January 2017

Oil Market Analysis for Teal

Akshay Satyanarayan Rao
Worcester Polytechnic Institute

Nicholaus D. Jasinski
Worcester Polytechnic Institute

Sarah Rose Terwilliger
Worcester Polytechnic Institute

Project Number: ZAZ-AAZX

Oil Market Analysis for Teal

A Major Qualifying Project Report:

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

Nicholaus Jasinski, Akshay S. Rao, Sarah Terwilliger

Date: December 14th, 2016

Approved:

____________________ Professor Kevin Sweeney, Main Advisor

____________________ Professor Alexander Smith, Co-Advisor

____________________ Professor Amy Zeng, Co-Advisor

Table of Contents

Table of Figures

Table of Tables

Abstract

The goal of our project was to identify key economic indicators that have a significant influence on the price of oil per barrel. We identified five key indicators: Change in Inventory, OPEC Policy, GDP, Rig Count, Social/Environmental Factors. We used SPSS to build a linear multi-regression model between the dependent variable (price of oil) and the five indicators. We identified statistically significant variables and examined multiple scenarios in respective case of fluctuations in social/environmental factors and OPEC policy.

Executive Summary

The major objective of our project is to help accomplish our sponsor, Teal's, goal of determining factors that most highly affect the price per barrel of oil. These indicators can then be used in a regression analysis model to see where the market is heading. From the model, Teal is able to get an estimate of the price per barrel of oil at a certain time in order to optimize their decision in terms of whether or not to make acquisitions and when they should act. The process-oriented, decision-making model that we came up with provided the equation of:

Oil Price= -147.642-0.816*(Quarter)-0.918*(Inventory)+0.019*(Rigs)+2.846*(OPEC) +4.041x10^(-12)*(GDP)-11.018*(Social/Environmental Factors)

From this equation, we were able to provide a predicted price of oil per barrel with an 85% confidence level. Based on the coefficients table that was generated as an output on the SPSS software, we were able to determine the significance of each independent variable with a certain confidence level. This allowed us to simplify our equation down to only the statistically significant factors: OPEC and Rig Count. The simplified equation can then be written as:

Oil Price= -6.431-0.550*(Quarter)+0.026*(Rigs)+4.327*(OPEC)

This result provides Teal with two variables that have been proven to be of high importance when it comes to determining the price per barrel of oil.

Our project sponsor, Teal, is particularly interested in two geographical regions: Fort McMurray in Canada and Permian Basin in Texas. Through our decision making model, we can see that a pertinent activity can have a direct impact on the price of per barrel of oil. This is evident in the fact that the price of oil was lowered by approximately $4/barrel in May of 2016 due to widespread and disastrous wildfire in Fort McMurray, Canada. On the other hand, the price of oil per barrel in the US (Western Texas Intermediate Benchmark) has increased by approximately $24/barrel from February of 2016 to its present value of $51.6/barrel. This is indicative of the fact that Permian Basin, one of the most promising oil producing regions in the US, is predicted to produce almost 5 million barrels per day in the near future.

Moving forward, Teal may customize this model to fit new data and/ or consider a different time frame since the market for oil is constantly changing in congruence with what is happening in the world.

1. Introduction

1.1. Uncertainty in the Oil Market

The price of oil per barrel has been in contention for a few years now. Prices of oil fell as low as $28/barrel in February of 2016 before stabilizing back to $61/barrel in December of 2016. This instability in the price of oil per barrel is of interest to our project sponsor, Teal. Uncertainty over whether the Organization of the Petroleum Exporting Countries (OPEC) will reach an output deal coupled with fears of Saudi Arabia not attending talks with non-OPEC countries to discuss supply cuts led in some significant fluctuations in the price of oil per barrel. Furthermore, tensions over Iraq and Iran’s diplomatic talks on exemptions from sanctions to limit the supply of oil has increased the speculation of a further drop in the price of oil. Not only has the OPEC policy and Social/Environmental factors affected the uncertainty, but China’s decrease in crude oil imports has affected the GDP of the respective countries to a certain extent. In addition to the above mentioned factors, excess inventory and rig count has increased supply while demand has been relatively stable. This surge in the OPEC output has led to market pushbacks in several regions, especially in areas with benchmarks, Western Texas Intermediate (WTI) and Dubai.

1.2. Introducing Teal

Teal is a company that provides workforce and temporary housing for a variety of situations as well as any other facilities that individuals may need to be safe and productive with their time. In the company's early years, they housed government officials for the Olympic games as well as those who needed assistance during periods of disaster relief. Today, a large source of Teal's income comes with providing workforce housing, and in correspondence with the efforts of this project, we will be focusing in on lodging provided to the oil operations workforce.

Teal thrives when they open a facility in areas that are remote, otherwise known as “ghost towns”. This includes successful facilities in regions of North Dakota and Texas, places where the nearest Wal-Mart or McDonald's are hundreds of miles away. Having an effective monopoly of an area such as this allows Teal to price appropriately to be compensated for the risk. Teal invests $20 to $70 million to construct a facility, and to recover this cost, Teal cannot be competing with hotel prices or any similar low-cost competitors. Additionally, Teal prides itself on the ability of their facilities to be the absolute best-in-class, secure areas where these customers have high-quality meals and safe shelter to come home to at night when it can reach temperatures of -60F, and many feet of snow. They have strict policies that are agreed upon with the clients such as no alcohol on the premises, no firearms, no weapons of any type, and are run semi-militaristically. These areas are owned by Teal, and are considered tangible personal property, not real estate assets, for Generally Accepted Accounting Principles purposes.

The company has had great success over the years, garnering recognition for two years in a row as Inc Magazine's fastest-growing private companies. Despite oil prices recently falling about 60%-70%, Teal was able to grow revenue to over $250 million with 83% year-over-year through diversifying their operations. One such effort was immigration housing in Dilley, Texas, which was over a $100 million total investment build completed as the oil market crashed. Teal has clear objectives, and to meet these objectives they must continue diversifying with organic growth and making strategic acquisitions to continue their growth and dominance of their market.

1.3. Project Goals and Objectives

In the year 2015, Teal recorded $250M in sales and roughly $100M profit. The goal of the company moving forward is to double sales through acquiring relevant companies and oil housing facilities in the United States and Canada as quickly as possible. In order to help pave the way to accomplishing this, we worked to come up with a model which illustrates the price per barrel of oil with consideration to a number of pertinent economic indicators.

It is clear that within the past 5 years Teal has become a leader in its industry due to their inherent success in remote regions such as North Dakota and Texas, but since only the strongest firms will survive the current economic downturn of the oil market, Teal must take the necessary steps to endure and thrive, and possibly capitalize on this unprecedented oil/commodity downturn.

The major objective we are faced with in helping to accomplish Teal's goal will lie in determining which factors most highly affect the price per barrel of oil so that these indicators can then be used in a decision-making model which will help Teal to see where the market is heading. From the model, Teal will be able to get an estimate of the price per barrel of oil at a given time in order to optimize their decision in terms of whether or not to make acquisitions and when to act. An additional benefit for Teal is that Teal may also use this methodology, once proven, to evaluate other commodities such as natural gas, copper, and/or iron to help Teal with their diversification strategy.

1.3.1. Creating a Process-Oriented Solution

In order to assist Teal in their decision-making process for whether and when to make acquisitions and open new facilities in congruence with what is happening in the oil market, we have concluded to create a process-oriented solution. A big piece of this puzzle lies in finding out which indices most powerfully affect the oil market. We discovered which factors should be taken into consideration as we built a linear regression model to predict the price per barrel of oil. From here, we were able to create a relevant data set to coincide with the indicators decided upon and use computer-aided software in order to develop a functional yet fully customizable model for Teal to work with.

2. Background and Literature Review

2.1. Crude Oil Market History

Oil is the one of the most important sources of energy and plays an important role in the world economy. The transportation sector relies heavily on petroleum products refined from crude oil- all motor vehicles, airplanes, trains, vessels, etc. These petroleum products (diesel, jet fuel, gasoline, heating oil) account for almost 33% of world's energy needs, while natural gas and coal account for 22% and 8% of the world's energy needs. Crude oil products are global commodities and their prices are determined by worldwide supply and demand. There are periods of time when the price of crude oil is relatively stable and other periods when it is highly volatile. The are many stages involved before crude oil is delivered to its desired location. These include: exploration, drilling and development of the well, production, refining, and distribution.

Production consists of finding, drilling, and excavation of oil. Once the oil is excavated and transported, it is refined to gasoline, petroleum, or one of its products. The last step includes marketing the product and distributing it to the customer.

If we talk numbers, May of 1980 was when the crude oil stock market saw its first big spike, reaching a price of $39.50 which almost matches the current price of about $44.50. Then, the price reached $39.50 again in September of 1990. One of the lowest points the market ever saw was in November of 1998, but after this time, the market began to skyrocket and never saw that low point again. In June of 2008, the price reached unparalleled highs, upwards of $140, however, it quickly drastically dropped during the stock market crash, decreasing all the way down to $41.73 in January of 2009. The next high point, which has been the highest price since 2009, was reached in April of 2011 at $113.39. The current extreme downturn of the market began in July of 2014. The lowest point during this time period was in January of 2016 at $33.71, which was the lowest price since January of 2004[1]

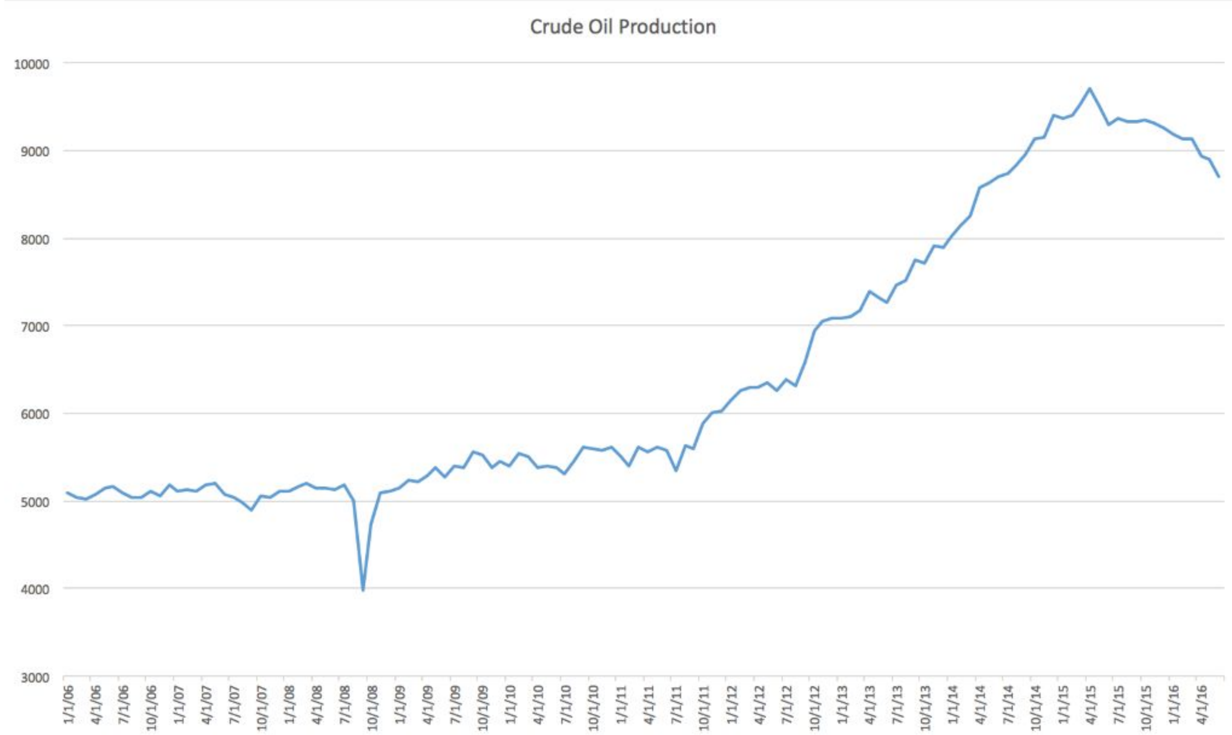
Each past example of the crude oil market has seen a recovery, many times reaching new historic highs after historic lows. The most recent comparison is the example of January of 2009, when the market greatly recovered from a dip. Does this mean the market will recover? Has crude oil phased out due to alternative energies such as electric, natural gas, etc.? What will the effects of this low be?

Since 2006, crude oil production has increased from 5,085 thousand barrels per day, to 8,701. Most of this increase was seen after the start of 2011. A sharp decline was seen in the fall of 2008, reaching as low as 3,983 thousand barrels per day.[2]

1 Crude oil 1946-2016 Data. (n.d.). Retrieved October 01, 2016, from http://www.tradingeconomics.com/commodity/crude-oil

2 Crude oil 1946-2016 Data. (n.d.). Retrieved October 01, 2016, from http://www.tradingeconomics.com/commodity/crude-oil

Figure 1: Crude Oil Production from 2006-2016



The above graph shows the price of oil over the past ten years, including a trend line to show the overall decrease. As shown above, the main decreases were seen in 2008 and 2014. The decrease which began in 2014 has since not recovered, as the price of oil is still hovering around historic lows.[3]

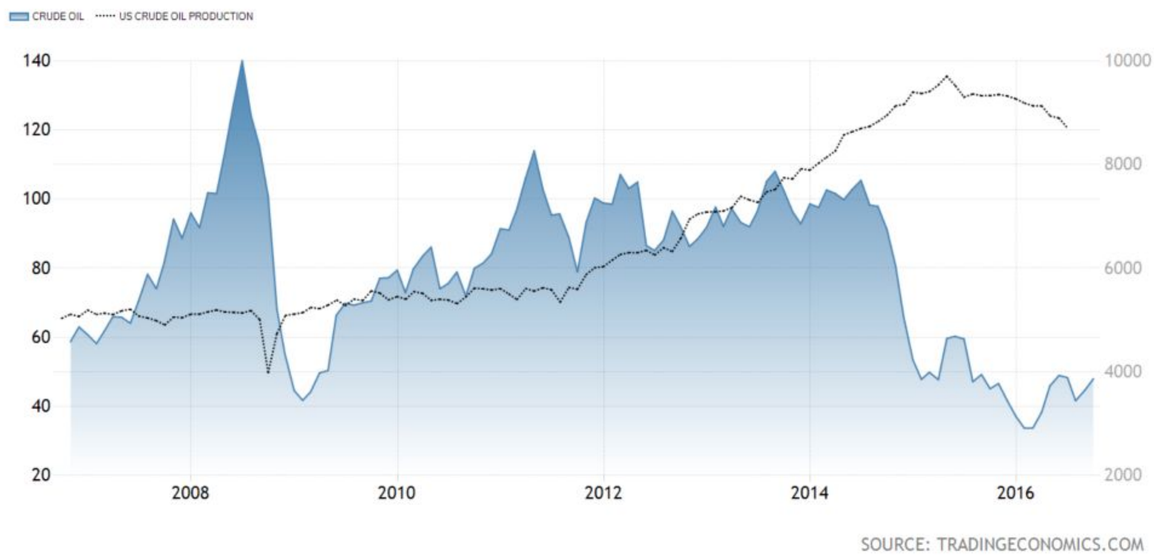
3 Crude oil 1946-2016 Data. (n.d.). Retrieved October 01, 2016, from http://www.tradingeconomics.com/commodity/crude-oil

Figure 2: Crude Oil Production vs. Crude Oil Stocks Exchange Trend Line

When comparing the oil production and stocks exchange of oil, the overall increasing trend of the production of oil can be seen on top of the overall decreasing trend of the stocks exchange. Despite the increasing trend of oil production, it has seen a decrease in recent times, coupled with the recent decreases in the price of oil.[4] When will the production rise again? Will it reach the same levels it has seen in the past? Will it ever rise again? What about for the price?

