WTI & Brent: The Two Giants of the Crude Oil Market

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I pledge my honor that I have neither received nor provided any unauthorized assistance during the completion of this work. (12/6/2013)

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(12/6/2013)
Executive Summary

The underlying mechanisms of the oil market can be defined and affected by many factors including what classification of oil is being discussed, the volatility of the price spreads, environmental and geo-political issues, and the fluctuations of futures prices. Oil as a general good is classified as a commodity due to its status as a primary, natural good that is attained through the utilization of agricultural excavation. In addition to this definition, crude oil is considered to be a hard commodity as it is obtained through a method of mining. Within the oil market, the good is classified even further through the definition of light, heavy, sweet, and sour, the definitions of which will be explored in the paper through the specific examination of West Texas Intermediate (WTI) and Brent Crude oil.

The paper will compare the spread in spot prices between the two classifications of crude oil, which after achieving parity this year, have begun to widen. In addition to examining the spreads of WTI and Brent, factors determined to affect their spot prices include natural disasters, geopolitical events, the influence of OPEC, and the existence of USO & BNO, ETFs that are linked to the two types of crude oil.

The correlation between the percentage change of net asset value for the Exchange Traded Funds (USO & BNO) and the spot prices of WTI and Brent is calculated and shows that the percentage change in net asset value of both funds does in fact closely follow the percentage change in the spot price of their underlying commodities, proving that ETF is doing what it is meant to. Finally, a time series model is run to see if there is a way to identify a trend in the spot prices of oil futures prices and then predict future prices. Upon constructing the model it was found that the movements in price are so random that a true prediction of oil price cannot be made with a high level of confidence. This can be attributed to the fact the price of oil relies heavily on determinants that are highly unpredictable.
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Introduction

What are commodities?

Commodities and commodity trading have to do with goods procured from agriculture, mining, and other means of acquiring a primary good. Rather than manufactured, commodities are natural goods that are the inputs for more complicated manufacturing. Within the commodities market are two subclasses of commodities: hard commodities, and soft commodities. Hard commodities include such products as gold, oil, and other resources that are considered to be “mined”. Soft commodities are agricultural and include such products as sugar, coffee, corn, wheat, and many others.

Commodities in the Market

Trading of commodities is broken into four different sectors: energy, metals, agriculture, and a group of “other” that includes such things as rubber and palm oil among other items. Each has its own infrastructure and trading methods with unique pricing and market sizes. The commodity market in the past has been mainly focused on futures trading as the harvesters of commodities use such trading to reduce risk within the market. For example, if a wheat farmer in North Dakota harvests his crop of spring wheat in the late summer, and due to past knowledge of price trends the farmer feels as if the price at the selling point will be lower than he needs to support himself. He would most likely opt for a futures contract that would secure the current price and delivery of his goods in order to make sure that his product is not only sold, but that he turns a reasonable profit until the next harvest. The farmer could also consider a forward contract but this is less likely as wheat is a heavily traded product and futures are marked to market and would better represent current movements in wheat.

Oil as a commodity

Due to the fact that it must be mined, oil is considered to be a “hard” commodity. It is also considered to be an “energy” commodity and is the one actively traded commodities (Exhibit 1). Oil futures contracts are thus highly liquid. Oil is used in some of our most important energy sources and it is

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estimated that around eighty-nine million barrels are consumed a day, worldwide. Therefore, as a commodity, it is globally very valuable. Oil is broken up into different classifications based on location, sulfur content, and other important factors. There are two main sets of descriptors for oil classifications that are used in the market: light vs. heavy (having to do with oil density), and sweet vs. sour (having to do with sulfur content). Oil is quoted in price per barrel and each futures contract represents 1000 barrels of crude oil (Exhibit 2). The two types of crude oil that will be discussed in this paper are Brent and WTI.

*I*nternational *E*nergy *A*gency

Brent Crude

Brent Crude is a classification of sweet, light crude oil from the North Sea region and is traded out of London. It is comprised of Brent Blend, Forties Blend, Oseberg, and Ekofisk crudes. It is now used as the international benchmark for crude oil, a title held originally by WTI until recently. In its Annual Energy Outlook for 2013, the EIA announced that for the first time, it would be using Brent as the benchmark for crude oil prices as opposed to WTI as the agency felt that the Brent spot price more closely represented global oil prices and its movements.

