A crude oil economic model for PSE applications

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Introduction

- Crude oil is **a reference component for the Oil&Gas** sector, as it is the precursor of a number of chemical processes, commodities and utilities.
- Its cost is well-known, largely available in several databanks such as EIA, IEA, ICIS, and periodically updated.
- Fluctuations in the crude oil prices have both **direct and indirect impact on global economy**.
- The prices of crude oil are tracked very closely not only by investors worldwide, but also by decision makers in process design. Crude oil is a reference component in **chemical supply chains** and plays a major role in Conceptual Design of chemical plants whenever the economic assessment and **feasibility study over short-, medium- and long-term horizons** are concerned.

- Fluctuations of crude oil quotations are driven by imbalances between supply and demand and by uncertainties originated by **political, economic and financial contributions, and geopolitical and weather-related incidents**.

Time	Event	Δprice (%)	Δtime (Q)	Absolute values (USD/bbl)
July - December 2008	Financial crisis	-69.3	3	From 133.37 to 41.12
Since 2011	Shale gas / decrease of crude oil imports in the US, and too many stocks in Cushing	shift WTI/Brent	13	-
15/02/2011 and 11/03/2011	War in Libya and tsunami in Japan / Fukushima	16	1	From 88.58 to 102.76
November 2011 - March 2012	Political tensions with Iran/ strikes of oil workers in Nigeria	9.3	2	From 97.13 to 106.16
May - July 2012	End of the tensions / slow growth in China	-14.6	2	From 94.65 to 87.9
June - August 2013	Threat of an American attack to Syria	11.3	1	From 95.77 to 106.57

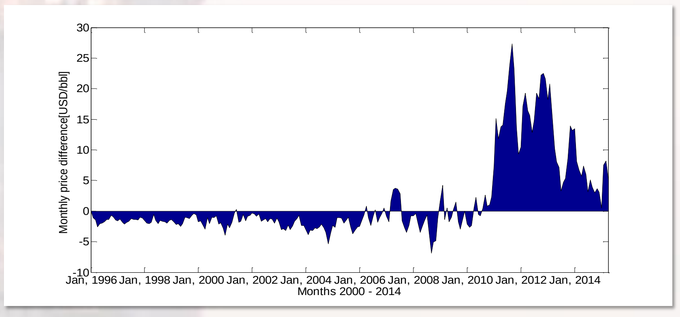
Methods

Econometric models do not take into account the forces that cause price fluctuations, but they are focused only on features of historical trends.

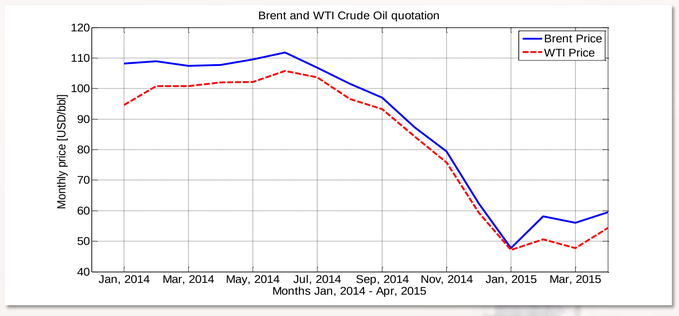
- Catch the historical fluctuations of prices;
- Short-, medium- and long-term horizons;
- Neglect the dependency of economic terms from the time-varying market oscillations;
- Price shocks are described by suitable stochastic contributions.

Economic models account for economic real variables and simulate the fluctuations of crude oil prices according to the Supply & Demand law.

- Take into account *physical* variables;
- Study the reasons of historical market trends;
- Need to be often updated because of unpredictable events;
- Difficult long-term forecast of involved variables.



