Evolution of Price of Commodities (Crude Oil) and related Financial Markets (Energy Equities)

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Abstract

The objective of this research is to understand the oil and gas value chain and the related energy and financial markets using traded and financial data. In the first stage, petroleum production, storage and supply system was studied, the value chain was reconstructed, and its dynamics is examined using available data from the U.S. Energy Information Administration (EIA) database. The correlation between NYMEX WTI crude oil prices is analyzed with other variables like production, supply, and In addition, the oil futures curves (using data from Bloomberg) were examined for the time period ranging from 2000 to 2015. Using these curves, the market perception of future oil prices were assessed.

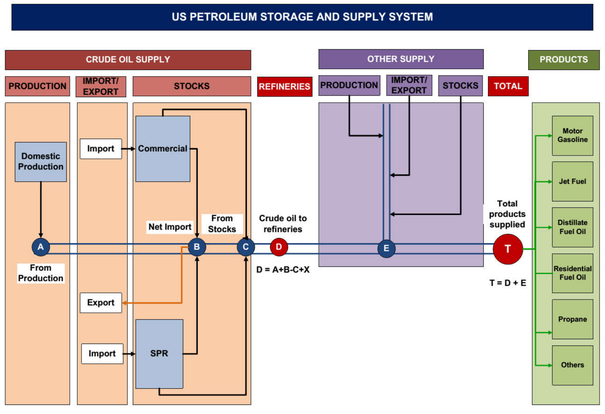
In the next phase, changes in oil market dynamics was investigated based on shale gas exploration in the U.S. The impact of shale exploration on oil price returns and realized variation were analyzed using the data from Wharton Research Data Services (WRDS) for the time period between 2000 and 2015. 2010 was used as the start of shale exploration for the dummy variable of the regression analysis In the third stage, the equities of some of oil exploration and production (E&P) companies mostly working in the Appalachian basin of USA were investigated based on their price movement.

Introduction

❑ Research Objectives

- **To understand U.S. crude oil economics – production, supply, storage since the new century.**
- **To understand Market perceptions of crude oil price based on WTI NYMEX crude oil futures.**
- **To analyze the impact of shale gas exploration on WTI crude oil price returns and realized variance**
- **To analyze equity returns, volatility and correlation among energy E&P companies involved in shale gas exploration.**

U.S. Crude Oil Value Chain



The oil and gas value chain consists of three stages:

I. **Upstream :** Upstream is concerned with exploration and production of crude oil and natural gas
II. **Midstream :** Midstream works with transportation and refining processes of crude oil to refined products
III. **Downstream :** Downstream is all about distribution of refined products and retail operations.

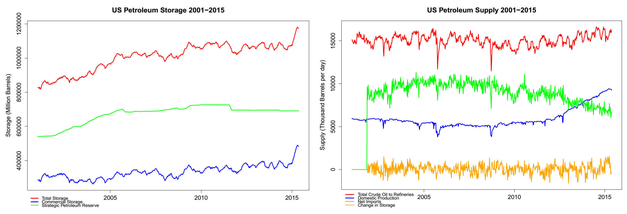
Methods

- Application of data analysis, analytics, data visualization and multivariate regression analysis.
- Three primary sources of data: U.S. Energy Information Administration (EIA) database, Bloomberg and Compustat database from Wharton Research Data Services (WRDS).
- R was used as the primary programming language (data processing, regression modelling, correlation analysis).

Results and Analysis

❑ U.S. Crude Oil Production, Supply and Storage

- In the period 2000-2015, there has been **substantial increase in U.S. crude oil production since 2010 along with reduction in imports**.
- Strong growth of production in U.S. after financial crisis can be attributed to commencement of shale gas revolution around 2010 in Utica and Marcellus shale regions in Appalachian basins.



❑ Understanding Market Perceptions of WTI NYMEX Crude Oil Futures

Analysis of futures price of a commodity can indicate the market perception of the possible price of the commodity in the future.

