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Trading with Real Option Pricing Model

Keywords: Black Scholes Model, Hedonic Pricing Model, Crude Oil, Stochastic Simulation

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Introduction

Commodity markets are very important for individual economies and the global economic network as a whole. Commodities are much more than just inputs for manufactured products. Commodities are traded in highly efficient exchanges such as CME and ICE using commodity futures and options. In the recent years investors have shown huge interest in commodity related investment options (Sanders and Irwin, 2012). Various types of investors use commodity futures and options as a risk-management or risk mitigation tool. Like any other investment, commodity derived investments are also exposed to risk. The largest risk component in commodity investing is commodity price volatility. Among various risk management tools on one of the most used ones is option pricing. Option pricing allows the investor to use the real option with respect to any investment decision and make a quantitative comparison with any other investment choice. Real option is a right but not the obligation to undertake a business initiative. In the case of commodity investment decision in the exchange, real option is the right but not the obligation to sell or buy a futures contract. These options are formally known as put and call option irrespectively. Investors take positions to make money when they anticipate markets prices and prices moves as predicted. This is not always the case and there is a risk of losing investment capital. That's when an option can be a great utility. To manage risk, investors use a hedge and combine futures and options. Black-Scholes model is a quantitative tool which helps the investors to overcome uncertainty and evaluate the option price in the market. The Black-Scholes model is a very powerful option pricing model and it is widely used throughout the academia and the industry. It is a continuous mathematical model used in quantitative finance. It is sufficiently complex to provide a widely acceptable framework for option pricing.

Knowing just the value of option is not sufficient to minimize risk and maximize gains. It is important to understand the market and the futures contract price drivers. In this paper we estimate a hedonic pricing model and a Black-Scholes model to predict the prices for WTI (West Texas Intermediate) sweet crude oil using historical prices from CME (Chicago Mercantile Exchange). The paper explains the methodology to use Black-Scholes model, a real pricing options tool with a hedonic pricing model to make more informed decisions in the market.

WTI Crude Oil Trading

WTI (West Texas Intermediate) is a light sweet crude oil stream consists of a blend from various U.S domestic light crude oil. The delivery point for WTI is in Cushing, Oklahoma. This location is a hub and transshipment point with many pipelines connecting. The proximity to various storage facilities and ease of access to suppliers and refiners make this location strategic for crude oil delivery. WTI crude oil is a year round traded commodity. It is also known as Light Sweet Crude Oil. WTI futures and options are the world's most actively traded energy contracts with 900,000 futures and options contracts daily. It is world's most liquid benchmark oil futures contract. It is also has the largest open interest reaching near record levels at 7.5 million lots, equivalent to more than 7.5 billion barrels. U.S is the largest consumer of crude oil in the world. In the U.S market crude oil is generally traded in 1000 barrel lots hence one WTI contract has 1000 oil barrels in it .The commodity is traded at NYMEX exchange operated by the CME group.

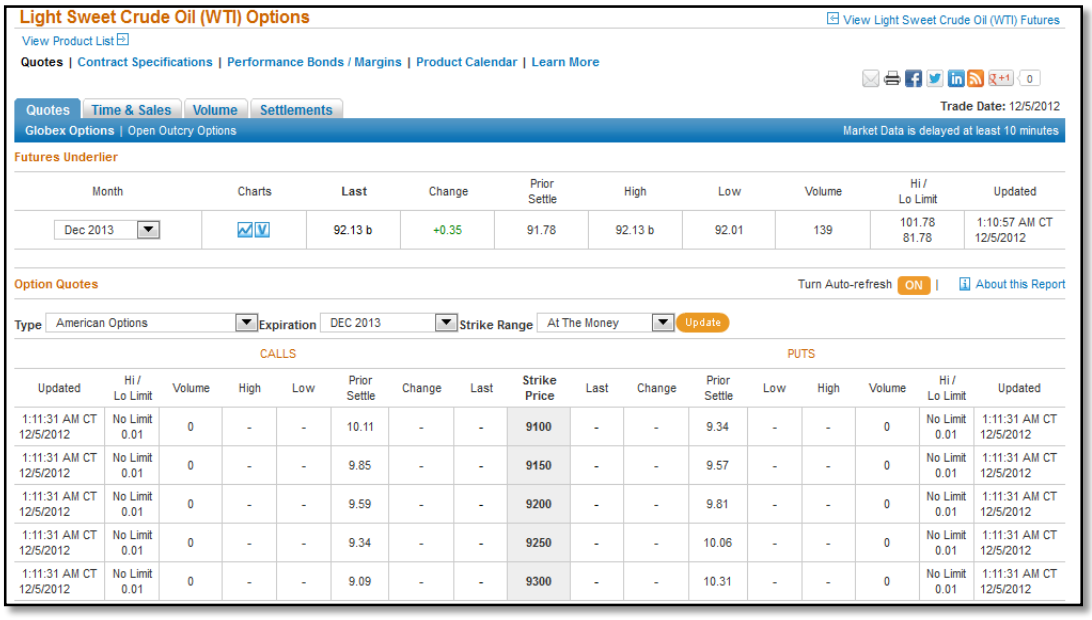
After drilling crude oil is refined in a complex series of processes and refineries produce various petroleum products from crude oil. Initial refining process is simply distillation and in distillation crude oil is heated lighter petroleum products such as gasoline and naphtha are separated. More complex and heavier products are separated later in the refining process such as residential