The **quotations of WTI and Brent** are respectively influenced by US and Europe markets and their political, economical, financial decisions/strategies.
Since 2011, WTI and Brent quotations have lost their mutual consistency, because the expansion in shale oil production resulted in the lack of outward flowing pipeline capacity from Cushing reservoir to the refineries on the US Gulf Coast, which saw WTI trade at substantial discount rates respect to Brent quotations.



The roots of Q4 2014 crash lie on different factors: the massive reduction in import growth of China, the stagnation of oil demand in western countries and Japan, the oversupply due to US fracking boom and growth of Canada's oil sands, an imbalance in price ratios between oil and natural gas, the role of speculative investors, and higher dollar/other currency ratios were responsible for the **50% drop of crude oil price from July, 2014 to Dec, 2014**.
This points out that no real support level exists in the current oil marketplace.

Results

Crude oil price model

$$P_t = \alpha_0 + \alpha_1 Days_t + \alpha_2 Quotas_t + \alpha_3 Cheat_t + \alpha_4 Caputil_t + \alpha_5 Delta_t$$

$$Days_t = \frac{Inventory_t}{Demand_t}$$

$$Cheat_t = Production_t^{OPEC} - Quotas_t$$

$$Caputil_t = \frac{Production_t^{OPEC}}{Capacity_t^{OPEC}}$$

$$Delta_t = Production_t^{OPEC} - Production_t^{USA}$$

Input variables

$$Demand_{t+1}^{OECD} = \beta_0 GGDP_{t+1} + \beta_1 P_t + \beta_2 Q_1 + \beta_3 Q_2 + \beta_4 Q_3 + \beta_5 Q_4$$

$$Inventory_{t+1}^{OECD} = \gamma_0 + \gamma_1 Capacity_t^{OPEC} + \gamma_2 Demand_{t+1}^{OECD}$$

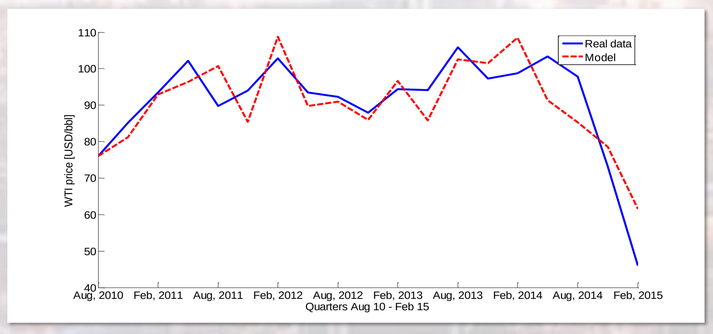
$$Capacity_{t+1}^{OPEC} = \delta_0 + \delta_1 Inventory_{t+1}^{OECD}$$

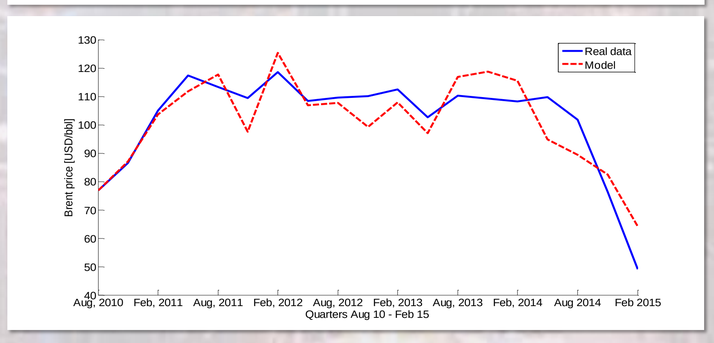
$$Production_{t+1}^{OPEC} = \vartheta_0 + \vartheta_1 Inventory_{t+1}^{OECD} + \vartheta_2 P_t$$

$$Production_{t+1}^{USA} = \omega_0 + \omega_1 Production_t^{USA} + \omega_2 Inventory_{t+1}^{OECD}$$

