Is the World Oil Market Unified?
Regions in Quality, Risk, & Space

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Since We Last Met..
The 2014 Price Forecast

$91.82 $93.00 $94.71 $101.00 $103.00 $105.00 $108.00 $112.00 $118.00 $130.00

Nomisma Energia Citi Link EIA Turner Mason Goldman Sachs BNP Parisbas BoA Oil Outlooks CIBC Barclays

Dollars per Barrel
A Bearish Forecast?

• Steady Growth in Supply
  • Additions to OPEC capacity (mainly Africa)
  • Increases in non-OPEC crude oil production (US)
  • Increases in natural gas production
• Slow grow in consumption
  • Slow economic growth
  • Increasing efficiency
• **Unified World Oil Market**
  - Production flows seamlessly across physical, technical, and political barriers.

• **Policy Implications**
  - Supply shocks
  - Inventory draws
Existing Results

• The crude oil market is unified
  - Oil prices cointegrate
  - Arbitrage models

• The crude oil market is regionalized
  - Not all price pairs cointegrate
  - Price discrimination
Three Questions

• Is the world crude oil market unified?
  - Daily spot prices for 33 crude oils
  - November 27, 2002 through December 31, 2010
  - Test 528 pairings for cointegration using ADF

• What factors regionalize the world oil market?
  - Logit Model (Cointegration = 1.0)
  - API gravity, Country Risk, Distance between Sources

• What are the costs of regionalization?
  - Price differences of crude oil price
### Unified vs. Regionalized ADF Results

<table>
<thead>
<tr>
<th>Critical value</th>
<th>Cointegrate</th>
<th>Do not cointegrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.90 (p = 0.01)</td>
<td>408</td>
<td>120</td>
</tr>
<tr>
<td>-3.33 (p = 0.05)</td>
<td>447</td>
<td>81</td>
</tr>
<tr>
<td>-3.04 (p = 0.10)</td>
<td>468</td>
<td>60</td>
</tr>
</tbody>
</table>
# Cointegration Varies by Crude Oil

<table>
<thead>
<tr>
<th>Crude Oil</th>
<th>Cointegrate</th>
<th>Non-Cointegrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kirkuk (Iraq)</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>Iranian Heavy</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Cabinda (Angola)</td>
<td>21</td>
<td>11</td>
</tr>
<tr>
<td>Es Sider (Libya)</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>Minus (Indonesia)</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Mars Blend (US)</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>Alaska North Slope (US)</td>
<td>32</td>
<td>0</td>
</tr>
<tr>
<td>West Texas Sour (US)</td>
<td>32</td>
<td>0</td>
</tr>
</tbody>
</table>
Logit Model

Dependent variable \((C_{ij})\)
- Pair cointegrates \((C_{ij} = 1, \text{ else } C_{ij} = 0)\)

Independent variables
- Light_Heavy \((40^\circ \text{ and } 34^\circ)\)
- High_Low \((\text{Low risk} = 0)\)
- Total Risk \((\text{Add country risk scores)}\)
- Distance \((\text{Distance between supply ports km)}\)
- Opec_NonOpec
- Sweet_Sour \((0.5\% \text{ vs } 1.5\% \text{ sulfur)}\)
- Ftr_t \((\text{Ocean, Road, Rail, inland)}\)
## Logit Results

<table>
<thead>
<tr>
<th></th>
<th>1 %</th>
<th>5 %</th>
<th>10 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.94**</td>
<td>5.15**</td>
<td>5.78**</td>
</tr>
<tr>
<td>Heavy_Light</td>
<td>-0.96*</td>
<td>-2.01**</td>
<td>-1.72**</td>
</tr>
<tr>
<td>High_Low</td>
<td>-1.58**</td>
<td>-2.12**</td>
<td>-2.15**</td>
</tr>
<tr>
<td>Total_Risk</td>
<td>-0.35**</td>
<td>-0.38**</td>
<td>-0.38**</td>
</tr>
<tr>
<td>Distance</td>
<td>2.58E-04**</td>
<td>3.18E-04**</td>
<td>3.28E-04**</td>
</tr>
<tr>
<td>Kirkuk</td>
<td>-1.57*</td>
<td>-2.42**</td>
<td>-2.95**</td>
</tr>
<tr>
<td>Iran_Heavy</td>
<td>-2.21**</td>
<td>-2.99**</td>
<td>-3.55**</td>
</tr>
</tbody>
</table>

Sweet_Sour, OPEC_NonOpec, Futures Not statistically significant
API Gravity

Refinery Flowchart

- CD
- HYT
- REF
- HR
- FCC
- VD
- COK

Products:
- Light Ends
- Gasoline
- Diesel Oil
- Lt Ends
- Gasoline
- Diesel Oil
- Coke
Regionlized 2002 Venezuela Strike

- U.S. imports of crude oil from Venezuela fell by 24.6 million barrels between November and December 2002
- Total US monthly imports fell by 23.9 million barrels
- Replacements available from Middle East (Saudi Arabia, Kuwait, and Iraq) but 30 day shipping
- US drew down crude oil inventories by about 10.5 million barrels.
Country Risk

- Risk of investing in a country; value depends on the overall stability of the business environment.
  - Regulatory changes through government action
  - Political events such as riots or civil wars
  - Natural events such as earthquakes and hurricanes
- Ability of suppliers to deliver crude oil
  - Revolutionary Armed Forces of Columbia (FARC)
  - Attacks on Caño Limon pipeline interrupted supply
Geographic Risk & Geographic Regions

- Panama Canal: 17 mbd
- Suez Canal/SUMED Pipeline: 3.4 mbd
- Strait of Hormuz: 2.9 mbd
- Bab el-Mandab: 3.0 mbd
- Strait of Malacca: 15.8 mbd
- Danish Straits: 3.4 mbd
- Turkish Straits: 3.0 mbd
Cost of Regionalization
Reasons for Price Differences

• Arbitrage (physical differences, location)
  - Constant of cointegrating relation
  - Average difference

• Disequilibrium
  - Error from cointegrating relation

• Regionalization (stochastic trend)
  - Differences beyond average difference
Cost of Regionalization

• Arbitrage (physical differences, location)
  - $1.26 Intercept cointegrating relation
  - $3.96 Average difference across regions
• Disequilibrium
  - $1.43 Error from cointegrating relation
  - $1.63 Average error
• Stochastic trend
  - $0.20 Differences beyond average difference
Policy Implications

• Supply Shocks
  - Unreliable supplier price discount
  - Does the market understate risk?

• Inventory Draws
  - SPR Light sweet crude oils
  - Match crude oils with local refining capacity