heating oil. Out of all the petroleum products refined by a barrel, 50 percent is gasoline, 40 percent is the diesel, heating oil, jet fuel and kerosene all together and roughly 10 percent is residential fuel oil. A list of petroleum products derived from crude oil is as follows, gasoline, diesel, propane, heating oil, diesel, petrol, jet fuel, kerosene, LPG, waxes and lubricants.

The world oil market is complex. Companies are often thought of as the primary actors in this market, but governments play a large role as well. The top 10 countries produced over 63 % of the world oil production in 2011. Top oil producing countries are Saudi Arabia, Russia, United States, Iran 215 (5.4 %), China, Canada, United Arab Emirates, Venezuela, Mexico, and Nigeria. Top crude oil exporters to the U.S are Canada (29%), Saudi Arabia (14%), Venezuela (11%), Nigeria (10%). US domestic production of crude oil is constantly increasing and it is forecasted that in the near future U.S will be a net exporter of crude oil.

Crude oil is traded as Light Sweet Crude Oil (WTI) Futures with the product symbol CL. It is traded at CME Globex, CME ClearPort, Open Outcry (New York). The contract size is 1,000 barrels. Price quotation is U.S. Dollars and Cents per barrel. Minimum fluctuation is $0.01per barrel. Table-1 below is a screen shot from CME website which reflects the future contract price and option prices as on 12/5/2012.

Table-1 (Screen shot from CME, reflecting futures and option prices: dated 12/5/2012)



Light Sweet Crude Oil (WTI) Options

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Trade Date: 12/5/2012

Globex Options | Open Outcry Options

Market Data is delayed at least 10 minutes

Futures Underlier

Month	Charts	Last	Change	Prior Settle	High	Low	Volume	Hi / Lo Limit	Updated
Dec 2013		92.13 b	+0.35	91.78	92.13 b	92.01	139	101.78 81.78	1:10:57 AM CT 12/5/2012

Option Quotes

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Type American Options Expiration DEC 2013 Strike Range At The Money Update

CALLS									PUTS							
Updated	Hi / Lo Limit	Volume	High	Low	Prior Settle	Change	Last	Strike Price	Last	Change	Prior Settle	Low	High	Volume	Hi / Lo Limit	Updated
1:11:31 AM CT 12/5/2012	No Limit 0.01	0	-	-	10.11	-	-	9100	-	-	9.34	-	-	0	No Limit 0.01	1:11:31 AM CT 12/5/2012
1:11:31 AM CT 12/5/2012	No Limit 0.01	0	-	-	9.85	-	-	9150	-	-	9.57	-	-	0	No Limit 0.01	1:11:31 AM CT 12/5/2012
1:11:31 AM CT 12/5/2012	No Limit 0.01	0	-	-	9.59	-	-	9200	-	-	9.81	-	-	0	No Limit 0.01	1:11:31 AM CT 12/5/2012
1:11:31 AM CT 12/5/2012	No Limit 0.01	0	-	-	9.34	-	-	9250	-	-	10.06	-	-	0	No Limit 0.01	1:11:31 AM CT 12/5/2012
1:11:31 AM CT 12/5/2012	No Limit 0.01	0	-	-	9.09	-	-	9300	-	-	10.31	-	-	0	No Limit 0.01	1:11:31 AM CT 12/5/2012

Data Sources

We use time series data for our analysis in this paper. We gather the data using DTN ProphetX. For petroleum products data we use U.S. Energy Information Administration (EIA) database. Interest rate data is from U.S. Department of the Treasury.

