Energy commodity price dynamics: understanding oil price volatility

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Outline

- Aim
- Some key literature
- Some results
- Conclusions
Aim

- To identify the various factors that affect the dynamics of crude oil spot prices
  - speculation vsn structural factors.
- To use a VAR framework to identify a relationship among WTI and some macroeconomic and financial variables.
The crude oil market has been experiencing serious changes caused by economic and political issues.

The price of crude oil took 4 years to move from \(US\$50/bl\) to \(US\$143/bl\) and in only 4 months went back to the original price in 2008.

In January 2011, oil analysts expected the oil price to reach \(US\$200/bbl\) (Nomura’s CEO on Jan 23).

From December 2010, WTI and Brent do not show a unique price (a spread of $25 on August 28, 2011!)

In the last 4 months there has been a new rapid change in oil price dynamics.
The main question

Do oil price increase for a speculative bubbles or simply reflects fundamental factors?

- oil bubble is not due to speculation but it may be a result of other variables linked to the growing consumption of emerging countries (China and India) and the increasing cost of drilling and exploration activities. (Krugman 2009)
- The demand growth from China is not the predominant reason for the dramatic oil price increase in 2002-2008. (Mu and Ye, The Energy Journal 2011, vol.32)
- "financial speculators have been responsible for driving crude oil prices to their peaks in the first hal of 2008..." (Soros 2008)
Some empirical studies:

- **Fundamentals vs speculation:**
  1. Hamilton (2009)

- **The role of exchange rates on oil price dynamics:**
  1. Chen et al. (2008); Amano and Norden (2008)

- **The role of gold:**
  1. Diba and Grossman (1984); Wang et al. (2010); Malliaris & Malliaris (2009)
The dataset

Monthly data over the period 1993-2010,

- West Texas Intermediate (WTI) crude oil spot price;
- 5-year Constant Maturities US interest rate
- $/€ exchange rate
- Futures Open Interest (n. contracts)
- gold prices $/oz
- US imports of oil (thousands of barrels)
Some graphs: WTI- Exchange Rates

1993-2000

2001-2009
Some graphs: WTI-Interest Rates

1993-2000

2001-2009
Some graphs: WTI- Futures Open Interest

1993-2000

2000-2009

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Uncertainty about the situation in Europe, along with the long-term fiscal outlook of the US, keeps gold underpinned both in terms of euros and in terms of dollars. Clearing Houses turned to gold collateral. That will continue to drive interest in gold.

[Graph showing the 5-year gold price in USD/oz from 2007 to 2011]
WTI- Gold

Gold prices

Crude oil

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The methodology

- Test the stationarity of the data.
- VECM framework (Johansen ’88, ’94) to estimate a possible cointegration relationship among these variables.
- Normalization imposing some overidentifying restrictions
- Test for weak exogeneity of some variables
Given oil prices and exchange rates may have experienced some structural breaks

1. To test for the presence of structural breaks (Bai, and Perron test: UD max vs WD max).

2. To run two different test for the order of integration Augmented Dickey-Fuller (ADF), and the Ng and Perron’ M-test.
The stationarity analysis

Table 2: Unit root test results.

<table>
<thead>
<tr>
<th></th>
<th>$WTI_t$</th>
<th>$r_t$</th>
<th>$FX_t$</th>
<th>$Im_t$</th>
<th>$OI_t$</th>
<th>$G_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series in level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADF</td>
<td>-0.80</td>
<td>-0.96</td>
<td>0.15</td>
<td>0.85</td>
<td>0.84</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>(0.85)</td>
<td>(0.76)</td>
<td>(0.66)</td>
<td>(0.55)</td>
<td>(0.56)</td>
<td>(0.99)</td>
</tr>
<tr>
<td>PP</td>
<td>-0.75</td>
<td>-1.09</td>
<td>-0.17</td>
<td>0.93</td>
<td>0.85</td>
<td>2.32</td>
</tr>
<tr>
<td></td>
<td>(0.87)</td>
<td>(0.24)</td>
<td>(0.62)</td>
<td>(0.71)</td>
<td>(0.89)</td>
<td>(0.99)</td>
</tr>
<tr>
<td>Series in first differences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADF</td>
<td>-6.52</td>
<td>-10.17</td>
<td>-10.41</td>
<td>-2.65</td>
<td>-16.09</td>
<td>-15.14</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>PP</td>
<td>-8.71</td>
<td>-10.16</td>
<td>-10.35</td>
<td>-3.86</td>
<td>-12.26</td>
<td>-15.14</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
</tbody>
</table>

Note: p-values are provided in parenthesis. The lag length was selected by using the Schwarz Information Criterion (SIC).
Some Results

Cointegration test results

Table 3: Cointegration rank test (1993-2009).

<table>
<thead>
<tr>
<th>Nr. of coint. vec.</th>
<th>Eigenvalue</th>
<th>$\lambda_{trace}$</th>
<th>$\lambda_{trace}^{0.05}$</th>
<th>$\lambda_{max}$</th>
<th>$\lambda_{max}^{0.05}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r = 0$</td>
<td>0.206</td>
<td>98.05</td>
<td>95.75</td>
<td>45.76</td>
<td>40.08</td>
</tr>
<tr>
<td>$r \leq 1$</td>
<td>0.095</td>
<td>52.28</td>
<td>69.82</td>
<td>19.92</td>
<td>33.87</td>
</tr>
<tr>
<td>$r \leq 2$</td>
<td>0.062</td>
<td>32.37</td>
<td>47.86</td>
<td>12.75</td>
<td>27.58</td>
</tr>
<tr>
<td>$r \leq 3$</td>
<td>0.051</td>
<td>19.62</td>
<td>29.79</td>
<td>10.26</td>
<td>21.13</td>
</tr>
<tr>
<td>$r \leq 4$</td>
<td>0.043</td>
<td>9.36</td>
<td>15.49</td>
<td>8.79</td>
<td>14.26</td>
</tr>
<tr>
<td>$r \leq 5$</td>
<td>0.0028</td>
<td>0.57</td>
<td>3.84</td>
<td>0.56</td>
<td>3.84</td>
</tr>
</tbody>
</table>

One cointegration vector is found
To interpret a cointegration relation we need to normalize the expression setting the coefficient of the WTI.
In order to do so we impose some restrictions on coefficients $B_2 = 1$.
We so obtain the following expression:

$$WTI = -43.95 + 0.44r_t - 0.44OI_t + 0.06IM_t + 2.80FX_t + 5.37G_t + \eta_i$$

All the coefficients result statistically significant at a 5% level.
Weak exogeneity test

Given the size of the coefficients we observe that gold and exchange rates may represent the main drivers of volatility for oil. We test for weak exogeneity of these variables looking at the adjustment coefficients of the VECM analysis. The null hypothesis run on the partitioned representation of the adjustment coefficients cannot be rejected so gold and exchange rates result to be weakly exogeneous with respect to the cointegration coefficients.
Concluding Remarks

A long run equilibrium among the chosen variables is found: The main role seems to be played by the exchange rate and the gold price. The two variables are found to be weakly exogenous respect to the long run equilibrium relationship. This means that gold and foreign exchanges fluctuations may be independent by the cointegrating relationship