4 Crude oil 1946-2016 Data. (n.d.). Retrieved October 01, 2016, from http://www.tradingeconomics.com/commodity/crude-oil

Figure 3: Crude Oil Production vs. Crude Oil Stocks Exchange

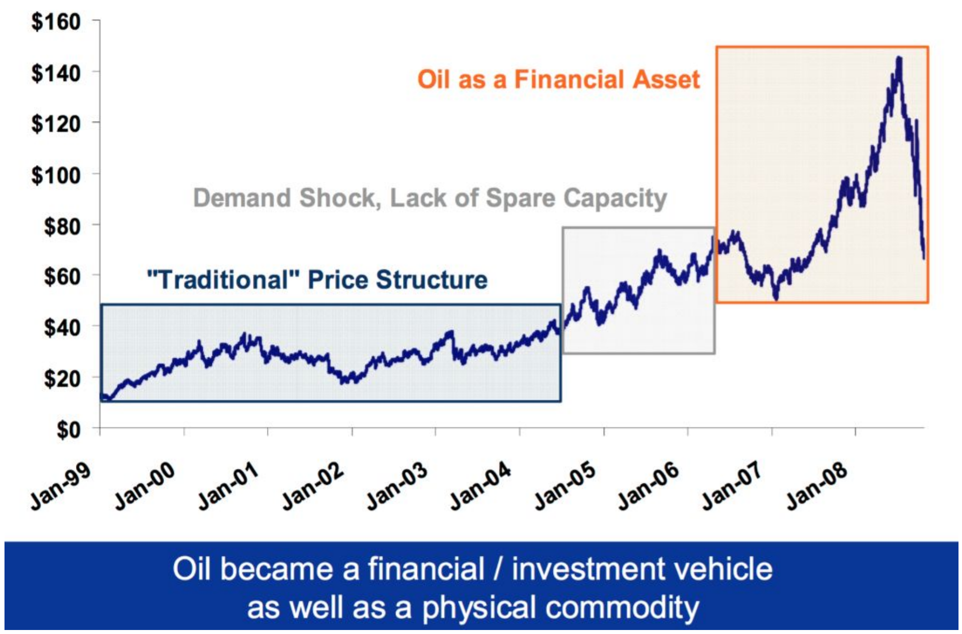


2.2. Understanding the Oil Market and What Drives It

The crude oil market is historically a very volatile market that has seen periods of drastic growth and decline before. The 2008 crash is the best example of how sometimes there are extreme cases in your data that must be discluded as outliers. This collapse in the price of oil can be attributed to massive deleveraging by financial institutions. The global economic downturn has resulted in the real decline in the demand for oil. Below, Figure 4 shows how oil became a "financial/investment vehicle" on top of being a physical commodity.[31] As the price of oil increased, it became a financial asset, and suddenly crashed thereafter. This shows how status the U.S. economy directly affects the status of the oil market[5].

[5] Kilian, L. (2008, May). Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy? Retrieved December 07, 2016, from http://www.mitpressjournals.org/doi/pdf/10.1162/rest.90.2.216

Figure 4: WTI Prompt Month Price

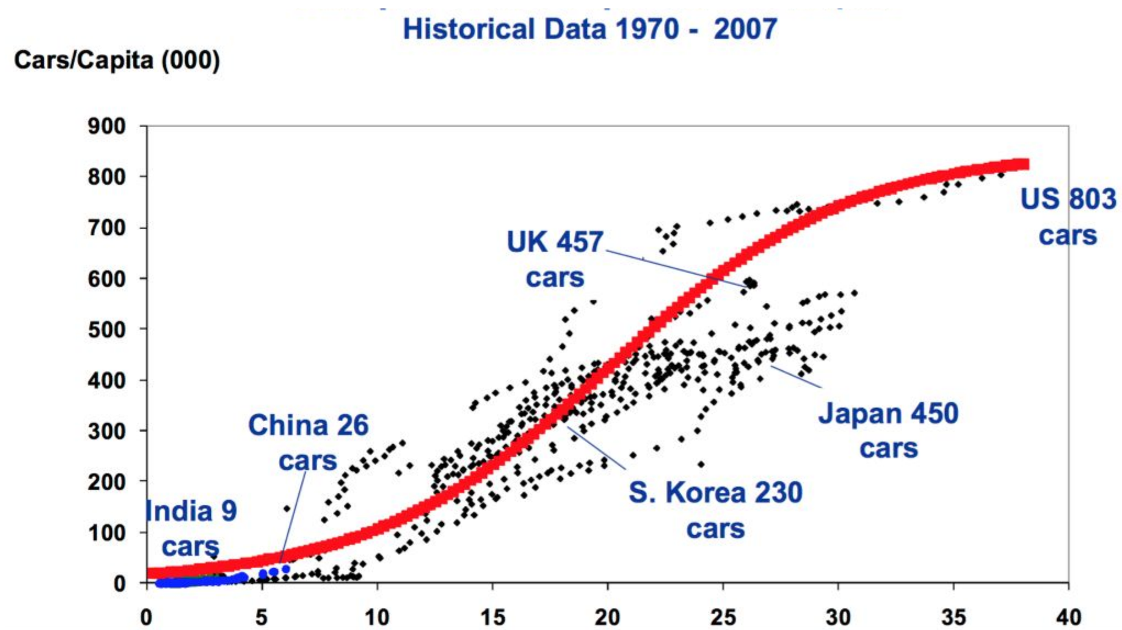


We believe the future state of the crude oil market depends on a few key factors; crude oil production, crude oil stock exchange, car production, and government spending. Specifically, the status of crude oil depends on the rig count, or production, and the price per barrel, or its commodity exchange. The price of oil can then be observed against the nearby occupancy of the area while the rig count is observed against utilization of the oil, which refers to how much of the oil is being used out of all oil that is produced daily. In the past, when the price fell, the number of rigs fell, and utilization then fell lastly. From 1970-2007, the production of cars saw a great increase, which drove the growth of oil demand. This can be seen in the below graph.[6]

---

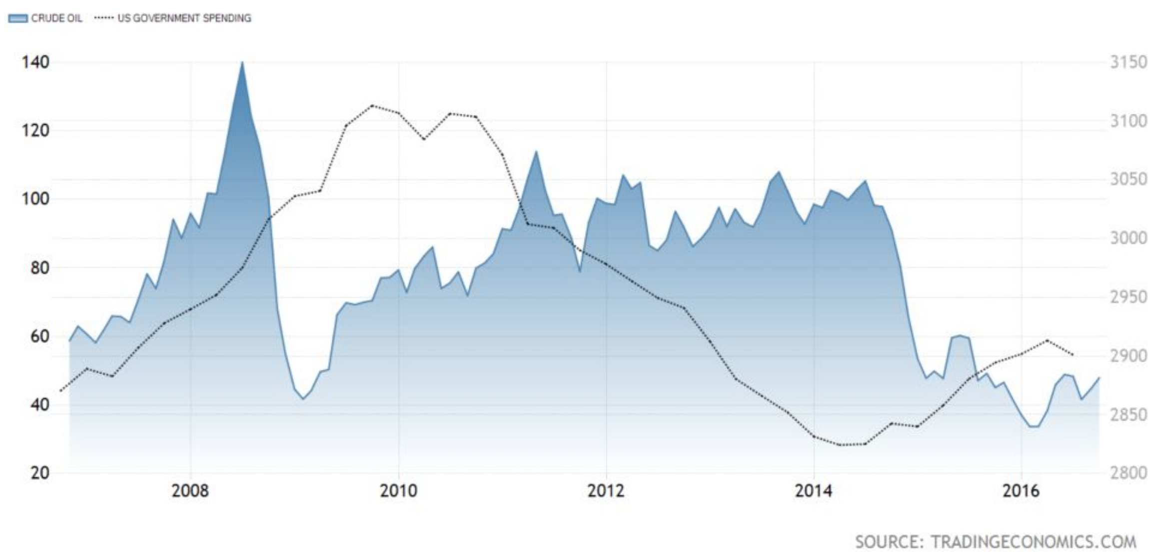
6 Watts, L. (2009, March). The Financial Crisis and its Impact on the Oil & Gas Industry. Retrieved October 1, 2016, from http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1234451048011/5827121-1239045090161/Watts_PFC.pdf

Figure 5: Cars per 1000 People vs. GDP/capita



The increase in cars per capita drove up oil demand because more oil was needed to fuel this rise in cars. Government spending comes into play because it leads to economic activity which then creates an effect on the demand for oil.

Figure 6: Crude Oil Stocks Exchange vs. Government Spending



Since 2010, U.S. government spending has decreased overall, despite seeing a slight increase since 2014.[7] However, the decrease leading up to 2014 appears to have been enough to help the oil market crash in 2015.

2.3. Influence of OPEC and Saudi Arabia

The Organization of Petroleum Exporting Countries (OPEC) owns the majority of global petroleum trade. As they make changes to production capacities, oil supply levels and prices are immediately affected. OPEC as a group works to maintain agreement between the nations involved to stay on set production targets.[8]

Within OPEC, Saudi Arabia alone can - and does - provide a direct influence on the crude oil market across the world. As the nation which holds the largest market

7 Government spending 2006-2016 Data. (n.d.). Retrieved October 01, 2016, from http://www.tradingeconomics.com/commodity/government-spending

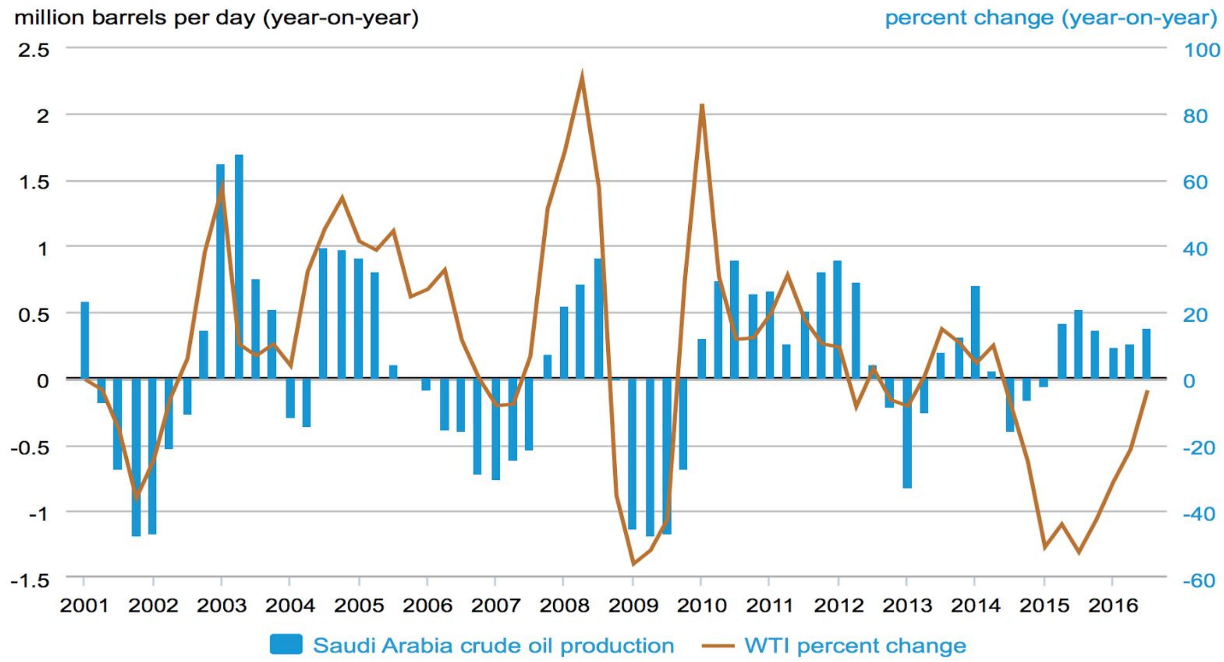
8 U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (n.d.). Retrieved October 06, 2016, from https://www.eia.gov/finance/markets/supply-opec.cfm

share in OPEC, if they decide to separate themselves from OPEC's agreements like in 2014, or agree to a production freeze with non-OPEC nations like in early 2016, the impact is immediate.[9] Since they have the money to sustain any drops in prices, they are not yet reaping any repercussions from a lower premium. As shown in figure 7 below, a graph from the U.S. Energy Information Administration (EIA) we can see that typically Saudi Arabia crude oil production paves the path which WTI crude oil prices will follow.[10]

9 Gallucci, M. (2016). Saudi Uncertainty Rattles Oil Markets. Retrieved October 06, 2016, from http://www.ibtimes.com/oil-markets-rattled-saudi-arabia-casts-doubt-global-crude-production-freeze-deal-2346959

10 U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (n.d.). Retrieved October 06, 2016, from https://www.eia.gov/finance/markets/supply-opec.cfm