West Texas Intermediate

More commonly referred to as “WTI” West Texas Intermediate is also a lighter and sweeter crude oil than BRENT. It originates from the US Midwest, and Gulf Coast areas. It is stored in Cushing, Oklahoma thus making Cushing, OK the delivery point for all futures contracts and the site of ultimate price settlement. The storage levels in Cushing help to determine the spot price of WTI. When the storage tanks fill up the price falls and when they are kept low, the price tends to increase. To go into more specifics, we will compare various aspects of each type of crude:


<table>
<thead>
<tr>
<th></th>
<th>WTI</th>
<th>Brent</th>
<th>Dubai Crude</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Gravity*</td>
<td>39.6</td>
<td>38.06</td>
<td>31</td>
</tr>
<tr>
<td>Specific Gravity*</td>
<td>0.827</td>
<td>0.835</td>
<td>0.871</td>
</tr>
<tr>
<td>Sulfur Content*</td>
<td>0.24%</td>
<td>0.37%</td>
<td>2%</td>
</tr>
</tbody>
</table>

*API (American Petroleum Institute) gravity is a measure of how much lighter or heavier an oil or petroleum is compared to water.
*Specific gravity is a ratio of the density of a substance to a certain reference substance. For oil and other liquids, this reference substance would be pure water, which therefore has a specific gravity of 1.000.
*Sulfur content: The less sulfur that is in the oil, the larger the amount that can be processed into other useful forms. Sulfur is pretty much a dilution of the crude oil.

### Spreads

In the past, the spread between WTI & Brent has been relatively stable but has seen steep falls and sharp climbs in the past two years. Geo-political events like war in the Middle East, Hurricane Katrina, and the Great Recession of 2008 greatly affected the spread in the futures spot price for the two crudes. After January of this year, price movements have taken place at a much more leisurely rate rising and falling but not making any dramatic movements, usually correcting and stabilizing when there are significant changes that take place.4

In 2012, the average spread between WTI and Brent was $19 per barrel. The year (2013) opened with an average spread of $18 per barrel in January, close to the 2012 average. That spread significantly narrowed during 2013 and achieved parity as of July 19, 2013, and by July 30th, the spread had only slightly widened to $4 per barrel5. As of December 4th, the spread between Brent and WTI was $14.34 per barrel with Brent at $111.54 and WTI at $97.20 according to Bloomberg (Exhibit 3).

Spreads had remained rather narrow after the financial crisis in 2008 and so when they started to widen in 2012, the widening was seen as short-term and many major investors bet on the spreads

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narrowing, only to be sorely disappointed. In the past, spreads between WTI and Brent had remained
narrow as the spot prices tended to move together. WTI has long been the heavier traded between the two
in terms of volume but was overtaken by BRENT in the summer of 2012\(^6\). BRENT has been favored as a
more accurate representation of global oil prices and as a result has seen an increase in trading volume\(^7\).
The spot prices of Brent and WTI had traded very close to each other until developments in US oil
production drastically increased the supply of crude oil. One technological advancement known as
Hydraulic Fracturing or “Fracking” has played the lead role in WTI’s increasing supply. Fracking is a
process by which chemicals and water are blasted into shale rock far below the ground at high pressures,
releasing gasses and liquids such as gas and petroleum\(^8\). The pipeline infrastructure of the past could not
handle the capacity thus resulting in the filling of the storage tanks in Cushing, Oklahoma, increasing the
spread. The supply of domestically produced crude oil so greatly overpowered the transportation
capabilities available that the WTI/BRENT spread reached more than $25 dollars per barrel in
2011(Exhibit 4)\(^9\). With 2013 came the approval or advancements in the approval of many pipeline
projects like the Keystone XL pipeline and Seaway pipeline allowing for increased transportation
capabilities and the easing of supply bottlenecks. Oil refineries also began operating at higher levels
closer to capacity. Both of these actions together resulted in the narrowing and relative stabilizing of the
spread to its current levels\(^10\).

With the addition of different pipelines inventory levels in Cushing have been decreasing as more
processed oil has been able to make its way through the pipelines, and is either distributed domestically or

\(^6\) Nguyen, L. (2012, August 1). London overtakes new york as brent oil beats wti. Retrieved from

\(^7\) Smith, G. (2012, November 26). Brent poised to depose wti as most-traded oil futures. Retrieved from


exported abroad. However, production is still increasing at quickening rates and inventories have started increasing. Bloomberg estimates that crude inventories in the United States increased by 800,000 barrels to 386.2 million barrels in the week ending November 8th\textsuperscript{11}. Additionally, if problems in countries like Syria continue to take place, the price of Brent will increase at a rate possibly greater than that of WTI, widening the spread.