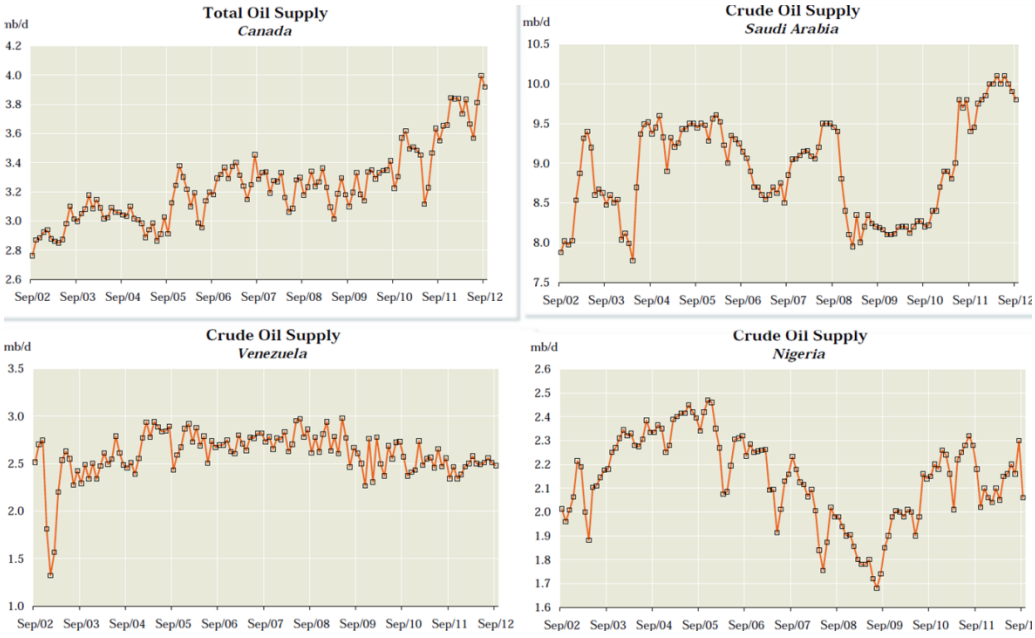
Model

In this section we first discuss our hedonic pricing model and then the Black-Scholes model separately.

1. Hedonic pricing model for WTI Crude Oil

The big four crude oil exporters to the U.S are Canada, Saudi Arabia, Venezuela and Nigeria. When we look at the crude oil supply for these countries in the month of September from 2002 to 2012 we see that other than Venezuela (whose supply is stagnant), the overall trend is of increasing supply (Table-2).

Table -2, Big 4 Crude Oil Exporters to the U.S



Second important variable is the domestic oil production in the U.S. Domestic production in on an upward trend and further Texas and North Dakota oil fields will further push the domestic oil supply in 2013.

Other than the above mentioned factors there are two more factors that affect the crude oil prices i.e. inventories and consumption. Inventories are still on the lower side but as the production will rise and Canadian imports will increase the inventories will rise. There is no reason for the consumption to rise dramatically in the U.S in 2013. Automobile sales are expected to go up a slightly but that will not be a significant factor. Seasonality also plays an important role in commodity prices but in this paper we focus on a one year investment crude oil investment.

Domestic crude oil production will increase to 6.8 million bbl/d in 2013, the highest level of production since 1993 as projected by U.S. Energy Information Administration (EIA).

The EIA predicts that the importance of Canadian crude oil to U.S. refiners has increased in 2012, as Canada supplied the United States with a record of nearly 2.5 million barrels per day during January-August 2012, according to the latest oil trade data from EIA. Total U.S. crude oil imports fell from 8.9 million barrels per day in 2011 to 8.7 million barrels per day through August 2012.

Total foreign imports are decreasing in the U.S but the Canadian imports are increasing (standing at 28 % increase). Canada is the largest supplier of foreign oil to the United States, followed by Saudi Arabia, Mexico, and Venezuela. Almost 99% of Canadian oil exports are sent to the U.S. market. It is very interesting to see that Canadian production is also expected to increase in 2013. Canadian oil supply is expected to move from 3.99 to 4.33 million barrels per day from Oct2012 to Dec 2013. This overflow of oil will end up in the U.S market.

The crude oil market is complex and it is difficult to make accurate predictions just by matching the demand supply estimates. Therefore to get a better understanding of WTI crude prices I take the theoretical framework of supply and demand and merge it with a hedonic pricing model. The hedonic pricing model is discussed in the next section and in the final subsection I stich everything together and construct an investment strategy.