Figure 7: Changes in Saudi Arabia Crude Oil Production and WTI Crude Oil Prices



Sources: U.S. Energy Information Administration, Thomson Reuters

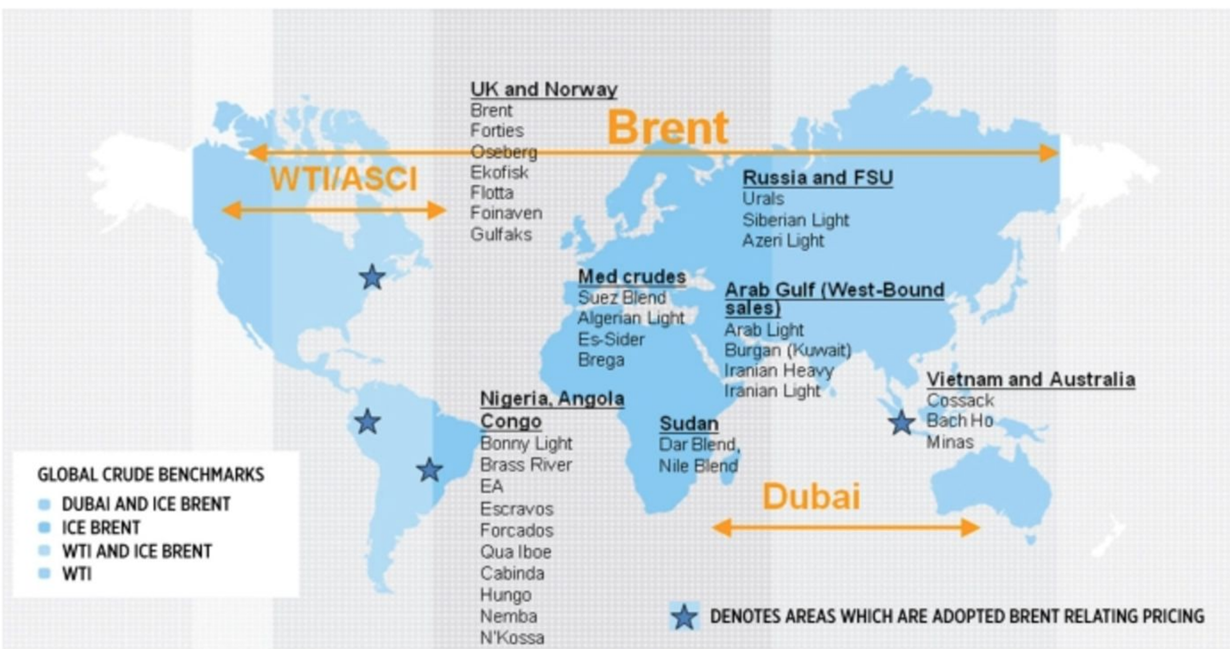
Production and prices continue to be affected as current events in the Middle East unfold. In the New York Times, Richard Mallinson, a European market analyst stated "What is coming back to the surface is how deeply divided and complex the Middle East is…"[11] Tensions between Saudi Arabia and Iran especially have an influence on the market.

11 Reed, S. (2016, January 4). Oil Market Settles Lower, Taking Iran-Saudi Dispute in Stride. Retrieved October 6, 2016, from http://www.nytimes.com/2016/01/05/business/energy-environment/oil-saudi-arabia-iran.html

2.4. Benchmarking

Due to the different types of crude oil available in the market, it is often difficult for analysts to value the commodity based on quality and location. Benchmarking allows the energy experts to analyze the pricing of crude oil produced around the world. Benchmarking is defined as a measurement of the quality of an organization's product in comparison to standard measurement. The three primary benchmarks used in the oil market are Brent Blend, West Texas Intermediate (WTI), and Dubai/Oman[12].

Figure 8: Oil Benchmarking by Region



Brent Blend is the most widely used benchmark worldwide, making up roughly two-thirds of all crude oil contracts. Brent refers to oil from four different oil fields in the

[12] Kurt, D. (2015, December 24). Understanding Benchmark Oils: Brent Blend, WTI and Dubai. Retrieved September 30, 2016, from http://www.investopedia.com/articles/investing/102314/understanding-benchmark-oils-brent-blend-wti-and-dubai.asp

North Sea: Brent, Forties, Oseberg, and ekofisk. The oil refined from these fields are typically light and sweet, thus ideal for refining of diesel, gasoline, etc. Brent is used as a benchmark to price oil produced in Europe, Africa, the Mediterranean, Australia, and some parts of Asia[13]. The chart below shows Brent crude oil prices from February 2016 to September 2016. Brent crude oil changed by +6.65% in the last week to $49.11, +4.04 in the last month to $48.64 (August 2016-September 2016), and +2.02% in the last year to $35.52 (February 2015-February 2016).

Figure 9: Brent Crude Oil Price

West Texas Intermediate (WTI) is crude oil extracted from wells in the United States and sent to the trading oil hub in Cushing, Oklahoma. Since oil wells are

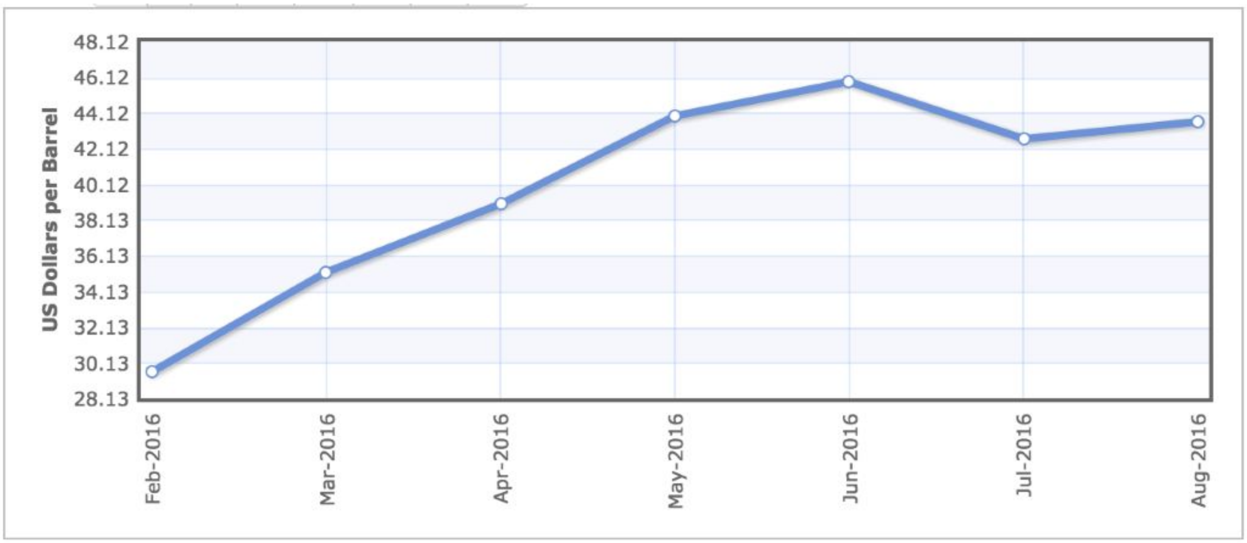
[13] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (2014, October 28). Retrieved September 30, 2016, from http://www.eia.gov/todayinenergy/detail.php?id=18571

landlocked in the United States, prices are often expensive to ship to other countries. WTI is used as a benchmark to for various types of crude oil including: Mars, sour crude oil produced in the Gulf of Mexico, Bakken, among others. WTI is the standard for crude oil imported from Canada, Mexico, and South America. The chart below shows WTI crude oil prices from February 2016-September 2016. WTI crude oil changed by +7.59% in the last week to $47.85, 7.25% in the last month to $46.82 (August 2016-September 2016), $7.15% in the last year to $32.56 (February 2016 to September 2016).

Figure 10: Western Texas Intermediate (WTI) Crude Oil Price

Dubai/Oman crude oil is the third major benchmark and is used in the Middle-East. The chart below shows Dubai crude oil prices for the last six months. The price per barrel in August was $44.12 compared to $30.13 in February 2016[14].

Figure 11: Dubai Crude Oil Price per barrel



2.5. Areas of Interest to Teal

2.5.1. Fort McMurray

Fort McMurray is an area located in northeast Alberta, Canada, as shown in Figure 12, that Teal is considering as a place to open a new facility.[15]

[14] Crude Oil (petroleum); Dubai Fateh Monthly Price - US Dollars per Barrel. (n.d.). Retrieved September 30, 2016, from http://www.indexmundi.com/commodities/?commodity=crude-oil-dubai
[15] Fort McMurray. (n.d.). Retrieved September 30, 2016, from https://www.britannica.com

Figure 12: Oil Sands Deposits in Fort McMurray

They are interested in this area to take advantage of a region that houses a large portion of the Athabasca oil sands. Especially now, this region is particularly interesting due to a widespread and disastrous wildfire in May of 2016 which left one of every five homes in the region destroyed.[16] Because there was a quick turnaround with rebuilding efforts as well as the return to oil sands production, the economy was able to offset a lot of the burden that would have otherwise been undertaken by the economic downturn from the fire.[17]

Despite the region being rich in oil sands since its discovery, it took until 1964 for a company to have permission to excavate crude oil from the sands because the

[16] Fritz, A. (n.d.). Fort McMurray wildfire evacuation was largest on record in Canada. Retrieved September 30, 2016, from https://www.washingtonpost.com/news/capital-weather-gang/wp/2016/05/04/hot-dry-and-windy-weather-stokes-the-violent-alberta-wildfire/

[17] Curry, B. (2016, May 17). Fort McMurray's economic hit likely to be offset by rebuilding, analysts suggest. Retrieved September 30, 2016, from http://www.theglobeandmail.com/news/politics/fort-mcmurrays-economic-hit-likely-to-be-offset-by-rebuilding-analysts-suggest/article30057847/

process itself is dirty and there had not previously been a feasible way to excavate. Since 1964, however, this region of Canada has been one of the major players in the oil industry.[18] The company in particular which presides fairly prominently over the oil sands in Fort McMurray is Sun Company of Canada, better known as Suncor.[19]

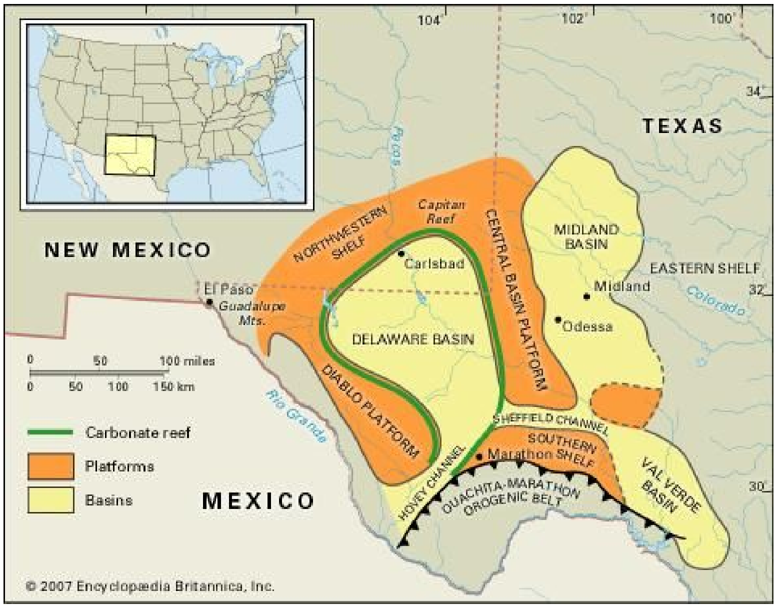
Fort McMurray shot up from being the home of just over a thousand citizens to housing ten thousand citizens in just ten years time when oil excavation began. From here, the population has only grown further. It has reached a point where today the region is definitely no longer considered to be very remote. There are a number of college facilities, historical landmarks, and many events for the community to be a part of. The area has become somewhat of a melting pot full of hundreds of different languages and cultures, which drives the question of whether temporary housing in this sort of region would be necessary.

2.5.2. Permian Basin

The Permian Basin region of Texas is located in the western sector of the state and stretches into southeastern New Mexico as shown in Figure 10.

[18] Pannekoek, F., & James-Abra, E. (n.d.). Fort McMurray. Retrieved September 30, 2016, from http://www.thecanadianencyclopedia.ca/en/article/fort-mcmurray/
[19] The Oil Sands Story (1960s, 1970s & 1980s) - Suncor. (n.d.). Retrieved September 30, 2016, from http://www.suncor.com/about-us/history/the-oil-sands-story

Figure 13: Oil Sands Deposits in Permian Basin



[20].

This is another area that Teal is strongly considering as potential grounds for future facilities. The Permian Basin produced 312 million barrels of oil in 2012. In 2014, the region was seeing 1.7 million barrels of production per day, and to this day the basin maintains status as a powerhouse for oil output.[21] In recent years, the area has only seen further booms in oil production due to the technological advancements with fracking and drilling.

Many feel as though the Permian Basin region will continue to rapidly improve in the coming years despite a drop in oil production. Scott Sheffeild, CEO of Pioneer Natural Resources, is quoted saying "…the Permian is going to be the only driver of

---

20 Permian Basin. (n.d.). Retrieved September 30, 2016, from https://www.britannica.com/place/Permian-Basin

21 Gold, R. (2014, September 01). Permian Basin in Texas to Drive Down Oil Prices. Retrieved September 30, 2016, from http://www.wsj.com/articles/permian-basin-in-texas-to-drive-down-oil-prices-1409613682

long-term oil growth in this country, and it's going to grow on up to about 5 million barrels a day…".[22]

One differentiating factor of the basin to take into consideration is that water is hard to come by and not allocated efficiently.[23] Additionally, one journalist in the basin mentions how the population changes should be considered too, stating "...growth of shale fracking has led to unprecedented population growth in the Permian concomitant with a building boom."[24] The region is also home to The University of Texas of the Permian Basin, which is a culturally diverse school.