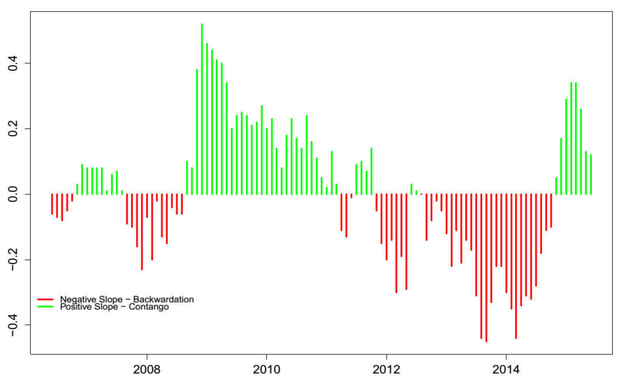
WTI NYMEX Crude Oil futures (Ticker CLA) are analyzed at monthly resolution for a period 2006-2015.

$$\textbf{Slope of future curve for month i} = \frac{P_{i+60} - P_{i+1}}{\Delta T}$$

P_{i+60} : Price of Future on the last month (60th)of the curve
P_{i+1} : Price of Future on the first month of the curve
ΔT : Time period (5years)

- Contango : Future prices increase with time → Positively Sloped
  Backwardation : future prices decrease → Negatively Sloped.
- WTI NYMEX crude oil future prices swayed back and forth from contango to backwardation and back from time to time.
- **Between 2013-2014, the slopes were negative indicating that the market had been perceiving drop in crude oil prices.**

Slopes of NYMEX WTI Crude Oil Future Curves 2006−2015



❑ Impact of Shale Exploration on WTI Cushing Crude Oil price returns and realized variance

Regression Modelling

Multivariate linear regression models are constructed using appropriate predictors and a factor to analyze the impact of shale gas exploration on each for oil price returns and oil price realized variance.

$$Y = \alpha + \sum \beta_j X_j + \gamma F$$

Y: output variable (oil price returns and realized variance)
Xi: ith predictor; F : Factor
α: the Intercept; β, γ : the coefficients

- Significance of coefficients using p-value approach → significant predictors and the significance of the factor.
- Stepwise regression using Akaike information criterion (AIC) as a criterion → selecting the predictors based on the lower AIC.
- A factor (dummy variable) → Impact of shale exploration on U.S. oil price returns and volatility. The first week of January 2010 is used as point of transition.

WTI Cushing Crude Oil Price Returns

The WTI crude oil weekly price returns for the period 2000-2015 are calculated as,

$$PR_i = \frac{(P_{i+1} - P_i)}{P_i}$$

PRi: price return for oil price
Pi: price of oil for the ith time period where the price is at weekly intervals

The predictors are transformed like returns to understand the price movement of oil with respect to the movement of predictors.

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-0.05888	0.01846	-3.19	0.00149
Total Storage	-2.54666	7.45283	-0.342	0.73268
Commercial Storage	0.36982	2.51244	0.147	0.88302
Domestic Production	0.11298	0.259	0.436	0.6628
Net Imports	0.11774	0.09836	1.197	0.23167
Total Oil to Refineries	-0.54555	0.29245	-1.865	0.06254
Factor	0.03032	0.01215	2.497	0.01277

- The p-value approach shows that the predictor total to refineries and factor are statistically significant.
- In stepwise regression, the lowest AIC were found corresponding to the predictors, total to refineries and factor.
- **The shale gas exploration has significant impact on WTI Cushing oil price returns.**

WTI Cushing Crude Oil Price Returns Realized Variance

Realized variance of oil price returns is calculated at weekly resolution for a period 2004-2014 using the formula.

$$RV = \frac{1}{n}\sum_{i=1}^{n} Ri^2$$

PRi: weekly realized variance
Ri: oil price returns for each day, n as number of trading days in the week