We use ordinary least square (OLS) to estimate crude oil pricing model as below:

$$P = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \varepsilon,$$

Where

Z = Factors affecting crude oil prices P

Z_1 *to* Z_{11} are independent variables viz. Inventory/Ending Stock, US Field Crude Production, East Coast, Field Production, Mid-West Field Production, Gulf Coast Field Production, Rocky Mountain Field Production, US Imports (OPEC Countries), US Imports (Nigeria),US Imports (Canada),US Interest Rates.

ε is the unobservable error term.

2. Black-Scholes Model

The Black Scholes model is widely used to calculate price of an option. The value of an option using Black Scholes model can be calculated using the following formula.

Price of a European call option:

$$\mathbf{Pc=S_0N(d_1)-Xe^{-rT}\,N(d_2)}$$

Where

$d_1=(\ln(S_0/X)+(r+\sigma^2/2)T)/\sigma\sqrt{T}$

$d_2=(\ln(S_0/X)+(r-\sigma^2/2)T)/\sigma\sqrt{T}$

N = standard normal distribution function (CDF),

S = the price of the underlying stock at time 0,

X = the strike price,

r = risk free interest rate,

σ = volatility of the underlying stock,

T = time to maturity of the option.

The most important variable in this model is the value of σ, volatility of the underlying stock. All other variables values can be easily acquired but finding an appropriate value for σ is critical as well as challenging (Figlewski, 1994). We follow a similar approach as Figlewski and calculated standard deviation for the underlying crude oil contracts for 5 year periods from 1983 to 2012 using monthly data. Though Black-Scholes model is a dynamic model, a major limitation of this model is the use of a single value for standard deviation. We overcome this problem by using stochastic simulation in our model.

Results and discussion

A good hedonic model is the one with few variables and higher R^2 and F values. While testing my model I analyzed various models using different dependent variables but in here I present the best model estimated (Table-4). I use the publically available data from U.S. Energy Information Administration and crude oil prices continuous data from DTN.

Table-4 (Hedonic Model for Crude Oil Prices)

Factors	Coefficient	t-Ratio	Oct 2012- Dec 2013 (eia)	Impact
Inventory/Ending Stock	0.443	3.070	373.2-344.5 (eia)	↓
US field Crude Production	-0.416	-2.850	6.62-7.05 MB (eia)	↓
East Coast Field Production	-0.443	-3.070	39.1- 49.6 MB (eia)	↓
Mid West Field Production	-0.443	-3.070	27-31.4 MB (eia)	↓
Gulf Coast Field Production	-0.436	-3.020	36-39.3 MB (eia)	↓
Rocky Mountain Field Production	-0.443	-3.080	3.1-3.5 MB (eia)	↓
US Imports (OPEC Countries)	0.007	2.960	Low impact	-
US Imports (Nigeria)	0.012	7.110	Low impact	-
US Imports (Canada)	3.112	5.260	Increase (eia)	↑
US Interest Rates	-0.393	-11.750	1 % Increase (forbes)	↓
R^2 = 99.98			F =284911.1 (0.000)	

The model has a very strong goodness of fit indicators. It shows that Canadian imports are very significant factors in price prediction but all the other important production, stock and interest rate figures tell us that there is a stabilization effect and one strong factors works against numerous other smaller factors. So it's a tug of war situation for the crude oil prices right now. We put all the predicted values for the dependent variables and found that all the values are expected to increase in 2013 December. It is clear from the historical price volatility (Figure-1) that the prices have the lowest fluctuation at present as the standard deviation is below 1.5. This justifies our hedonic model results.