2.6. Forecasting Analysis

Forecasting Analysis can be defined as the use of historical data to predict what might occur in the future with a level of uncertainty. Due to this uncertainty, it is important to forecast with the highest possible accuracy. Modeling multiple regressions would involve more than one predictor. The seven methods for an accurate forecasting are listed below.[25]

22 Helman, C. (2016, August 4). America's Saudi Arabia? Why Investors Are Still Hot On The Permian Basin. Retrieved September 30, 2016, from http://www.forbes.com/sites/christopherhelman/2016/08/04/americas-saudi-arabia-why-investors-are-still-hot-on-the-permian-basin/#14296c4567be

23 Guerin March 19, 2014 Web Exclusive Print Share Subscribe Donate Now, E. (2014, March 19). Permian Basin: America's newest fracking boom where there's not much water. Retrieved September 30, 2016, from http://www.hcn.org/blogs/goat/permian-basin-in-new-mexico-and-west-texas-americas-newest-fracking-boom

24 A. A. (2015, April 07). Materialized Dreams: Boom and Bust in the Cultural Landscape of West Texas - Edge Effects. Retrieved September 30, 2016, from http://edgeeffects.net/texas-boom-and-bust/

25 How to Forecast Demand Accuracy - 7 Methods. (n.d.). Retrieved October 29, 2016, from https://www.logility.com/library/white-papers/demand-planning-papers/media/7-methods-that-improve-forecasting-accuracy

Figure 14: Statistical Modeling Methods

Type	The 7 Methods	Description
Best-Fit statistical	Modified Holt / Holt-Winters	Use Holt when demand is trended, but does not vary by the time of the year. Use Holt-Winters when demand is often higher or lower during particular times of the year.
	Moving Average	Use for products with demand histories that have random variations, including no seasonality or trend, or a fairly flat demand.
Derived	Inhibited	Use to produce a zero forecast.
	Modified Parent-Child	Use to forecast products as a percent of the forecast for another product (dependent demand).
Intermittent Demand	Modified Croston	Use for products with low demand or for some zero demand periods, such as slow-moving parts.
Attribute-based	Demand Profile	Employs user-defined attributes to model new product introductions, seasonal or fashion driven products, and product end-of-life retirement.
Causal	Promotions	Use to calculate "lift" from promotions in addition to the normal forecast.

An important assumption of our data analysis for decision model will be that it is linear in its parameters. This stochastic process $\{(x_{t1}, x_{t2}, \ldots, x_{tk}, y_t): t = 1, 2, \ldots, n\}$ follows the linear model of:

$$Y = B_0 + B_1X_1 + B_2X_2 + \ldots + B_nX_n$$

Where b_0 is the intercept and $B_{1\ldots}B_n$ are the coefficients representing the independent variables $X_{1\ldots}X_n$.[26] Our model will be observing an outcome, the actual price of oil, and how random variables affect this outcome. We do not know what the price of oil will be, what the inventory change will be, what OPEC policy will be, etc., which makes these

[26] Wooldridge, J. M. (2014). *Introduction to econometrics*. Hampshire: Cengage Learning.

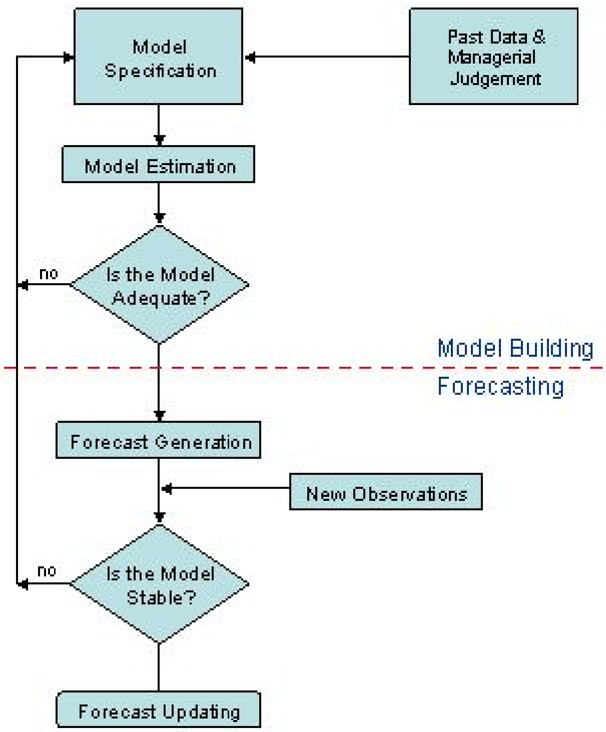
random variables since these outcomes are not foreknown. This sequence of random variables indexed by time is represented by a stochastic, or time series, process. Once we collect our dataset, we obtain a possible outcome, or realization, of the overall process. The sample size for this dataset is represented by the number of time periods for which the variables of interest are observed.[27]

The image below highlights the various phases of modeling and decision making process.[28] As we have talked earlier, one of the foremost steps in building a process-oriented model is to specify the independent and dependent variables for our model (Model Specification). Once the variables have been specified, we can generate paraments for the variables and/or define specific constraints (Past Data and Managerial Judgement). Once the first two steps have been clearly established, we estimate the model and determine whether it is accurate (Model Estimation, Accuracy). From the image below, we can see that the the next phase is forecasting and interpretation to identify potential solutions or recommendations.

[27] Wooldridge, J. M. (2014). *Introduction to econometrics*. Hampshire: Cengage Learning.

[28] By extrapolating our models beyond the period over which they were estimated, we can make forecasts about near future events. This section shows how the single-equation regression model can be used as a forecasting tool. (1994). Time Series Analysis for Business Forecasting. Retrieved September 30, 2016, from http://home.ubalt.edu/ntsbarsh/stat-data/forecast.htm#rhowmulregan

Figure 15: The Model Building and Decision Making Phases



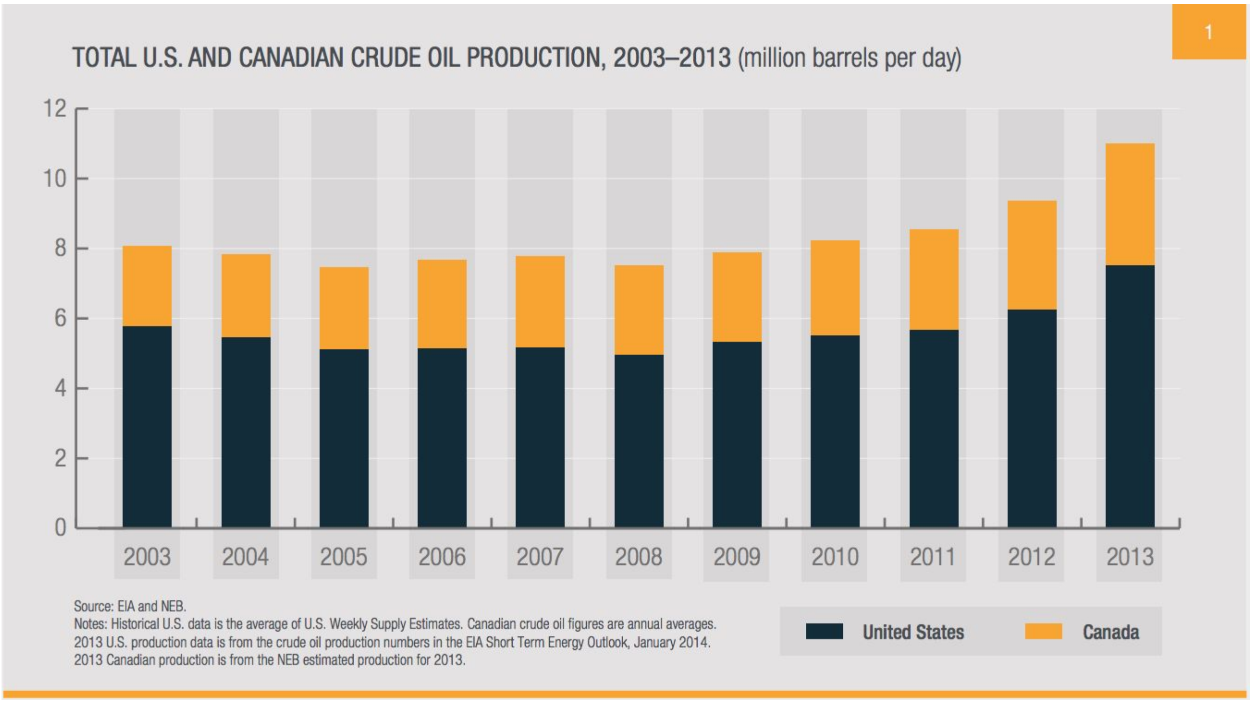
3. Methodology

3.1. Determining Indicators for Decision-Making Process

3.1.1. Selecting Indicators

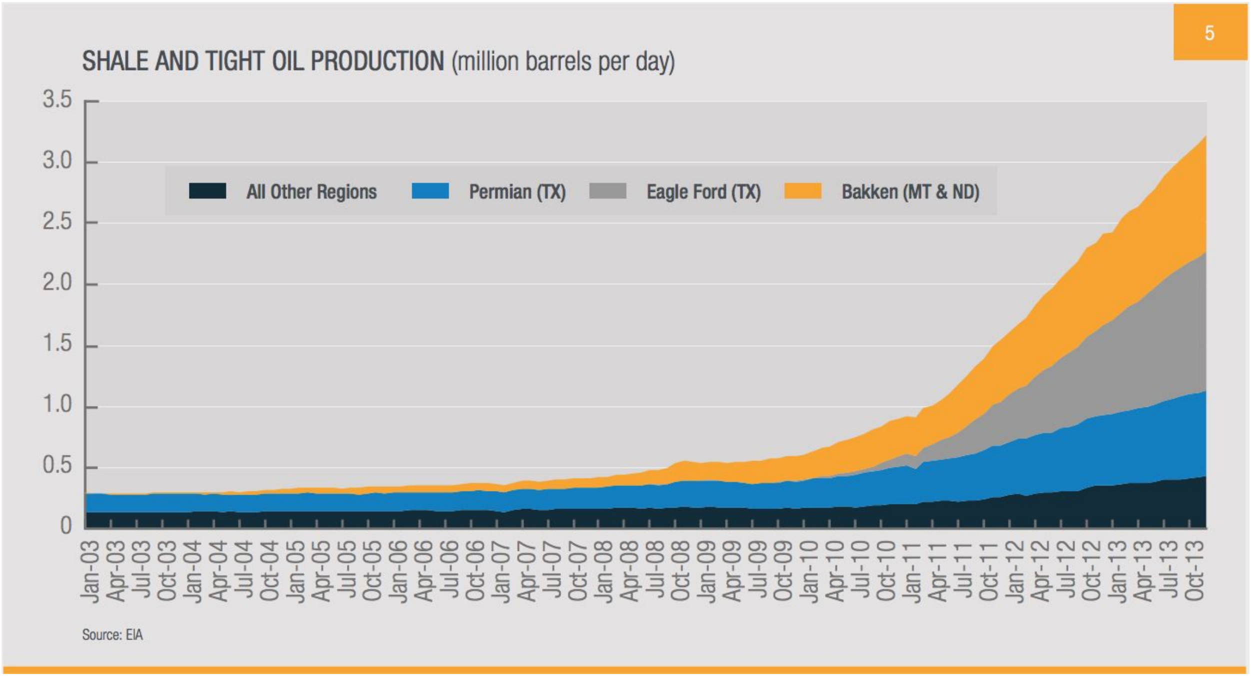
Crude oil production in the United States and Canada has grown substantially in the last few years. There has been an increase of 46% in the total production from 2008 to 2013, from 7.5 million barrels a day to 11 million barrels a day. This increase in the production of crude oil has reduced America's dependence on other countries.

Figure 16: Total U.S. and Canadian Crude Oil Production, 2003-2013



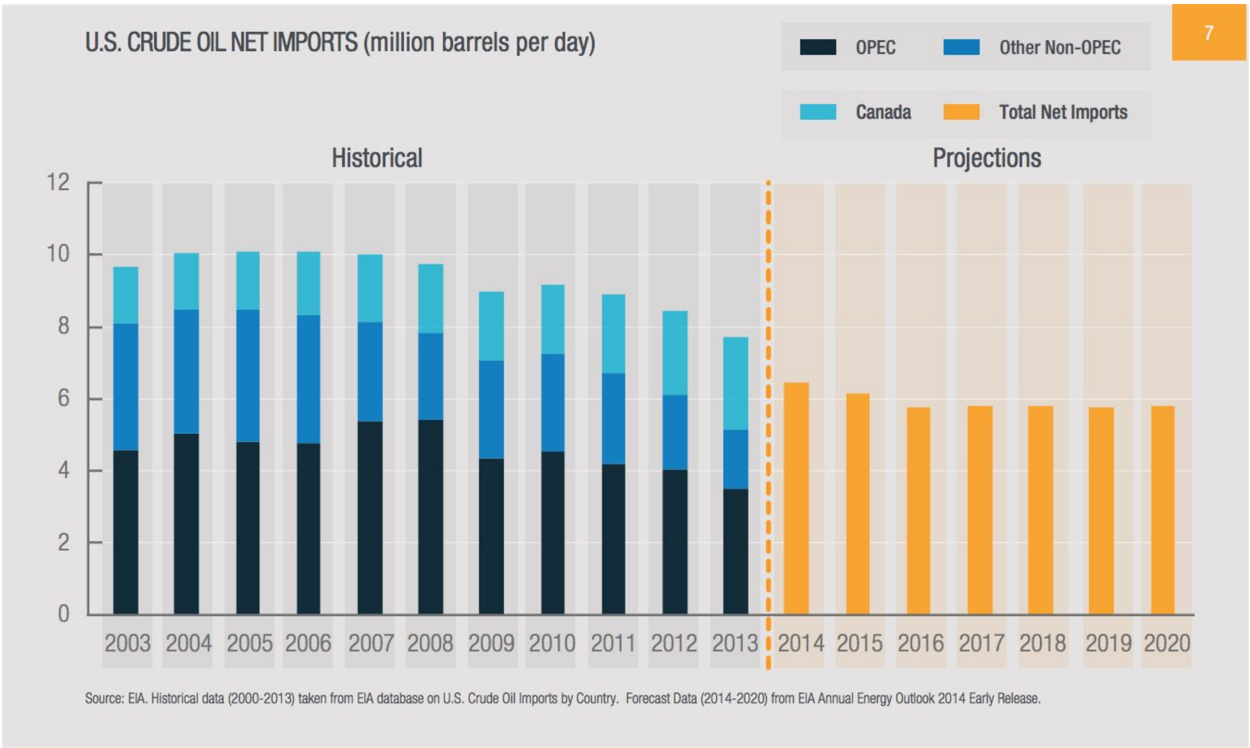
One of the major factors that has led to an increase of production of crude oil has been due to advancements in technology. Horizontal drilling and hydraulic fracturing techniques are just two examples that have made production more accessible and economically feasible. As we can see from the figure below, US shale and tight oil production in Eagle Ford, Bakken, and Permian rose from 0.4 million barrels per day in 2007 to more than 3.2 million barrels per day.