**Determinants of Oil Price Movements**

Since movements in the oil market can cause a disruption in the economy, it is vital to understand what causes the spot price of crude oil to rise or fall. A few determinants of oil prices have been identified and are explored below.

*Supply and Demand*

One of the determinants of changes in spot prices is simply supply and demand. Oil production is not solely dictated by supply and demand in the market, prices are driven by geo-political events, natural disasters, and mass speculation.

The rapid economic expansion as seen in developing countries such as China and India has increased the demand for oil, driving up oil prices but also making these prices more sensitive to geo-political or weather related events in these countries. There are numerous factors that influence the movements of oil prices. Global supply is a factor that very heavily affects crude oil prices. The uncertainty in the availability or access to oil inversely affects the price; as the supply of oil decreases, the price increases, and vice-versa. Alongside supply, oil prices are affected by the demand for oil, which today largely comes from emerging markets with growing economies that demand industrial commodities. This increase in the demand for oil pushes the aggregate world demand for oil, making it a more valuable commodity. With uncertainty in regards to the supply levels of oil, there is greater incentive in storing oil. Additionally, expected deficits, driven by geo-political events prompt the storage

of oil to account for future consumption. This shortage in oil can be as a result of production deficits due to geo-political conflicts in oil producing regions or from a spike in demand. The increase in demand for storing oil increases the price. 

The price of oil is determined in the futures market. In an oil futures contract, the buyer agrees to purchase oil by the barrel from the seller at a predetermined price and on a predetermined day in the future. Both buyers and sellers are bound by the contract to fulfill the terms of the agreement on the predetermined date in the future. The futures contracts are traded largely by traders on the floor of the Chicago Mercantile Exchange registered with the Commodity Future Trading Commission (CTFC).

Within the futures market exist two types of future traders: hedgers and speculators. Hedging is the practice of establishing a futures contract as a means of protecting against an increase or decrease in prices. Using oil futures as a hedge could create speculation in the market and greatly affect the spot price. The other side of a commercial hedger’s trade is often taken by a speculator or another commercial hedger seeking protection in the opposite direction. An example of both hedging and speculation comes from a trade by Southwest Airlines that greatly reduced the price they paid for oil. Southwest Airlines entered a futures contract and prevailed from hedging in 2007 while other airline companies suffered as a result of oil trading at above $90/ barrel. Southwest locked in rates as low as $51/ barrel through 2009, avoiding the high fuel costs, which allowed it to remain profitable. In this example, Southwest used hedging as a means of protecting itself from a spike in the price of oil.

Speculation involves the purchase of a commodity with the expectation that the price of the commodity will increase or decrease at a later time and can thus be sold for a profit. In the oil market, traders purchase oil futures, sell it before the delivery date and reinvest further in other futures contracts.

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A speculator plays the role of contemplating the direction of the price of crude oil in the future without any intent to purchase oil. For example, in March 2012, speculators pounced at the possibility of war as a result of tension regarding the Iran nuclear program. As a country that exports 2.2 million barrels of oil a day, concern rose around shortage in supply in the event of military action. At this news, money managers (speculators) flooded the market, betting the price of oil will increase, driving the price of oil up without the shot of a single bullet. With the expectation that oil prices will increase in the future, investment firms purchase future contracts with the motive to make a profit. This increase in the demand for the futures contracts increases the price of the futures, which then drives the price of oil up.  

There are numerous factors that cause speculation and thus result in fluctuating oil prices. One of the factors that play a role in the volume, amount and frequency of traders’ bids is the supply of crude oil that exists. This is accomplished by understanding the production quota established by OPEC. If traders believe that the supply will decrease, a bid for an increase in price will be placed. If there is speculation of an increase in supply, traders will bid for a decrease in the price. Oil demand is also a factor that is observed to forecast the price of oil. Historically, demand increases during the summer season when people are out driving as well as during the winter season to cater to the increase of home heating. Both the demand and supply factors are utilized by analysts and traders to either bid the price for oil up or down.  