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	0.0011	0.0001	9.0020	< 2e-16
Total Storage	0.0413	0.0121	3.4110	0.0007
Domestic Production	-0.0016	0.0017	-0.9590	0.3378
Net Imports	-0.0011	0.0007	-1.6200	0.1058
Total Oil to Refineries	0.0027	0.0019	1.4200	0.1560
Factor	-0.0003	0.0001	-4.6060	5.01e-06

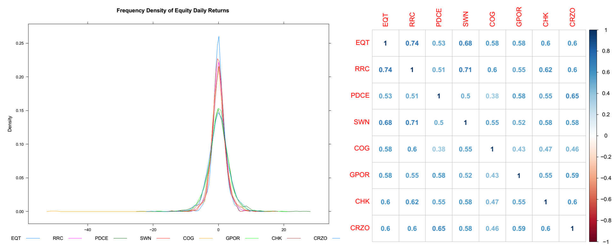
- The p values corresponding to the factor and the predictor oil production are statistically significant.
- In stepwise regression, the lowest AIC corresponds to factor and oil production.
- **Statistical significance of factor indicates shale gas exploration plays important role in realized variation of WTI Cushing oil price returns.**

❑ Analysis of Energy Equities related to Shale Gas Exploration

Daily price returns of equities for eight energy E&P companies related to shale gas exploration were analyzed for Jan 2000 to Jun 2015.

- These equities have low daily returns of range (-0.031% to 0.144%), annualized returns are more than 15% for four equities.
- They have very high annualized volatility (daily volatility measured by standard deviation of daily realized variance), seven are > 500%.
- Correlation matrix of these equities shows 24 out of 28 pairs have correlation of more than 0.5.

	Mean Daily Returns (%)	Annualized Return (%)	Variance (Daily)	Daily Volatility (Standard Dev. %)	Annualized Volatility (%)
EQT	0.063	15.84	3.63	1.90	476.11
RRC	0.026	6.42	5.22	2.28	571.02
PDCE	0.140	34.99	12.02	3.47	866.81
SWN	-0.031	-7.68	4.37	2.09	522.68
COG	0.035	8.64	9.41	3.07	766.95
GPOR	0.144	35.90	10.34	3.22	804.01
CHK	-0.029	-7.21	6.39	2.53	632.09
CRZO	0.095	23.83	9.62	3.10	775.27



	EQT	RRC	PDCE	SWN	COG	GPOR	CHK	CRZO
EQT	1	0.74	0.53	0.68	0.58	0.58	0.6	0.6
RRC	0.74	1	0.51	0.71	0.6	0.55	0.62	0.6
PDCE	0.53	0.51	1	0.5	0.38	0.58	0.55	0.65
SWN	0.68	0.71	0.5	1	0.55	0.52	0.58	0.58
COG	0.58	0.6	0.38	0.55	1	0.43	0.47	0.46
GPOR	0.58	0.55	0.58	0.52	0.43	1	0.55	0.59
CHK	0.6	0.62	0.55	0.58	0.47	0.55	1	0.6
CRZO	0.6	0.6	0.65	0.58	0.46	0.59	0.6	1

Conclusions

- **In the period 2000-2015, substantial increase in U.S. Crude Oil production since 2010 along with reduction in imports.**
- **Strong growth of production in U.S. after financial crisis can be attributed to commencement of shale gas exploration around 2010 in Utica and Marcellus shale regions in Appalachian basins.**
- **WTI NYMEX crude oil future prices swayed back and forth from contango to backwardation and back with time.**
- **In 2013-2014, the slopes were negative indicating that the market had been perceiving drop in crude oil prices.**
- **Shale gas exploration has significant impact on WTI Cushing oil price returns.**
- **Shale gas exploration plays important role in realized variation of WTI Cushing oil price returns.**
- **Analysis of eight companies related to shale gas exploration show that four equities have high annualized returns (>15%), all have very high annualized volatility (>500%) and most pairs are highly correlated (>0.5).**

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