Figure 17: Shale and Tight Oil Production



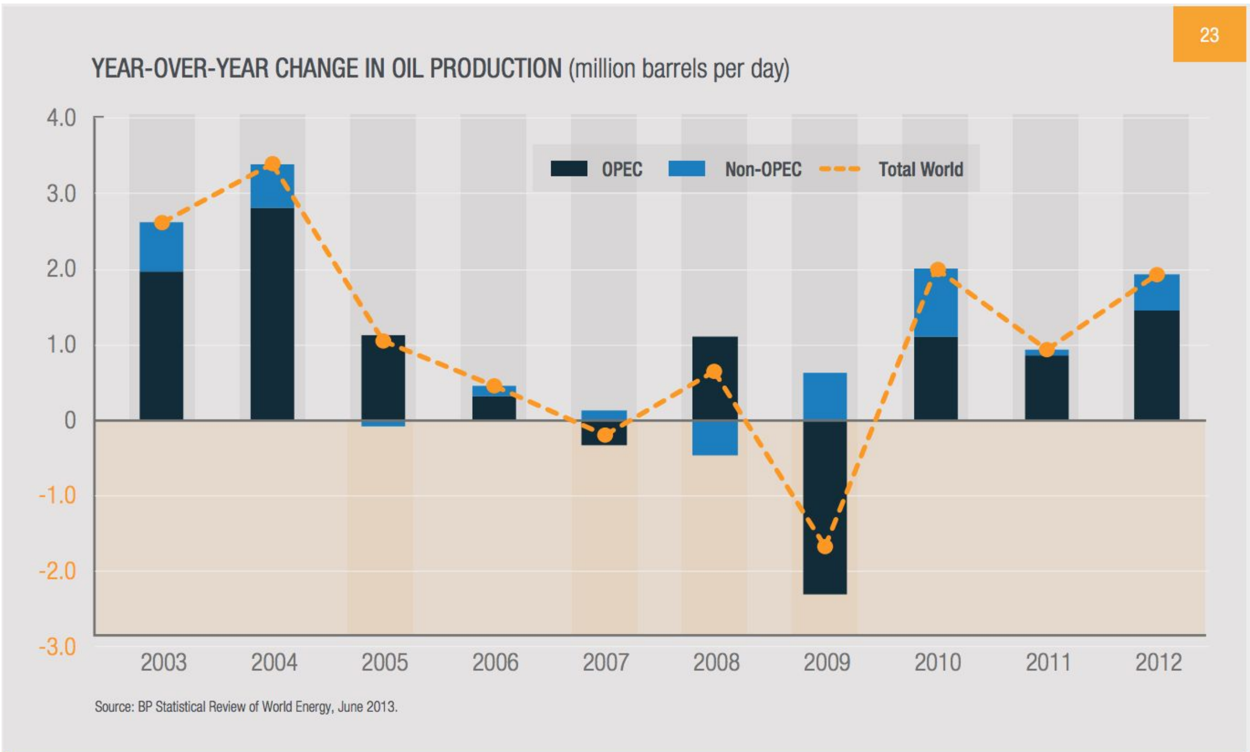
Increase in production of crude oil in North America has led to a decline in net imports from OPEC countries. From over 10 million barrels per day in 2007 to less than 8 million barrels per day in 2013, there has been a significant economic effect on OPEC and non-OPEC countries. The graph below shows that net imports are set to go down further with increasing production of crude oil in North America.

Figure 18: U.S. Crude Oil Net Imports



Another significant factor that plays into existence is the world economy. The 2008 financial crisis and economic recession had a deep impact on oil consumption in North America. At the same time, there was an increase in the production of crude oil in OPEC countries. This led to an overall decrease in prices per barrel. As OPEC made production cuts in 2009, demand in crude oil was still low as North America was recuperating from the recession. As the economy started to recover, oil demand was on the rise, with substantial growth in Asia, including China and India. Continued growth through 2010 played a key role in oil prices across the globe. While there has been an increase in demand for crude oil in the Asia-Pacific region, social and environmental factors in the Middle-East have disrupted crude oil production. The graph below talks about year over year change in oil production in major markets, including OPEC, and non-OPEC (North America).

Figure 19: Year over Year Change in Oil Production



Therefore, we can conclude that the major factors that play a role in the determination of price per barrel of crude oil include:

- Inventory Change
- Rig Count
- OPEC
- Gross Domestic Product (GDP)
- Social/Environmental Factors

For the purposes of our model, we have decided to analyze major indicators from 2006 through 2016 in order to capture trends before the economic recession in 2008 and the market recovery since.

The historical trends of the crude oil market will be an important piece of our project because although it is impossible to predict exactly what the future will hold, this will reveal how the market has reacted in the past. Being the world's most actively traded commodity, this rich information will provide us with insight on possible market reactions for the current market downturn.

We presented the indicators listed above to Teal for further discussion. We decided to finalize the following five indicators that play a critical role in the determination of price of crude oil per barrel:

- Inventory change
- Rig count
- OPEC policy
- World Gross Domestic Product (GDP)
- Social and environmental factors

3.1.2. Determining Scales

Since we are unable to predict economic changes moving forward, we are using a sliding scale to provide a metric for world economy. On a scale of one through five, the individual using our tool will be able to put in a value for the extremity and direction in which the indicator is affecting the market. Using a value of negative five, the individual would be telling the model that in the current global economic state, they feel as though the market for oil will strongly increase due to no activity that would trigger down the price of oil. Conversely, using a value of positive five, the individual would be telling the model that in the current global economic state they feel as though the market for oil will strongly decrease due to a lot of global activity playing an effect on the price of oil. A value of zero would be neutral whereas two and four would indicate somewhat of a increase, or somewhat of an decrease, respectively.

Table 1: Indicator Scale Rubric

Rubric for OPEC and Social/Environmental Factors	Activity
-5	Positive Significant activity or policy decision to trigger the price per barrel of oil up in the range of $30 and upwards
-4	Some significant activity that can have a direct impact to raise the price in the range of $20-30
-3	Little activity that can have an impact on the price in the range of +$15-20
-2	Little activity that can have an impact on the price in the range of +$10-15
-1	Little activity that can have an impact on the price in the range of +$5-10
0	Neutral
1	Little activity that can have an impact on the price in the range of -$5-10
2	Little activity that can have an impact on

	the price in the range of -$10-15
3	Little activity that can have an impact on the price in the range of -$15-20
4	Some significant activity that can have a direct impact to lower the price in the range of $20-30
5	Significant negative activity to trigger the price per barrel of oil down in the range of $30 and upwards

The table above is a rubric that can provide an estimate when selecting a scale for calculating the price per barrel of oil. An example of using -5 in our calculations would be positive OPEC policies being implemented and a peaceful social environment. Similarly, we can use the other values on the scale depending on pertinent activities happening that can trigger the price per barrel of oil. The table above is meant to be used as a reference purposes only.

Table 2: Indicator Scale

-5	Worst	Drives value up
0	Neutral	No change
5	Best	Drives value down

3.1.3. Developing Dataset

In order to build a data set, we setup a spreadsheet to include the six chosen indicators and their corresponding data values for the past ten years. These ten years were then broken down quarterly, and time trend values were assigned 1-40 to represent each quarter over the ten year time period. The data for actual oil price (dollars per barrel), inventory change (million barrels per day), and international rig count were gathered using Baker Hughes. This source was chosen because it is an American industrial services company, and a world-leading oil field services company, which provides extensive data regarding the oil industry in over 90 countries. Once found on their website, the data for these three indicators was added to the spreadsheet for all 40 time trend values.

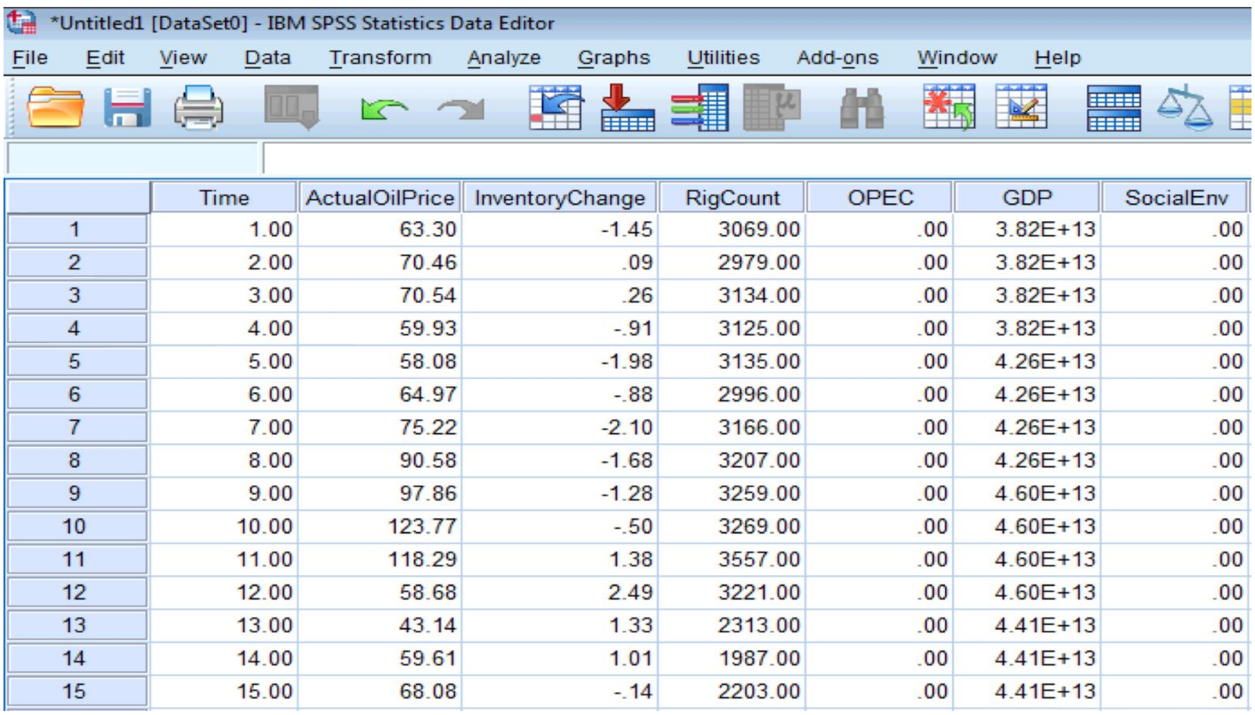
We determined the OPEC and social and environmental indicator values were determined using research into the relevant areas, and consulting from Teal employees. It was determined that OPEC did not have a significant effect on the price of oil until the third quarter of 2014. Social and environmental factors were found to not have a significant impact on the price of oil until the first quarter of 2011.

Lastly, we agreed with Teal employees that determining the major players in the world economy would be an accurate representation for the world GDP, since there was no aggregate GDP for the entire world found. To accomplish this, we combined the GDP’s of the United States, European Union, China, Japan, Russia, and India to give us the world GDP for all 40 time trend values.

3.2. Building the Model

We used IBM's SPSS software to build this model. We chose this software because it performs many different types of regression analysis and other statistical functions. The first step in building the model was to open SPSS and paste our data into a new file.

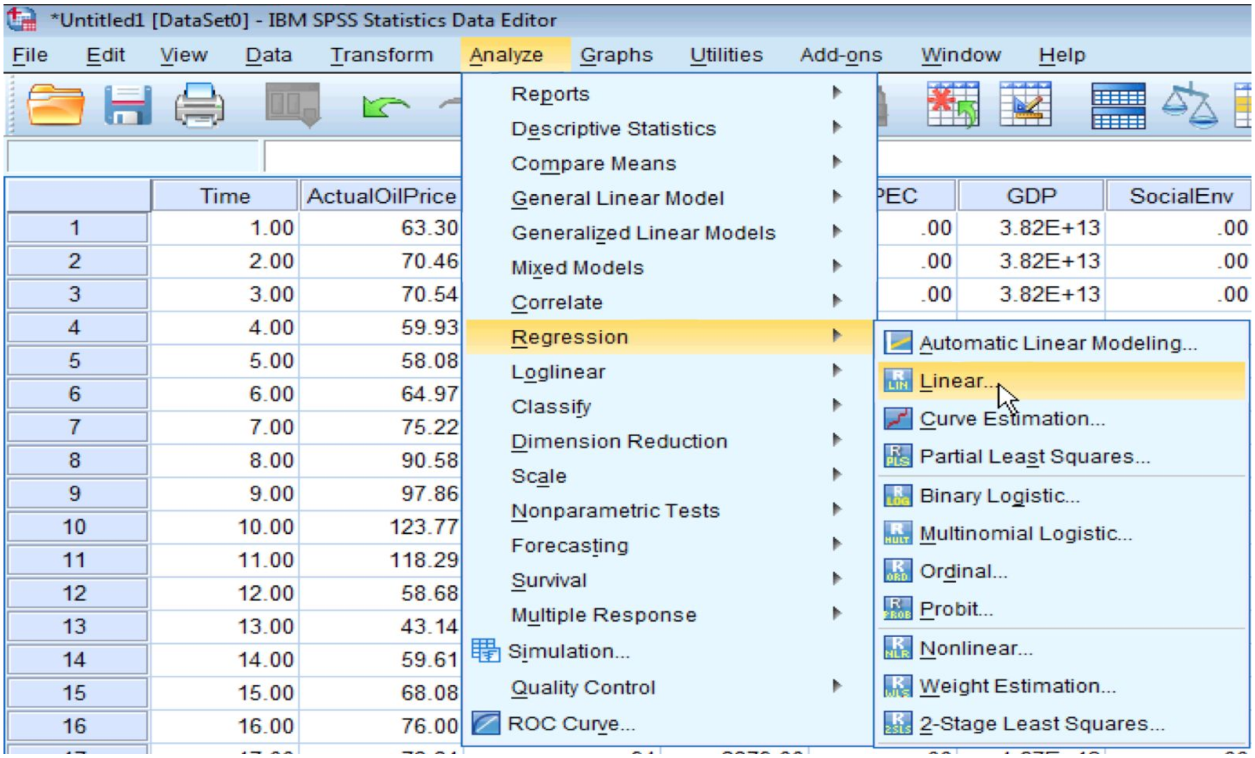
Figure 20: First Step to Model Building



	Time	ActualOilPrice	InventoryChange	RigCount	OPEC	GDP	SocialEnv
1	1.00	63.30	-1.45	3069.00	.00	3.82E+13	.00
2	2.00	70.46	.09	2979.00	.00	3.82E+13	.00
3	3.00	70.54	.26	3134.00	.00	3.82E+13	.00
4	4.00	59.93	-.91	3125.00	.00	3.82E+13	.00
5	5.00	58.08	-1.98	3135.00	.00	4.26E+13	.00
6	6.00	64.97	-.88	2996.00	.00	4.26E+13	.00
7	7.00	75.22	-2.10	3166.00	.00	4.26E+13	.00
8	8.00	90.58	-1.68	3207.00	.00	4.26E+13	.00
9	9.00	97.86	-1.28	3259.00	.00	4.60E+13	.00
10	10.00	123.77	-.50	3269.00	.00	4.60E+13	.00
11	11.00	118.29	1.38	3557.00	.00	4.60E+13	.00
12	12.00	58.68	2.49	3221.00	.00	4.60E+13	.00
13	13.00	43.14	1.33	2313.00	.00	4.41E+13	.00
14	14.00	59.61	1.01	1987.00	.00	4.41E+13	.00
15	15.00	68.08	-.14	2203.00	.00	4.41E+13	.00

Then, under the "Analyze" tab, we selected the linear regression option. This is because the data which we have gathered will be linear in nature, due to the fact that we have only gone back ten years in data.