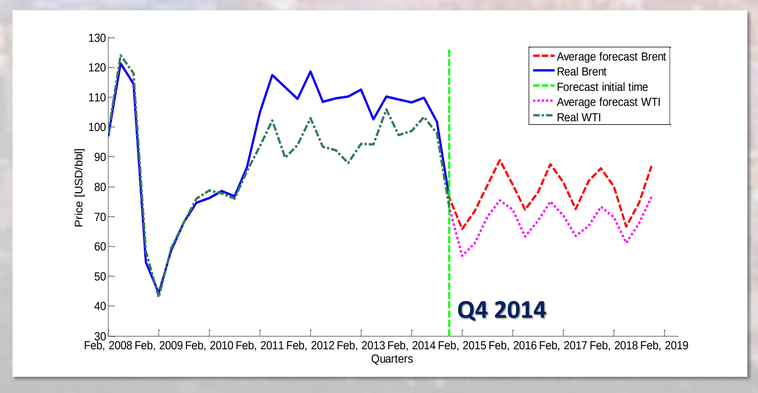
Coefficient	WTI	Brent
α_0	717.1619	629.7461
α_1	-7.4439	-7.2994
α_2	-36.0783	-46.5462
α_3	-40.8353	-52.1525
α_4	513.3242	768.8437
α_5	18.4018	25.7076
R	0.83	0.88

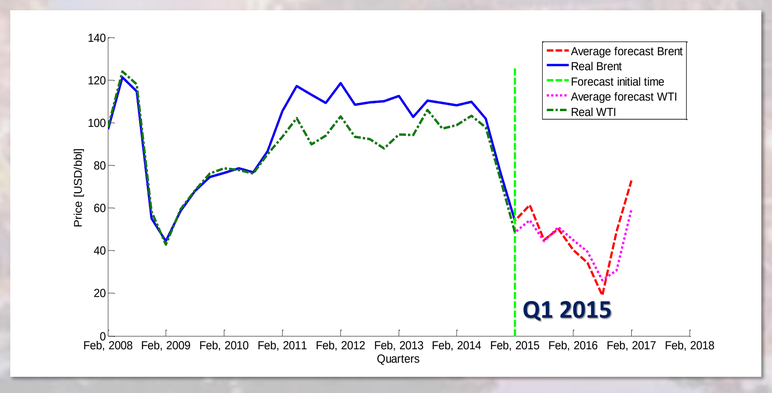
The model is **linear** in the adaptive parameters whose values are calculated by a regression procedure.
The **sign of estimated parameters** is consistent with previous literature results. It is worth observing the different values of Brent parameters respect to WTI ones. This is mainly due to the **dissimilar evolution of Brent and WTI quotations**.





The results of **one-step ahead simulations** are acceptable over short- and medium–term horizons, i.e. for planning and scheduling problems.





The need for distinct scenarios comes from the necessity to solve both planning and scheduling problems.
These **scenarios** are created under the hypothesis of **bullish trend of GGGDP** (i.e. 2% annual constant increase). We can see that in the next future quarters the expected trend of crude oil prices fluctuates between 30 and 60 USD/bbl.

Conclusions

- **OPEC model** is a new revised economic model to forecast the evolution of crude oil quotations over **short- and medium-term horizon (i.e. scheduling and planning)**.
- The power of the proposed economic model consists in its capability to account for the **stochastic nature of crude oil prices**, and for both **oil producers and consumers** to influence and determine the price dynamics.
- The proposed model can simulate different **reference scenarios** based on a set of stochastic trends and physical variables evolution, which identify possible distributions of economic trends to answer the typical question of PSE applications about the feasibility of products and processes;
- The economic background of producer and consumer countries has changed in the last 5 years, as OPEC and OECD do not include the so-called BRIC countries (i.e. Brazil, Russia, India, and China) and other emerging countries such as Indonesia. Consequently, it is advisable to update the model parameters rather often (i.e. every year) because of the **ever-changing events** that may influence market quotations.

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