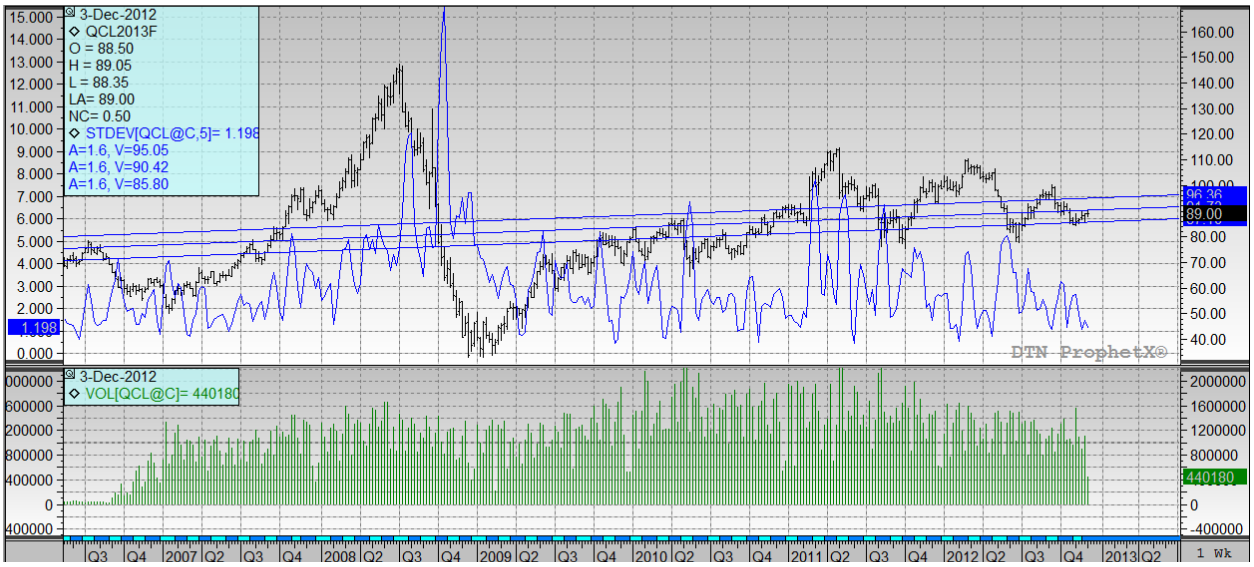


Figure-1, WTI Prices and Standard Deviation

First we fit a distribution for over periodic data from 1983 to 2012. We found that the standard deviation for crude oil has a Pareto (0.8737, 2.335) distribution. The main goal of using Black-Scholes model is to calculate the price of the option. We simulate the price of option with a stochastic measure of volatility of underlying WTI sweet crude oil contract. We use the exactly the same values as our previous hedonic model in our option pricing model. We choose 10,000 iterations to get a robust option value. In the following paragraph we discuss the put option simulation results as call prices can be calculated using a put-call parity formula for Black Scholes model. We assume a fixed 5 percent risk free rate in our model.

We find that the put has a wide price range from as high as $87.64 to as low as $ 1.16 per put (Figure-2). This is an interesting result as we can see that prices of call show lower volatility (20.01) than the overall underlying contract volatility (27.32) but the underlying 5 year periodic volatility (7.6) for the contract is much less than the option volatility. The periodic volatility makes more sense as the price of option move up significantly with the fluctuation in underlying

contract prices or higher contract price standard deviation and the option prices should always be more volatile than underlying (Black and Scholes, 1973 and Jackwerth, Rubinstein 2012).

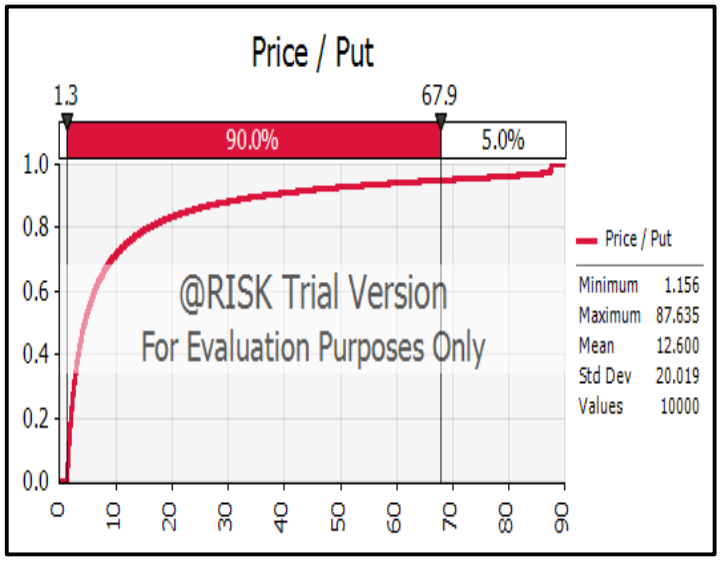


Figure-2, Put Price from Black Scholes Simulation

We found in our model that the put option price from the simulation has a log-normal distribution with a mean value of $12.60. We take the mean value of $12.60 as the current theoretical value of put

Conclusion

Currently put for $92 December 2013 is trading at $ 9.81. Therefore we conclude that which is undervalued. Buying put options along with the futures contracts is a good investment strategy for December 2013 contracts. Calculation of theoretical option using Black Scholes model can be very advantageous for an investor but the value of standard deviation should be skillfully selected. We found that it is more accurate to use periodic standard deviation values for shorter periods rather than using standard deviation derived from a long time series of underlying. Crude

oil prices in the U.S depends upon Canadian imports significantly but in the future as domestic production will increase significantly this factor will lose its strength. Approach discussed in the paper can be extended to other commodities as well as stock trading (with minor modification for dividends).

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