Figure 21: Second Step to Model Building

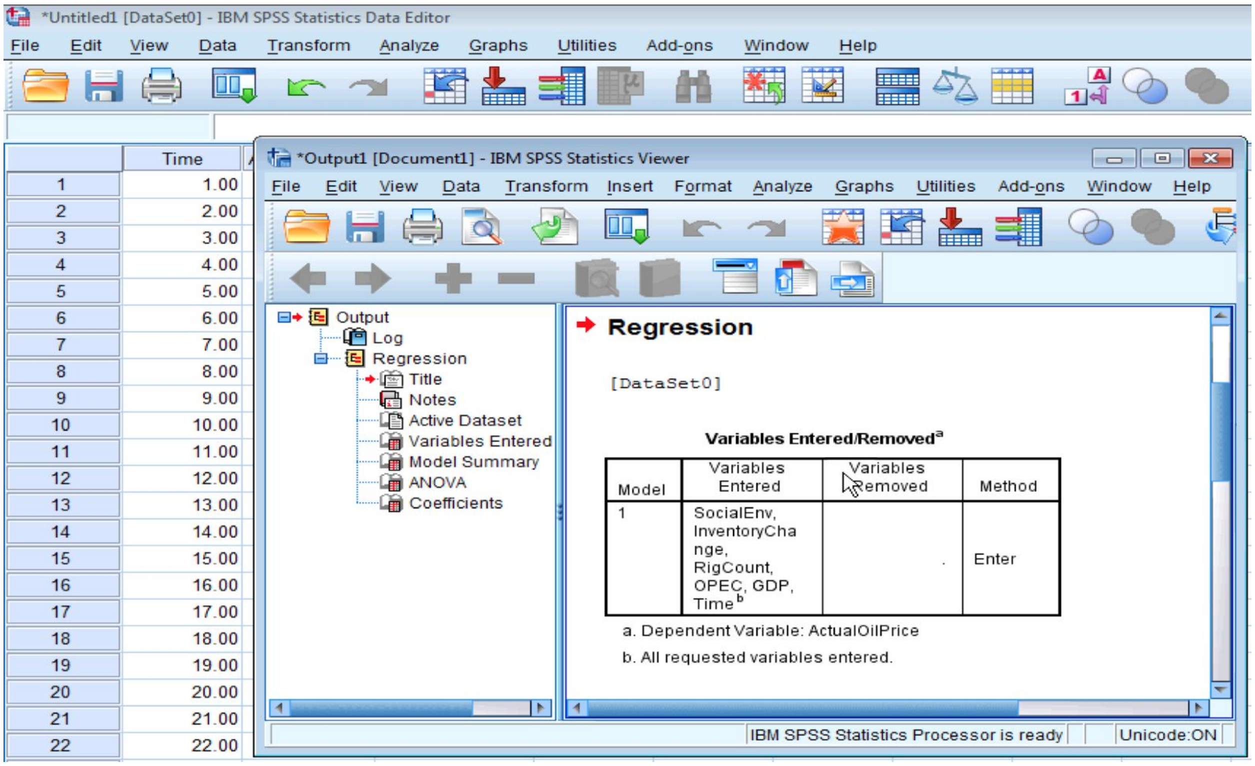


Next, the actual oil price was set as the dependent variable, with all other values as the independent variables. This is because we are determining the indicators which drive changes in the price of oil. As each of these variables increase or decrease independently, the price of oil therefore changes based upon these.

This then provides the output which displays our linear regression analysis, including many different sources of information.

We will be specifically focusing on the “Coefficients” section, which provides beta and statistical significance values, which are most important for our model.

Figure 22: Third Step to Model Building



4. Results

4.1. Analyzing the Model Output

The most important aspect of our regression output is the beta values. These values will serve as the coefficients for each indicator in our final model equation, representing the importance and weight of each indicator on determining the price of crude oil. The higher the beta value, the heavier the impact will be on the price, and vice versa for lower beta values. Given our results (dataset attached in Appendix), the final model equation is:

Oil Price=

-147.642-0.816*(Quarter)-0.918*(Inventory)+0.019*(Rigs)+2.846*(OPEC)+4.041x10^(-12)*(GDP)-11.018*(Social/Environmental Factors).

The equation above helps us explain the relationship between a dependent variable, price of oil per barrel, and multiple independent variables:

Ypredicted = b0 + b1*x1 + b2*x2 + b3*x3 + b4*x4

The independent variables are on the right side of the equation. Through linear regression, we are able to identify the strength of the effect of independent variables on the dependent variable. Regression analysis can be divided into three stages. The first stage is to establish a correlation by interpreting the results. The second stage is to forecast an effect based on the coefficients generated. The third and final stage is to evaluate the validity and usefulness of the model.

Table 3: ANOVA Output

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11568.502	6	1928.084	13.201	.000[a]
	Residual	4819.812	33	146.055		
	Total	16388.314	39			

a. Predictors: (Constant), SocialEnv, InventoryChange, RigCount, OPEC, GDP, Time
b. Dependent Variable: ActualOilPrice

The SPSS allows us to specify multiple models in a single regression run. The ANOVA summary tells us whether our model is significant with an 85% confidence interval. The table above shows that the p-value of 0.000 is less than 0.15, hence we can validate that our data is statistically significant. Furthermore, it also tells us the number of models being reported. The total variance of 16388.314 is split into variance that can be explained by the independent variables and the variance that cannot be explained by the independent variables. From the table above, we can see that a variance of 11568.502 (70.5%) can be explained by independent variables whereas a variance of 4819.812 (29.4%) cannot be explained by independent variables and hence accounted as error. The df column mentions the degrees of freedom associated with the sources of variance. The Regression degrees of freedom corresponds to the number of estimated coefficients minus 1. Therefore, including the intercept, there are 6 coefficients, so the model has N-1= 5 degrees of freedom. For the Residual degrees of freedom, there are 34 observations, so the model has N-1=33 degrees of freedom. In total, there are 40 observations, so the model has N-1= 39 degrees of freedom.

Table 4: Coefficients Output

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-147.642	58.733		-2.514	.017
	Time	-.816	.865	-.465	-.943	.353
	InventoryChange	-.918	2.116	-.053	-.434	.667
	RigCount	.019	.007	.457	2.882	.007
	OPEC	2.846	1.704	.251	1.670	.104
	GDP	4.041E-12	.000	1.028	2.323	.026
	SocialEnv	-11.308	9.410	-.279	-1.202	.238

a. Dependent Variable: ActualOilPrice

The model generates beta weights that analyze relative importance of independent variables. The beta values are standardized coefficients we would obtain if we standardized all the coefficients and ran the regression. The values are really useful for correlation analysis as it puts all the independent variables on the same scale. This allows us to compare the magnitude of each coefficient and determine which one has more effect on the dependent variable. From the table above, the following correlation can be established amongst the independent variables and can be written in the following order: OPEC>Rig Count>GDP>Inventory Change>Social Environmental Factors. For a 85% confidence interval, the independent variable is significant if its p-value is less than 0.15. Therefore, using sensitivity analysis[29], for a 85% confidence interval, we can conclude the following:

29 Sensitivity analysis is defined as a process to determine how different values of an independent variable would impact the dependent variable.

- Inventory Change (-0.918): The coefficient for inventory change is not significantly different from 0 because its p-value of 0.667 is greater than 0.15.
- Rig Count (0.019): The coefficient for rig count is statistically significant because its p-value of 0.007 is less than 0.15.
- OPEC (2.846): The coefficient for OPEC is statistically significant because its p-value of 0.104 is greater than 0.15.
- GDP (4.041e-12): The coefficient for GDP is statistically significant because its p-value of 0.026 is less than 0.15.
- Social/Environmental Factors (-11.308): The coefficient for Social/Environmental factors is not statistically different from 0 because its p-value of 0.238 is greater than 0.15.

Table 5: Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.840[a]	.706	.652	12.08532

a. Predictors: (Constant), SocialEnv, InventoryChange, RigCount, OPEC, GDP, Time

The R value mathematically explains the correlation between the observed and predicted values of the dependent variable. An R-value of 0.706 represents a strong linear relationship between the observed and predicted values of price of oil per barrel. The adjusted R-squared value estimates a value in case of addition of independent variables to the model that do not exhibit a strong correlation between the dependent and independent variables. An adjusted R-squared value of 0.652 represents a strong correlation between the price of oil per barrel and OPEC, Rig Count, GDP, Inventory Change, Social/Environmental Factors regardless of the addition of a few predictors to the model. The Standard Error of the Estimate is also known as the root mean squared error. The root mean squared error helps us assess the fit of the regression model and is the absolute measure of fit of the model. Therefore, a value of 12.08532 indicates a good fit if the model is used for prediction.

Based on the calculations above, we have identified OPEC and Rig Count as the two most significant variables that influence the price of oil per barrel. Using SPSS, we reran the model with Rig Count and OPEC as the two independent variables and Price of Oil as the dependent variable. Based on the updated parameters, we can write the equation for price of oil per barrel based on statistically significant indicators:

Oil Price= -6.431-0.550*(Quarter)+0.026*(Rigs)+4.327*(OPEC)

Table 6: Updated Coefficients Output

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-6.431	14.114		-.456	.651
	Time	.550	.232	.314	2.373	.023
	RigCount	.026	.005	.617	5.534	.000
	OPEC	4.327	1.609	.382	2.689	.011

a. Dependent Variable: ActualOilPrice

Using the same process from earlier in this section, we can obtain standardized coefficients to update our simplified equation from the coefficients table above. There are several insightful trends which can be concluded from the output from SPSS, however it is important to note that these indications are not causal. These relationships instead reveal how one variable tends to change as another changes during corresponding time periods. This updated equation, including two independent variables, verifies Teal's initial hypothesis that there would only be about two crucial variables which affected the final price of oil.

4.2. Making Sense of the Model Output

From the coefficient values given in our model, we can conclude several relationships. Time, rig count, and OPEC policy are all positive associated with the price of oil. This means that as time passes, or increases, the price of oil rises on average $0.55 per quarter, which was the time period used for this model. As each additional rig is built, therefore increasing the overall rig count, the price of oil rises by a factor of $0.026 per rig. In terms of OPEC policy, as the model value for this indicator increases, that would mean that the overall OPEC policy is bettering, or thriving. This positive relationship increases the price of oil by $4.327 as the OPEC policy values increase. Conversely, a decrease in any of these values would correlate to a decrease in the price of oil.

Figure 23: Time vs. Rig Count and OPEC

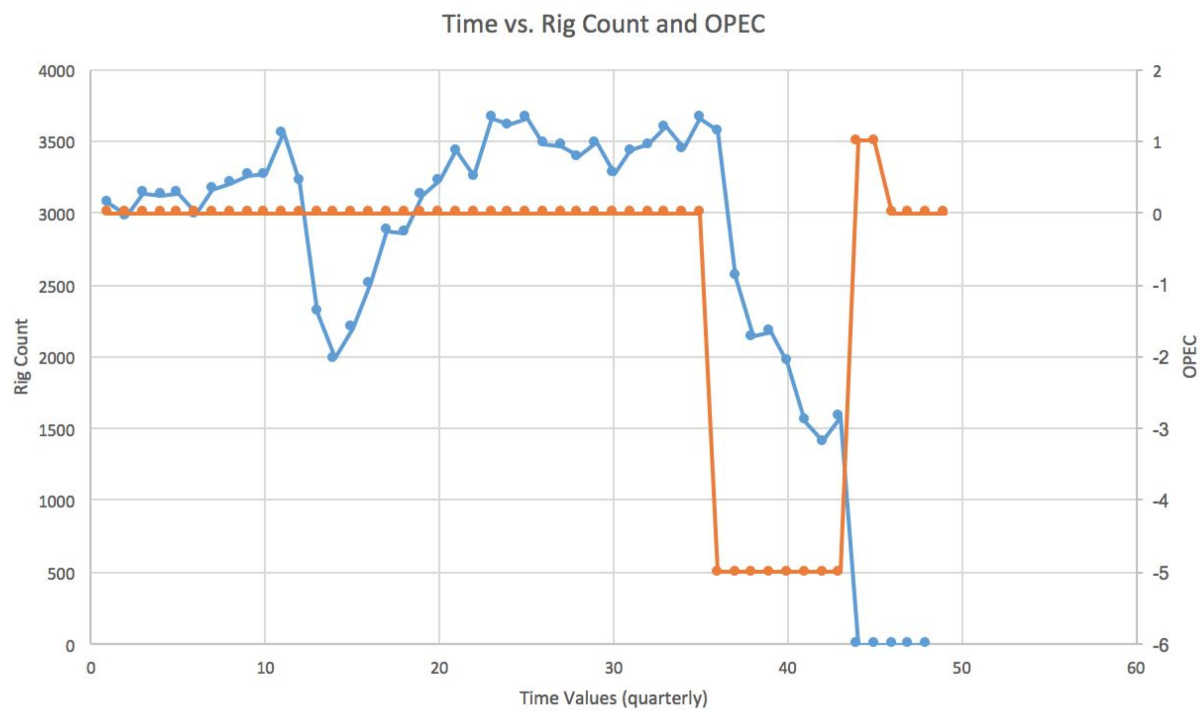


Figure 23 below is a graphical representation of time vs Rig Count and OPEC. As we can see from the graph below, there are a few downward peaks between quarter 35 and 45. This is during January of 2016 when oil prices fell to a 10 year low of around $30/barrel.

