	59,29	1,41	82,7722	95296	46400	92900	2396	47473	474,73	31,2	33,48	3640,13
ene-2015	47,22	1,98	84,1971	94286	46400	94905	-619	46855	468,55	36,905	33,17	3606,56
feb-2015	50,58	1,98	87,5393	94265	46400	94905	-640	46215	462,15	38,403	33,16	3580,62
mar-2015	47,82	2,14	89,2001	95236	46400	94905	331	46547	465,47	46,63	33,75	3674,08
abr-2015	54,45	2,14	91,7395	95470	46034	94156	1314	47861	478,61	48,923	33,96	3686,83
may-2015	59,27	2,20	90,9386	95050	45668	93407	1643	49503	495,03	50,067	33,86	3679,85
jun-2015	59,82	2,26	89,2010	95984	45300	92655	3329	52833	528,33	50,346	34,40	3719,46
jul-2015	50,9	2,12	89,7398	96478	44975	91990	4488	57321	573,21	51,515	34,56	3748,39
ago-2015	42,87	1,97	91,7276	96670	44650	91325	5345	62666	626,66	52,279	34,47	3738,63
sep-2015	45,48	2,17	91,9344	95989	46600	95314	675	63341	633,41	46,931	34,54	3737,59
oct-2015	46,22	1,87	91,7358	96305	46500	95109	1196	64537	645,37	44,627	34,40	3730,74
nov-2015	42,44	1,76	91,2567	96753	46400	94905	1848	66385	663,85	42,534	34,40	3719,86
dic-2015	37,19	1,54	93,9403	97200	46300	94700	2500	68885	688,85	40,762	34,16	3702,62
ene-2016	31,68	0,69	94,1403	96933	46233	96531	402	69287	692,87	44,326	34,19	3703,91
feb-2016	30,32	0,78	95,2896	96667	46167	96392	275	69562	695,62	50,757	34,07	3671,86