USO & BNO: TWO New Financial Instruments within the Oil Market

In the past decade, the financial markets have turned its focus to the commercialization of commodity index trading. “Estimates indicate that assets allocated to commodity index trading rose from

$13 billion in 2004 to $260 billion in March 2008."\(^\text{18}\) Crude oil plays a very significant role in commodities trading (Exhibit 5). Traditionally, the financial instruments commodities like crude oil consisted largely of futures and options. Commodities like crude oil were seen as entire asset classes on their own, traded by Financial Institutions through the Chicago Mercantile Exchange. Within the past decade however, came the creation of Exchange Traded Funds like USO in 2006 and BNO in 2010 that brought these commodities to the common investor and made trading oil as easy as trading stock\(^\text{19,20}\). The USO or “United States Oil Fund” is a fund that aims to have its percentage change in price mirror that of the underlying commodity which in this case is WTI. The same is true for BNO or the “United States Brent Oil Fund” and Brent crude oil. With the increased ease of trading came an increase in speculation in the price of these commodities. These financial instruments can be seen to affect the demand of the underlying commodity because the futures contracts are being brought to the market by Financial Institutions and opening them (futures contracts) to trade.

**Natural Disasters and Oil Prices**

Natural disasters such as Hurricane Katrina and the tsunami in Japan also greatly contribute to oil prices. Not only did Hurricane Katrina cause a rise in the price per barrel, but it also temporarily shut down oil production along the Gulf Coast, affecting 12% of the United States oil production. Prior to Hurricane Katrina, no natural disaster had ever had this big of an effect on US production. “No hurricane has ever destroyed as much of the entire value-chain of energy infrastructure, from offshore rigs to underwater pipelines to refineries and power lines on shores.”\(^\text{21}\) The hurricane led to a substantial increase in the price of the barrel, causing President Bush to make the decision to release barrels from the

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U.S. oil reserves as a means of bringing the price back down. The Department of Energy had to tap into 30 million barrels of the oil reserve to mitigate the shortage in supply and normalize oil prices. This disaster did not have a lasting effect on the world crude-oil market as the markets were over supplied with the crude oil at the time of the event. The oil prices had risen, but within days fell back down to due to the release of the oil reserve.  

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is traded in the futures market (Exhibit 6). After the United States decided to not strike Syria, there was greater certainty in the market, and prices corrected, falling to a more normalized price.  

**Statistical Analysis**

**USO & WTI**

The United States Oil Fund (USO) is an Equity Traded Fund with the objective of having the percentage change of its net asset value reflect the percentage change in the spot price of WTI Crude Oil. The United States Oil Fund ranks 32nd within the top 50 most traded ETFs by volume. The portfolio currently consists completely of WTI futures and is collateralized with a range of debt instruments including US Currency (Exhibit 7). When compared to WTI in terms of percentage price change, it can be concluded that USO does achieve its goal in reflecting the percentage of price change in WTI. Upon running a Minitab regression for the maximum amount of time available (April 17th, 2007 – November 20th, 2013) for USO and WTI, we found the standard coefficient (beta coefficient) to be 1.02317 with an R-Squared of 79.4%. This shows that a close positive correlation exists and that the percentage change of its net asset value does closely follow the percentage change of WTI crude oil (Exhibit 8). The mean spread for the period ranging from 2007 to 2013 for USO and WTI is $45.7444 with the high taking place on the sixth of September in 2013 and the low taking place on the second of February in 2007 (Exhibit 9).

**BNO & BRENT**

Being that the United States Oil Fund is meant to closely follow WTI and not BRENT, as a source of comparison to USO&WTI, we chose to analyze BNO&BRENT. The United States Brent Oil Fund (BNO), similar to the USO has an objective of having the percentage of change in the net asset’s value reflect the percentage change of the price of Brent Crude Oil. When running a regression analysis for the maximum amount of time available (June 2nd, 2010 – November 14th, 2013) of the spread between

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BNO & BRET, we found a standard coefficient of 1.01046 and an R-squared of 96.5 % (Exhibit 10). Similar to the relationship between USO & WTI, the standard coefficient of 1.01046 shows a close relationship between the percentage change of net asset value in BNO and the percentage change in spot price of WTI.

Both of these Exchange Traded Funds fulfill achieve their goal of closely following the changes in the spot price of their underlying commodity.

What affects the spread between WTI and BRET?

Over the past decade, the spread of WTI and BRET has widened rapidly and then narrowed rapidly at times often going against the predictions of analysts. As previously stated, it has been deduced that the major determinants of the spread between WTI and BREN are geo-political events and weather, both of which usually lead to speculation that in turns moves the prices of the two crudes at disproportionate levels, thus affecting the spread. When comparing the movements in price during various geo-political events and weather we found that events in the Middle-East affect both of the spot prices in the same general manner, either resulting in a drop or an increase in spot price. However, Geo-political events in the Middle East and extreme weather in areas outside of the United States, like Asia, tend to move BRET spot prices more than WTI spot prices. Similarly, geo-political events in the United States and extreme weather in the United States moved the spot prices of WTI more than those of BRET. Two examples have been chosen to illustrate this point.