4.3. Scenario Analysis

Scenario analysis is defined as a process of analyzing future possible events by considering alternative outcomes. For the purposes of our model, we will calculate three alternative outcomes using the established scales of -5, 0, +5.

Table 7: Scenario Analysis Table

Corresponding Value on Scale	Price of Oil Per Barrel	Scenario
OPEC: -5, Social/Environmental Factors: -5, Quarter: 44, Inventory Change: -1.23, Rigs: 1584, GDP: 52565720000000	-147.642-0.816*(44)-0.918*(-1.23)+0.019*(1584)+2.846*(-5)+4.041x10^(-12)*(52565720000000)-11.018*(-5)= **$100.957**	Best
OPEC: 0, Social/Environmental Factors: 0, Quarter: 44, Inventory Change: -1.23, Rigs: 1584, GDP: 52565720000000	-147.642-0.816*(44)-0.918*(-1.23)+0.019*(1584)+2.846*(0)+4.041x10^(-12)*(52565720000000)-11.018*(0)= **$60.097**	Neutral
OPEC: +5, Social/Environmental Factors: +5, Quarter: 44, Inventory Change: -1.23, Rigs: 1584, GDP: 52565720000000	-147.642-0.816*(44)-0.918*(-1.23)+0.019*(1584)+2.846*(+5)+4.041x10^(-12)*(52565720000000)-11.018*(+5)= **$19.237**	Worst

Scenario One (OPEC: -5, Social/Environmental Factors: -5, Quarter: 44, Inventory Change: -1.23, Rigs: 1584, GDP: 52565720000000):

Price of Oil Per Barrel=

-147.642-0.816*(44)-0.918*(-1.23)+0.019*(1584)+2.846*(-5)+4.041x10^(-12)*(52565720000000)-11.018*(-5)

= $100.957

Scenario One considers the best case scenario for OPEC and Social/Environmental Factors. A value of negative five indicates no global activity or a drastic OPEC policy that would trigger a change in the price of oil per barrel. As we can see from the calculation above, having a value of -5 for OPEC and Social/Environmental Factors drives up the value of price of oil per barrel.

Scenario Two (OPEC: 0, Social/Environmental Factors: 0, Quarter: 44, Inventory Change: -1.23, Rigs: 1584, GDP: 52565720000000):

Price of Oil Per Barrel=

-147.642-0.816*(44)-0.918*(-1.23)+0.019*(1584)+2.846*(0)+4.041x10^(-12)*(52565720000000)-11.018*(0)

=$60.097

Scenario Two considers the neutral case scenario for OPEC and Social/Environmental Factors. A value of zero indicates no significant global activity or an OPEC policy that would trigger a change in the price of oil per barrel from its previous point. As we can see from the calculation above, having a value of 0 for OPEC and Social/Environmental Factors has no effect on the value of price of oil per barrel.

Scenario Three (OPEC: +5, Social/Environmental Factors: +5, Quarter: 44, Inventory Change: -1.23, Rigs: 1584, GDP: 52565720000000):

Price of Oil Per Barrel=

-147.642-0.816*(44)-0.918*(-1.23)+0.019*(1584)+2.846*(+5)+4.041x10^(-12)*(52565720000000)-11.018*(+5)

=$19.237

Scenario Three considers the worst case scenario for OPEC and Social/Environmental Factors. A value of positive five indicates heavy global activity or a drastic OPEC policy that would have a direct impact on the price of oil per barrel. As we can see from the calculation above, having a value of positive five for OPEC and Social/Environmental Factors has significant effect on the value of price of oil per barrel.

4.4. Limitations of the Study

An important point of discussion when looking at these results from the model lies in the effects of constraints. A root cause of constraints throughout this project came from subjectivity. As we worked to create this model we did not go to a third party for certain indicators such as OPEC data points. In this case, we worked together with Teal in order to come up with a set of parameters that everyone felt made sense in fitting the project objectives. The sliding scale that was decided upon provided a means of showing whether, for instance, OPEC had a strong negative, positive, or neutral effect on the price of oil in that particular quarter over the years of our data. Of course, working with a party directly involved in this project can bias the results and therefore it is important to note that had a third party been involved in setting these parameters instead, the outputs could have been different.

Additionally, in the instance of scaling where we used subjective measures it is evident that if a larger or smaller scale had been used, the results would have been affected. This is because scaling up a variable in a linear model directly scales up the corresponding coefficient as well. As you dive further into looking at the results from the data, one can know whether a result was highly significant or not based on the coefficient. A smaller significance value means that there is a smaller chance that the result happened by chance and therefore would likely have an important effect on the output.

Due to the size and scope of this project, a number of factors could have changed in order to affect our data and these constraints cannot be ignored. For one, the subjectivity mentioned earlier played a role in the outputs we obtained. Additionally, working with a larger data set or different parameters would also have affected our results. For the purposes of our model we worked with a timeframe of ten years, however, working with a data set of say fifty years would have had a more precise result. Furthermore, there were several economic, environmental, social, political, ethical, health and safety, manufacturability, and/or sustainability constraints that we've talked about throughout the paper.

4.5. Applying External Driving Factors

Using information calculated in Section 4.2, we can see that a pertinent activity can have a direct impact on the price of oil per barrel. This is evident in the fact that the price of oil was lowered by approximately $4/barrel in May of 2016 due to widespread and disastrous wildfire in Alberta, Canada. On the other hand, the price of oil per barrel has increased by approximately $24/barrel from February of 2016 to its present value of $51.6/barrel. This is indicative of the fact that it is one of the most promising oil producing regions in the US and is predicted to produce almost 5 million barrels per day in the near future. Due to the results we found in our model for the price per barrel of oil and the understanding we have developed of the regions Fort McMurray and Permian Basin, we believe that Fort McMurray does not provide a great location for Teal to look into further. They are already a highly developed region with many accommodations for housing available, and Teal tends to thrive in remote settings. Permian Basin appears to be a safer choice for acquisitions and moving forward.

5. Discussions and Future Studies

5.1. Assessing the Model

From our model and the results obtained we were able to achieve our project goal to be able to say it is apparent OPEC and rig count tend to have a very strong effect on the price of oil, whereas for indicators such as social/ environmental factors and inventory, we cannot verify there is much of an effect at all. However, we must also note that the model has strengths and weaknesses associated with this analysis. On the positive side, this is a model that can be very easily customized to fit new data and be altered for scenario analyses and further review. To this end, it is a very useful tool for Teal moving forward given that the oil market is not static and therefore constantly changes to reflect what is going on in the world. The values that are being plugged into the model can consistently be updated to represent the current trends in the market and the new timeframe being considered as more recent data becomes available. However, one must also note the constraints which provided limitations in our project, discussed in Section 4.3, as weaknesses to be inferred from the model. The level of subjectivity and the size of the data set used are unavoidable downfalls to consider.

Additionally, several Industrial Engineering concepts played a significant role in the analysis of our model output:

- Regression Analysis
- Scenario Analysis
- Constraint Analysis
- Sensitivity Analysis

Linear Regression was the basis of designing model building process. Engineering design is defined as the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which engineering sciences as well as basic science and mathematics are applied to develop a solution to a problem that meets stated objectives.

Using SPSS, we were able to estimate the relationship between the independent variables and its dependence on the price of oil per barrel (dependent variable). As we have talked earlier, we determined standardized coefficients for each of the independent variables and its significance. Constraints due to subjectivity, size of data, and scaling played an affect on our results as stated previously. Further, through sensitivity analysis, we were able to determine how each independent variable impacts the price of oil per barrel with an 85% confidence level. Each independent variable increases or decreases by a factor of its standardized coefficient for any change in value.

5.2. Value Provided to Teal

The true value which this project provides to Teal is providing a reiteratively modifiable model, which can take in new inputs as markets and economies change over time; with this, updated coefficient values and oil prices could be outputted. It is important to note that although predicting a numerical value for the price of oil in the future is a main component and goal of the model, the decision-making process that goes into determining the price of oil is also crucial. This includes many different pieces to the process, including how to determine the most important indicators, how to build the actual model, and how to interpret the output of the model. Through the following, we were able to integrate systems, one of the integral components of designing the system. We used the fundamental elements of the design process by establishing objectives and evaluation criteria, synthesis, analysis, construction, testing, and evaluation. Later on, we will be talking about the constraints that the project encountered.

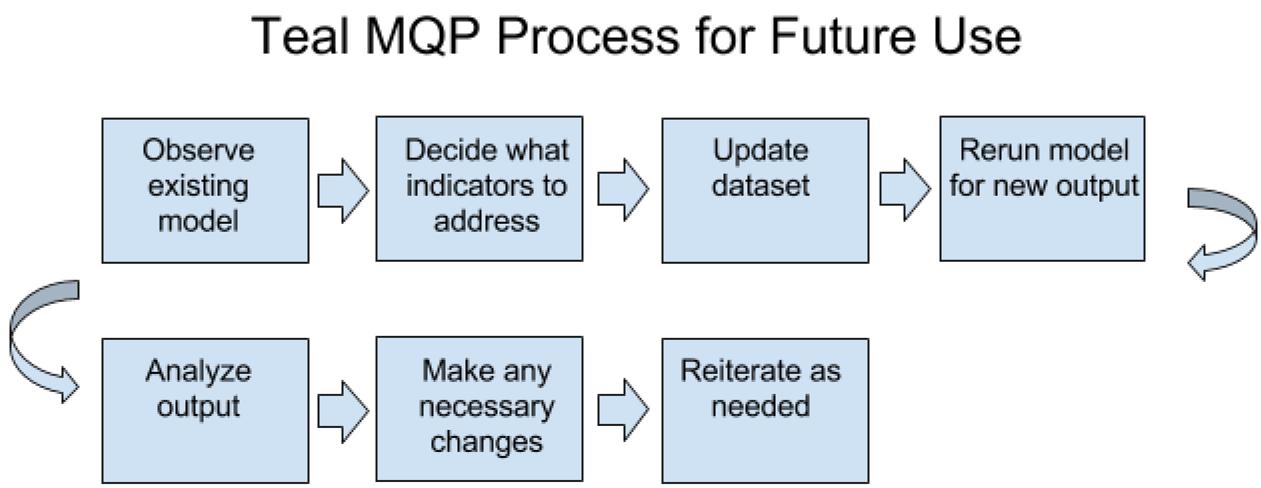
The value-added to Teal’s business by this process management is the piece of the project that will be most directly influential and beneficial. From these findings, Teal can make several strategic decisions, such as what indicators to look at during any given time period which could make significant changes to the price of oil, how volatile the market is at any given time, where the market is projected to go, and whether or not to make acquisitions of other companies in certain areas.

5.3. Future Use of the Model

As this project provides a model that can be manipulated and used for any set of data values, there is much value to in the future use of the model. In order to use the model in the future, Teal must first determine what aspect of the model is changing. If inventory levels are changing dramatically throughout the world and are expected to disrupt the price of oil, then this data must be updated. However, most of the time, each indicator used in the model will need to be updated to accurately reflect the price of oil. The updated data can be found from the previously used sources, with which this project's dataset was built.

First, the data must be copied and pasted into the spreadsheet used, which is organized by time trend values and indicators in each column. Once this dataset is complete, SPSS can be opened, and the process to build the model can be reiterated as found in section 3.3. The resulting output can then be analyzed as in section 4.1. This process can be seen in the below flowchart:

Figure 24: Future Use Flowchart



5.3.1. Prioritization of Future Use

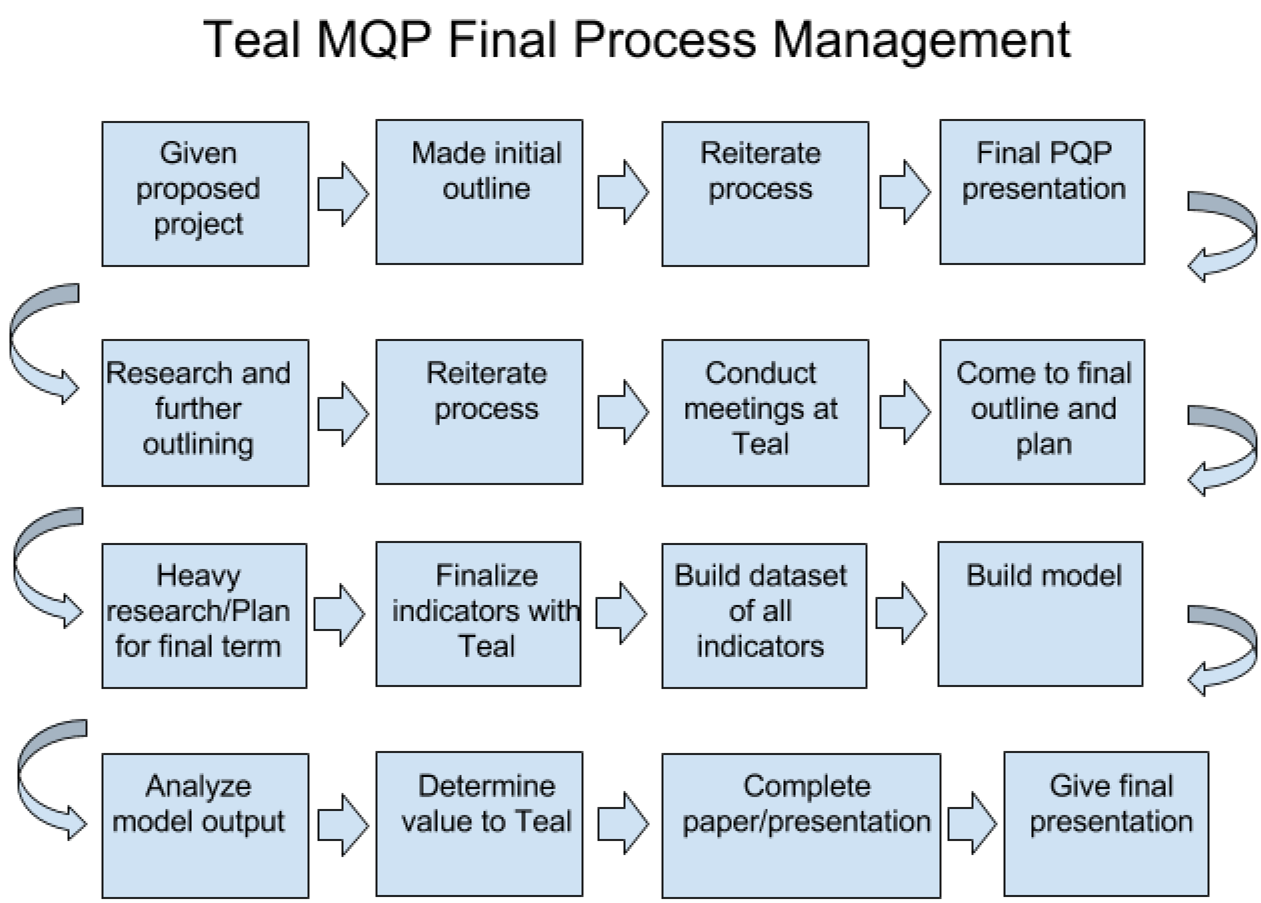
In terms of specific next steps, we suggest that Teal begins by developing an understanding of how to use the SPSS software, and how to build and implement the dataset. Once they are able to input the dataset, run the model, and achieve a correct output, they can move on to further validating the model our team has developed. We suggest this is done in order to further prove if this model is both relevant and helpful to the company. This can be done through several ways, such as checking the model against the most recent news and updated oil prices.