The first event we are going to examine is the conflict in the Middle East between Israel and Palestine. On August 26th, 2013, the Wall Street Journal reported that the Palestinians had put off peace talks with the Israeli’s after Israeli forces killed three Palestinians in a raid. Oil prices responded drastically because conflict in the Middle East could result in major supply setbacks. It could also cause fighting that may spill over into other Middle Eastern nations like Egypt and Saudi Arabia, further affecting overall supply. BRET would be affected more than WTI would and the changes in spot price on August 26th show this. Spot prices increased 3.04% rising from $108.57 to $111.87. WTI spot prices
on the other hand, increased .88% rising from $104.16 to $106.90. BRENT’s spot price increased more because BRENT crude has a bigger presence outside of the United States while WTI dominates the domestic oil markets. BRENT’s disproportional rise in relation to WTI’s spread lead to a widening of the overall spread from $4.41 to $4.97.

An example of a case of severe weather within the United States that also affected the spread was Hurricane Katrina. During the week of August 23rd to August 30th, 2005 the spot price of WTI increased 6.2% from $65.81 to $69.91 while BRENT only marked a 1.5% increase moving from $65.16 to $66.15. Being that Hurricane Katrina was a tragic event of severe circumstances that was focused within the United States, WTI’s spot price increased dramatically because the production of oil was interrupted and it was speculated that supply would lessen, leading to a higher demand-to-supply ratio and in return, a higher price. In order to determine whether the drastic movement in the spot price of oil was unique, and not in tandem with the market, we compared the movement in both spot prices (WTI & BRENT) to the movements in the S&P500. During the 7 days from August 23rd to August 30th the S&P 500 Index ticked up .2% from $1205.10 to $1208.41.

When considering the aforementioned data and comparing it to historical data, it was found that in recent years the returns of crude oil futures have more closely related to the returns on the S&P 500 (Exhibit 11). We have found that during the times of many geo-political events or periods of severe weather, the spot prices of WTI and BRENT tend to follow the same general trend of the S&P 500 but moves at a magnified rate.

Time Series Forecasting

With the available historical WTI and Brent prices, Time Series methods were used as a means to forecast future spot prices. When performing a preliminary analysis, all of the available data from 1987 onwards was used to better gauge a forecast. Due to the high volatility in the prices, especially due to spikes in prices that occurred in 2008, it was important to eliminate outlying data. To avoid any discrepancies when forecasting the prices, stock prices post the financial crisis was used. Data after 2010
was used for the forecasting as by then markets had steadied (Exhibit 12&19). When observing the autocorrelation function graph (ACF), it is seen that data points did not extend past the significance bands (Exhibit 13). Additionally, the data in the ACF was exponentially decreasing which is indicative of non-stationary data. To make this data stationary, a difference of the data was taken. To understand what predictor model could be used, the ACF and the partial autocorrelation (PACF) of the difference graph was observed (Exhibit 14&15). Based on these graphs, there is a spike that extends past the significance band in the ACF and the PACF. After a great deal of trial and error, the best fitting model was an ARIMA (0,1,1). When a forecast was run based on the model, it returned a future average Brent price of $110.819 and WTI price of $91.0678. The residuals for this model were strong because there was white noise as depicted by the data within the significance bands (Exhibits 16&17). Additionally, the p-values as depicted in the Ljung-Box were significant as it was well above the 0.05. Though this is the case, the parameters were not significant because it was well above the 0.05 (Exhibit 25). Due to the randomness of the data, the system automatically implemented a naïve no change method. A naïve no change forecast entails using the price of the stock today and predicting that it will remain the same tomorrow. Since the data bars do not extend past the significance bands for both the Brent and WTI projections, it can be concluded that the data is far too random to accurately forecast. It is important to note that it is not practical to create a forecasting model for oil prices due to the high volatility and the large number of unpredictable determinants (geo-political events, weather, etc.) that affect the price of oil.

**CONCLUSION**

Looking at the spot prices for WTI and Brent over the past 25 years, the prices follow a general upward trend. They have increased in price dramatically in the past 10 years as the availability of oil has diminished, war in oil rich zones has broken out, and political positions have impacted the oil market. Examining the data for WTI, the difference in price from 1987 to 2012 increased 79.58% from $19.20/barrel to $94.05 per barrel. Brent prices have experienced even larger increases in price with an
83.40% increase from $18.53/barrel in 1987 to $111.63/barrel in 2012.\textsuperscript{26} This is without accounting for inflation (Exhibit 27).

The spot prices for both WTI and Brent from before 2002 experienced relative price hikes as well as price drops keeping a steady average hovering near $20/barrel, while the prices beginning in 2002 and continuing on to 2012 experience only significant price increases with every year, effectively growing at least $10/barrel every year (with the exception of 2008-2009 during the worst of the US economic recession). This change in prices from a relatively steady price fluctuation to a steep rise in prices exhibits an exponential growth trend for both WTI and Brent (plotted on included graph in Exhibit 26).

While the aforementioned data concretely points to a futures projection of infinitely increasing oil prices, there exist external factors that may suddenly prove these predictions to be false. As discussed in the paper, the spot prices of WTI & Brent are affected by everything from geo-political events and the storage levels in Cushing, Oklahoma to instances of severe weather. These determinants are extremely unpredictable and thus do not allow for oil price predictions that are significant enough to produce predictions with strong confidence. This is displayed in the time series model completed. As one of the highest traded commodities in the world, crude oil is one that has proven to be both highly profitable at times and highly unpredictable. As the introduction of Exchange Traded Funds like USO & BNO has allowed for heavier trading activity and more speculation due to ease of access to the market, WTI & Brent are sure to experience many more unpredictable changes in price. As two of the main types of crude oil, nobody knows what lies in the future of WTI and Brent, all we can do is wait and watch.

\textsuperscript{26} Energy Information Administration, (2013). \textit{Spot prices for crude oil and petroleum products}. Retrieved from Thomson Reuters website: \url{http://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm}
References


"Commodity ETF and Futures Trading Center." Commodity HQ. http://commodityhq.com/trading-center/


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Exhibits

Exhibit 1: Crude Oil Contract Liquidity

<table>
<thead>
<tr>
<th>Contract</th>
<th>Total Volume</th>
<th>Platform</th>
<th>Monthly Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>13,792,055</td>
<td>NYMEX</td>
<td>23.8%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>6,991,269</td>
<td>NYMEX</td>
<td>21.8%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>5,288,616</td>
<td>CBOT</td>
<td>53.6%</td>
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<tr>
<td>Corn</td>
<td>4,919,498</td>
<td>CBOT</td>
<td>43.2%</td>
</tr>
<tr>
<td>Gold</td>
<td>3,458,162</td>
<td>COMEX</td>
<td>3.8%</td>
</tr>
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http://commodityhq.com/trading-center/

Exhibit 2: Oil Futures Contracts

<table>
<thead>
<tr>
<th>Contract</th>
<th>Size</th>
<th>Quotation</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper (HG)</td>
<td>25,000 pounds</td>
<td>U.S. Cents per pound</td>
<td>COMEX</td>
</tr>
<tr>
<td>Corn</td>
<td>5,000 bushels (127 Metric Tons)</td>
<td>Cents per bushel</td>
<td>CBOT</td>
</tr>
<tr>
<td>Cotton</td>
<td>50,000 pounds</td>
<td>U.S. Dollars per pound</td>
<td>NYMEX</td>
</tr>
<tr>
<td>Gold (GC)</td>
<td>100 troy ounces</td>
<td>U.S. Dollars and Cents per troy ounce</td>
<td>COMEX</td>
</tr>
<tr>
<td>Heating Oil (HO)</td>
<td>42,000 gallons</td>
<td>U.S. Dollars and Cents per gallon</td>
<td>NYMEX</td>
</tr>
<tr>
<td>Light Sweet Crude Oil (WTI) (CL)</td>
<td>1,000 barrels</td>
<td>U.S. Dollars and Cents per barrel</td>
<td>NYMEX</td>
</tr>
<tr>
<td>Natural Gas (Henry Hub) (NG)</td>
<td>10,000 million British thermal units (mmBtu)</td>
<td>U.S. dollars and cents per mmBtu</td>
<td>NYMEX</td>
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<tr>
<td>RBOB Gasoline (RT)</td>
<td>42,000 gallons</td>
<td>U.S. dollars and cents per gallon</td>
<td>NYMEX</td>
</tr>
<tr>
<td>Silver (SI)</td>
<td>5,000 troy ounces</td>
<td>U.S. Cents per troy ounce</td>
<td>COMEX</td>
</tr>
<tr>
<td>Sugar (No. 11)</td>
<td>112,000 pounds</td>
<td>U.S. Dollars per pound</td>
<td>NYMEX</td>
</tr>
</tbody>
</table>

http://commodityhq.com/trading-center/
Exhibit 3: Brent & WTI End of Day price as of 12/4/2013