After validating if the model is significant and provides useful insight for the price of oil, Teal should move on to the aforementioned process of updating the model as they believe is fit in the market. With these updates to the model complete, the necessary tables and values will be available for the company to analyze. This insight will allow them to make strategic business decisions, such as mergers and acquisitions to grow the company. Beyond this, Teal can apply the external driving factors to these analyses in order to make further business decisions geographically. Bringing all of this work together, our team believes there is immense value to be provided for future use.

5.4. Final Process Management

Throughout its completion, the Teal MQP went through many different steps and iterations, all of which can be seen in the flowchart below:

Figure 25: Final Process Management Flowchart



This final process began when we were given the initial groundwork of the project in spring of 2016. This was a high level overview of the solution we were to work towards, which included analyzing the future of the oil market, and how to identify possible mergers and acquisitions for Teal. With this, we made an initial outline of how we interpreted the problem. Through occasional meetings during the next seven weeks, we reiterated our initial outlining and came to the end of the term with a final PQP presentation. This included background of Teal's business and what they do, the current state of the oil market, how this is problematic for Teal, how data will be used for future projections, and how to use acquisitions to create opportunity.

This presentation was a good jump start at developing our project's process, but it needed much iterating and further research in order to continue and execute the project. This began in the next term, as we began researching into statistical methods, modeling, and how to approach the oil market. We began the decision-making on which indicators within the oil market would be useful. Initially, we thought this would include things like car production, industrial production, construction spending, etc.; however, we narrowed down and changed this list as we continued to perform research and meetings. It was found that we would need to perform regression analysis to bring these indicators together into one single equation, in order to determine how each of them affect the price of oil. This is also when we learned that it would be important to also look at the cultural and political aspects of different areas, which would be sure to affect the price of oil. In doing these things, it was crucial that we went to Teal's offices and conducted meetings. This allowed us to bring them the work that we had thus far, get their feedback, and figure out where we should be focusing our efforts, therefore bringing us closer to our final outline and plan.

Coming into the final seven weeks of the project, we went straight into in-depth research into statistical regression equations and finalizing the indicators which would be used in this equation. After finalizing these indicators through further meetings, an entire afternoon was set aside at Teal's offices to begin building the resulting dataset, which the process can be found for in section 3.2. Once this was completed, we moved on to building the model, which process can be found for in section 3.3. After several iterations and tests of different types of regression, we found that linear modeling was the best solution for our dataset. We then analyzed the output and came to our final equation for the price of oil, given ten years of data.

Given this model and all of its output, along with further analyses such as the application of cultural and political factors, the value to Teal's business model had to be determined. This was the final part of the overall process, and can be found in section 5.2. Once this was completed, the paper and final presentation were finalized, making us ready for our final presentation.

After completing our project, we learned several things regarding our overall process. Although we were aware that structuring business problems takes time before one can be able to begin developing a solution, we were not expecting how substantial this time and effort would be. It took over seven weeks to take the initial proposed project, begin to outline it, recursively update it through meetings with Teal and our advisors, and come to a final project structure. Despite the lengthy efforts, this was extremely important to learn how to get right, and will be essential in any problem structuring in the future. This ideology could be applied to most parts of our final process management, as we learned that each piece must be fully analyzed and completed before moving on. Many times we were urgent to move forward with the process before we were absolutely finished, but we learned to break this process down into steps to achieve the most effective and efficient result. In terms of the overall structure, we believe that our process was still effective and built very well. We were able to accomplish a great deal of analysis, given our limited amount of time for such a massive operation.

5.5. Lifelong Learning

There are several things which we learned from this project which are applicable to our lifelong learning in business, engineering, and everyday life. This begins with the time it took to structure the problem we were given. We learned that this takes extensive time and resources, and is crucial to be complete before moving on in the development of the solution. It also requires constant communication between all disciplines involved in the project. In the real world, it will be very important to achieve this when working with various functions of any company and the third parties involved. This will involve working with many diverse backgrounds of people, as we have learned as well.

Furthermore, we have learned how to take concepts from class and apply them to real world applications. We have taken concepts such as regression analysis, forecasting, process management, scenario analysis, and building a decision-making model and used them together to provide value to a real company.

One of the most essential aspects of completing a business solution is effective teamwork. This stems from many things such as strong communication, constant idea generation and acceptance, and giving constructive feedback. After getting to know each other on both personal and strengths-and-weaknesses levels, we were able to come together as a team very early. Throughout the entire process, we managed to work effectively together, smooth out minor differences, bring in diverse sets of skills and strengths, and communicate on a very regular basis, all of which made our final project possible.

Bibliography

(2015, April 07). Materialized Dreams: Boom and Bust in the Cultural Landscape of West Texas - Edge Effects. Retrieved September 30, 2016, from http://edgeeffects.net/texas-boom-and-bust/

By extrapolating our models beyond the period over which they were estimated, we can make forecasts about near future events. This section shows how the single-equation regression model can be used as a forecasting tool. (1994). Time Series Analysis for Business Forecasting. Retrieved September 30, 2016, from http://home.ubalt.edu/ntsbarsh/stat-data/forecast.htm#rhowmulregan

Crude oil 1946-2016 Data. (n.d.). Retrieved October 01, 2016, from http://www.tradingeconomics.com/commodity/crude-oil

Crude Oil (petroleum); Dubai Fateh Monthly Price - US Dollars per Barrel. (n.d.). Retrieved September 30, 2016, from http://www.indexmundi.com/commodities/?commodity=crude-oil-dubai

Curry, B. (2016, May 17). Fort McMurray's economic hit likely to be offset by rebuilding, analysts suggest. Retrieved September 30, 2016, from http://www.theglobeandmail.com/news/politics/fort-mcmurrays-economic-hit-likely-to-be-offset-by-rebuilding-analysts-suggest/article30057847/

Fort McMurray. (n.d.). Retrieved September 30, 2016, from https://www.britannica.com

Fritz, A. (n.d.). Fort McMurray wildfire evacuation was largest on record in Canada. Retrieved September 30, 2016, from https://www.washingtonpost.com/news/capital-weather-gang/wp/2016/05/04/hot-dry-and-windy-weather-stokes-the-violent-alberta-wildfire/

Gallucci, M. (2016). Saudi Uncertainty Rattles Oil Markets. Retrieved October 06, 2016, from http://www.ibtimes.com/oil-markets-rattled-saudi-arabia-casts-doubt-global-crude-production-freeze-deal-2346959

Gold, R. (2014, September 01). Permian Basin in Texas to Drive Down Oil Prices. Retrieved September 30, 2016, from http://www.wsj.com/articles/permian-basin-in-texas-to-drive-down-oil-prices-1409613682

Government spending 2006-2016 Data. (n.d.). Retrieved October 01, 2016, from http://www.tradingeconomics.com/commodity/government-spending

Guerin March 19, 2014 Web Exclusive Print Share Subscribe Donate Now, E. (2014, March 19). Permian Basin: America's newest fracking boom where there's not much water. Retrieved September 30, 2016, from http://www.hcn.org/blogs/goat/permian-basin-in-new-mexico-and-west-texas-americas-newest-fracking-boom

Helman, C. (2016, August 4). America's Saudi Arabia? Why Investors Are Still Hot On The Permian Basin. Retrieved September 30, 2016, from http://www.forbes.com/sites/christopherhelman/2016/08/04/americas-saudi-arabia-why-investors-are-still-hot-on-the-permian-basin/#14296c4567be

How to Forecast Demand Accuracy - 7 Methods. (n.d.). Retrieved October 29, 2016, from https://www.logility.com/library/white-papers/demand-planning-papers/media/7-methods-that-improve-forecasting-accuracy

Kilian, L. (2008, May). Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy? Retrieved December 07, 2016, from http://www.mitpressjournals.org/doi/pdf/10.1162/rest.90.2.216

Kurt, D. (2015, December 24). Understanding Benchmark Oils: Brent Blend, WTI and Dubai. Retrieved September 30, 2016, from http://www.investopedia.com/articles/investing/102314/understanding-benchmark-oils-brent-blend-wti-and-dubai.asp

Pannekoek, F., & James-Abra, E. (n.d.). Fort McMurray. Retrieved September 30, 2016, from http://www.thecanadianencyclopedia.ca/en/article/fort-mcmurray/

Permian Basin. (n.d.). Retrieved September 30, 2016, from https://www.britannica.com/place/Permian-Basin

Reed, S. (2016, January 4). Oil Market Settles Lower, Taking Iran-Saudi Dispute in Stride. Retrieved October 6, 2016, from http://www.nytimes.com/2016/01/05/business/energy-environment/oil-saudi-arabia-iran.html

The Oil Sands Story (1960s, 1970s & 1980s) - Suncor. (n.d.). Retrieved September 30, 2016, from http://www.suncor.com/about-us/history/the-oil-sands-story

U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (n.d.). Retrieved October 06, 2016, from https://www.eia.gov/finance/markets/supply-opec.cfm

U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (2014, October 28). Retrieved September 30, 2016, from http://www.eia.gov/todayinenergy/detail.php?id=18571

Watts, L. (2009, March). The Financial Crisis and its Impact on the Oil & Gas Industry. Retrieved October 1, 2016, from http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1234451048011/5827121-1239045090161/Watts_PFC.pdf

Wooldridge, J. M. (2014). *Introduction to econometrics*. Hampshire: Cengage Learning.

Appendix A: Data Set

	A	B	C	D	E	F	G	H
1	Time Period	Time Trend	Actual Oil Price ($/barrel)	Inventory Change (million barrels/day)	International Rig Count	OPEC	Combined GDP of Major Players (United States, Euro Area, China, Japan, Russia, India) in the Market ($)	Social/Env Factors (-1,0,1)
2	**Q1 2006**	1	63.3	-1.45	3069	0	38176578000000	0
3	Q2	2	70.46	0.09	2979	0	38176578000000	0
4	Q3	3	70.54	0.26	3134	0	38176578000000	0
5	Q4	4	59.93	-0.91	3125	0	38176578000000	0
6	**Q1 2007**	5	58.08	-1.98	3135	0	42581050000000	0
7	Q2	6	64.97	-0.88	2996	0	42581050000000	0
8	Q3	7	75.22	-2.1	3166	0	42581050000000	0
9	Q4	8	90.58	-1.68	3207	0	42581050000000	0
10	**Q1 2008**	9	97.86	-1.28	3259	0	46040260000000	0
11	Q2	10	123.77	-0.5	3269	0	46040260000000	0
12	Q3	11	118.29	1.38	3557	0	46040260000000	0
13	Q4	12	58.68	2.49	3221	0	46040260000000	0
14	**Q1 2009**	13	43.14	1.33	2313	0	44122170000000	0
15	Q2	14	59.61	1.01	1987	0	44122170000000	0
16	Q3	15	68.08	-0.14	2203	0	44122170000000	0
17	Q4	16	76	0.71	2509	0	44122170000000	0
18	**Q1 2010**	17	78.81	0.94	2879	0	46682260000000	0
19	Q2	18	77.82	0.41	2859	0	46682260000000	0
20	Q3	19	76.07	-0.92	3122	0	46682260000000	0
21	Q4	20	85.22	-0.95	3227	0	46682260000000	0
22	**Q1 2011**	21	94.07	-0.36	3434	0	51088260000000	1
23	Q2	22	102.02	-0.2	3257	0	51088260000000	1
24	Q3	23	89.49	-1.2	3662	0	51088260000000	1
25	Q4	24	94.09	-0.6	3612	0	51088260000000	1
26	**Q1 2012**	25	102.94	1.4	3663	0	51818680000000	1
27	Q2	26	93.29	0.55	3484	0	51818680000000	1
28	Q3	27	92.17	-0.85	3468	0	51818680000000	1
29	Q4	28	88.01	-0.9	3390	0	51818680000000	1
30	**Q1 2013**	29	94.33	-0.57	3488	0	53142800000000	1
31	Q2	30	94.05	0.12	3277	0	53142800000000	1
32	Q3	31	105.83	-0.49	3431	0	53142800000000	1
33	Q4	32	97.5	-0.87	3478	0	53142800000000	1
34	**Q1 2014**	33	98.68	0.3	3597	0	54885470000000	1
35	Q2	34	103.35	0.59	3445	0	54885470000000	1
36	Q3	35	97.87	0.35	3659	-5	54885470000000	1
37	Q4	36	73.21	1.85	3570	-5	54885470000000	1
38	**Q1 2015**	37	48.48	1.66	2557	-5	52565720000000	1
39	Q2	38	57.85	1.81	2136	-5	52565720000000	1
40	Q3	39	46.55	1.2	2171	-5	52565720000000	1
41	Q4	40	41.94	2.25	1969	-5	52565720000000	1
42	**Q1 2016**	41	33.35	1.35	1551	-5	-	1
43	Q2	42	45.46	0.22	1407	-5	-	1
44	Q3	43	44.85	0.22	1584	1	-	1
45	Q4	44	47.24	1.23	x	1	-	1
46	**Q1 2017**	45	47	0.73	x	x	x	x
47	Q2	46	48.03	0.94	x	x	x	x
48	Q3	47	51	-0.03	x	x	x	x
49	Q4	48	53.65	0.41	x	x	x	x