Crude Oil & Natural Gas

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Units</th>
<th>Price</th>
<th>Change</th>
<th>% Change</th>
<th>Contract</th>
<th>Time(ET)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil (WTI)</td>
<td>USD/bbl.</td>
<td>97.20</td>
<td>+1.16</td>
<td>+1.21%</td>
<td>Jan 14</td>
<td>12/04/2013</td>
</tr>
<tr>
<td>Crude Oil (Brent)</td>
<td>USD/bbl.</td>
<td>111.54</td>
<td>-1.08</td>
<td>-0.96%</td>
<td>Jan 14</td>
<td>17:43:13</td>
</tr>
<tr>
<td>TOCOM Crude Oil</td>
<td>JPY/kl</td>
<td>68,430.00</td>
<td>-780.00</td>
<td>-1.13%</td>
<td>May 14</td>
<td>13:59:31</td>
</tr>
<tr>
<td>NYMEX Natural Gas</td>
<td>USD/MMBtu</td>
<td>3.96</td>
<td>-0.02</td>
<td>-0.40%</td>
<td>Jan 14</td>
<td>12/04/2013</td>
</tr>
</tbody>
</table>

http://www.bloomberg.com/energy/

Exhibit 4: WTI/Brent Spread
Exhibit 5: Crude Oil’s Role in Commodity Trading

Exhibit 6: Effect of Syrian Conflict on Brent & WTI Spot Prices

Intensification of unrest in Syria followed by announcement of possible U.S. strike in August.

Exhibit 7: USO

Source: Bloomberg
Exhibit 8: Regression Analysis: WTI vs. USO % Change

Regression Analysis: WTI vs. USO % Change

The regression equation is
% change_1 = -0.000307 + 1.02 % change

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.000307</td>
<td>0.000365</td>
<td>-0.83</td>
<td>0.405</td>
</tr>
<tr>
<td>% change</td>
<td>1.02317</td>
<td>0.01277</td>
<td>80.15</td>
<td>0.000</td>
</tr>
</tbody>
</table>

S = 0.0150295  R-Sq = 79.4%  R-Sq(adj) = 79.4%

Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>1</td>
<td>1.4510</td>
<td>1.4510</td>
<td>6423.69</td>
<td>0.000</td>
</tr>
<tr>
<td>Residual Error</td>
<td>1662</td>
<td>0.3754</td>
<td>0.0002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1663</td>
<td>1.8264</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Residual Plots for USO vs. WTI

Normal Probability Plot

Histogram

Versus Fits

Versus Order

Source: Minitab
Exhibit 9: Mean spread USO and WTI

Source: Bloomberg
Exhibit 10: BNO and Brent

Regression Analysis: BNO vs. Brent % Change

The regression equation is
% change_3 = 0.000379 + 1.01 % change_2

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.000379</td>
<td>0.0002421</td>
<td>1.57</td>
<td>0.118</td>
</tr>
<tr>
<td>% change_2</td>
<td>1.01046</td>
<td>0.00662</td>
<td>152.72</td>
<td>0.000</td>
</tr>
</tbody>
</table>

S = 0.00703889  R-Sq = 96.5%  R-Sq(adj) = 96.5%

Analysis of Variance
Source | DF | SS   | MS   | F     | P     |
Regression | 1  | 1.1556 | 1.1556 | 23324.22 | 0.000 |
Residual Error | 844 | 0.0418 | 0.00000 |
Total | 845 | 1.1974 |

Residual Plots for Brent vs. BNO

Source: Minitab
Exhibit 11: Increasing Correlation Between Crude Oil and S&P 500 Returns

Correlations (+ or -) between daily returns on crude oil futures and financial investments have also strengthened

Source: www.eia.gov
Exhibit 12: Time Series Plot for Brent
Exhibit 13- Autocorrelation Graph for Brent

Exhibit 14- Difference 1 Autocorrelation Graph
Exhibit 15 - Difference Partial Autocorrelation Graph for Brent

Exhibit 16 - Autocorrelation Graph of Residuals for Brent
Exhibit 17 - Partial Autocorrelation Graph for Brent

PACF of Residuals for Brent Prices
(with 5% significance limits for the partial autocorrelations)
Exhibit 18: Residual Plots for Brent Prices
Exhibit 19: Time Series Forecast for WTI prices

![Time Series Plot of WTI Prices]

Exhibit 20: Partial Autocorrelation Graph for WTI

![PACF of Residuals for WTI Training](with 5% significance limits for the partial autocorrelations)
Exhibit 21: Difference Partial Autocorrelation Graph for WTI

Exhibit 22: Autocorrelation Graph of Residuals for WTI
Exhibit 23: Difference autocorrelation graph in WTI prices

Exhibit 24: Residual Plots for WTI
Exhibit 25: Ljung Box for WTI

Final Estimates of Parameters

<table>
<thead>
<tr>
<th>Type</th>
<th>Coef</th>
<th>SE Coef</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>1</td>
<td>0.0213</td>
<td>0.0320</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Differencing: 1 regular difference
Number of observations: Original series 977, after differencing 976
Residuals: SS = 2407.81 (backforecasts excluded)
MS = 2.47 DF = 975

Modified Box-Pierce (Ljung-Box) Chi-Square statistic

<table>
<thead>
<tr>
<th>Lag</th>
<th>Chi-Square</th>
<th>DF</th>
<th>P-Value</th>
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</thead>
<tbody>
<tr>
<td>12</td>
<td>5.5</td>
<td>11</td>
<td>0.906</td>
</tr>
<tr>
<td>24</td>
<td>19.2</td>
<td>23</td>
<td>0.691</td>
</tr>
<tr>
<td>36</td>
<td>29.9</td>
<td>35</td>
<td>0.712</td>
</tr>
<tr>
<td>48</td>
<td>38.4</td>
<td>47</td>
<td>0.811</td>
</tr>
</tbody>
</table>

Exhibit 26: Historical Spot Prices (WTI & Brent)
### Exhibit 27: Historic Crude Oil Prices for WTI & Brent

<table>
<thead>
<tr>
<th>Date</th>
<th>Cushing, OK WTI Spot Price FOB (Dollars per Barrel)</th>
<th>Europe Brent Spot Price FOB (Dollars per Barrel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>15.05</td>
<td>18.53</td>
</tr>
<tr>
<td>1987</td>
<td>19.2</td>
<td>18.53</td>
</tr>
<tr>
<td>1988</td>
<td>15.97</td>
<td>14.91</td>
</tr>
<tr>
<td>1989</td>
<td>19.64</td>
<td>18.23</td>
</tr>
<tr>
<td>1990</td>
<td>24.53</td>
<td>23.76</td>
</tr>
<tr>
<td>1991</td>
<td>21.54</td>
<td>20.04</td>
</tr>
<tr>
<td>1992</td>
<td>20.58</td>
<td>19.32</td>
</tr>
<tr>
<td>1993</td>
<td>18.43</td>
<td>17.01</td>
</tr>
<tr>
<td>1994</td>
<td>17.2</td>
<td>15.86</td>
</tr>
<tr>
<td>1995</td>
<td>18.43</td>
<td>17.02</td>
</tr>
<tr>
<td>1996</td>
<td>22.12</td>
<td>20.64</td>
</tr>
<tr>
<td>1997</td>
<td>20.61</td>
<td>19.11</td>
</tr>
<tr>
<td>1998</td>
<td>14.42</td>
<td>12.76</td>
</tr>
<tr>
<td>1999</td>
<td>19.34</td>
<td>17.9</td>
</tr>
<tr>
<td>2000</td>
<td>30.38</td>
<td>28.66</td>
</tr>
<tr>
<td>2001</td>
<td>25.98</td>
<td>24.46</td>
</tr>
<tr>
<td>2002</td>
<td>26.18</td>
<td>24.99</td>
</tr>
<tr>
<td>2003</td>
<td>31.08</td>
<td>28.85</td>
</tr>
<tr>
<td>2004</td>
<td>41.51</td>
<td>38.26</td>
</tr>
<tr>
<td>2005</td>
<td>56.64</td>
<td>54.57</td>
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<tr>
<td>2006</td>
<td>66.05</td>
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</tr>
<tr>
<td>2007</td>
<td>72.34</td>
<td>72.44</td>
</tr>
<tr>
<td>2008</td>
<td>99.67</td>
<td>96.94</td>
</tr>
<tr>
<td>2009</td>
<td>61.95</td>
<td>61.74</td>
</tr>
<tr>
<td>2010</td>
<td>79.48</td>
<td>79.61</td>
</tr>
<tr>
<td>2011</td>
<td>94.88</td>
<td>111.26</td>
</tr>
<tr>
<td>2012</td>
<td>94.05</td>
<td>111.63</td>
</tr>
</tbody>
</table>

Source: [www.eia.gov](http://www.eia.gov)