Quantifying the Risk and Price Impact of Energy Policy Events on Physical Natural Gas Markets Using R

Soumya Kalra and Vincenzo Giordano
sokal1456@gmail.com and vincenzo.giordano01@gmail.com

May 29, 2015
There are hundreds of federal, state, and local government offices in the US.
Energy Policy Maker Considered: FERC

Under the Natural Gas Act (NGA), FERC has jurisdiction over:
- transportation and sale of natural gas;
- approval of new pipelines.

FERC is also responsible for preventing fraud and manipulation on energy markets.
Henry Hub Natural Gas Price is the industry benchmark price
Natural Gas is primarily driven by weather events and commercial and residential demand.
There are several Henry Hub future contracts available on NYMEX. In this study we consider future contracts up to 12 month because policy events i.e. new pipeline approvals will not impact immediate contracts.
There are several steps in FERC rulemaking process. In this study we only consider the following events: (1) rule is announced (NOI/NOPR); (2) rule is made final (Final); (3) rule is made effective (Effective).
Our Goals with this project

1. Identify significant policy events from FERC that can have a potential impact on natural gas demand and supply.
2. Estimate the expected magnitude market movement using Henry Hub futures curves.
3. Derive a sentiment from the policy type to indicate the market impact direction.
Henry Hub returns summary statistics

Historical prices from May 2010 to May 2015

<table>
<thead>
<tr>
<th>Contract</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG1</td>
<td>-0.028</td>
<td>2.736</td>
<td>0.309</td>
<td>2.395</td>
</tr>
<tr>
<td>NG2</td>
<td>-0.03</td>
<td>2.598</td>
<td>-0.206</td>
<td>5.531</td>
</tr>
<tr>
<td>NG3</td>
<td>-0.031</td>
<td>2.304</td>
<td>0.294</td>
<td>1.543</td>
</tr>
<tr>
<td>NG4</td>
<td>-0.032</td>
<td>2.133</td>
<td>0.055</td>
<td>2.394</td>
</tr>
<tr>
<td>NG5</td>
<td>-0.034</td>
<td>1.959</td>
<td>0.175</td>
<td>1.031</td>
</tr>
<tr>
<td>NG6</td>
<td>-0.038</td>
<td>1.882</td>
<td>0.363</td>
<td>2.295</td>
</tr>
<tr>
<td>NG7</td>
<td>-0.041</td>
<td>1.817</td>
<td>0.411</td>
<td>3.062</td>
</tr>
<tr>
<td>NG8</td>
<td>-0.042</td>
<td>1.737</td>
<td>0.138</td>
<td>1.264</td>
</tr>
<tr>
<td>NG9</td>
<td>-0.041</td>
<td>1.667</td>
<td>-0.134</td>
<td>1.951</td>
</tr>
<tr>
<td>NG10</td>
<td>-0.041</td>
<td>1.569</td>
<td>-0.212</td>
<td>2.846</td>
</tr>
<tr>
<td>NG11</td>
<td>-0.043</td>
<td>1.493</td>
<td>-0.36</td>
<td>4.939</td>
</tr>
<tr>
<td>NG12</td>
<td>-0.043</td>
<td>1.446</td>
<td>-0.181</td>
<td>5.361</td>
</tr>
</tbody>
</table>
## Henry Hub volatility summary statistics

**Historical prices from May 2010 to May 2015**

<table>
<thead>
<tr>
<th>Contract</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG1</td>
<td>2.071</td>
<td>1.788</td>
<td>2.002</td>
<td>7.394</td>
</tr>
<tr>
<td>NG2</td>
<td>1.951</td>
<td>1.714</td>
<td>2.793</td>
<td>19.85</td>
</tr>
<tr>
<td>NG3</td>
<td>1.785</td>
<td>1.456</td>
<td>1.716</td>
<td>5.674</td>
</tr>
<tr>
<td>NG4</td>
<td>1.654</td>
<td>1.347</td>
<td>2.024</td>
<td>9.638</td>
</tr>
<tr>
<td>NG5</td>
<td>1.539</td>
<td>1.212</td>
<td>1.537</td>
<td>4.353</td>
</tr>
<tr>
<td>NG6</td>
<td>1.457</td>
<td>1.191</td>
<td>2.009</td>
<td>8.795</td>
</tr>
<tr>
<td>NG7</td>
<td>1.402</td>
<td>1.157</td>
<td>2.237</td>
<td>11.912</td>
</tr>
<tr>
<td>NG8</td>
<td>1.353</td>
<td>1.09</td>
<td>1.663</td>
<td>4.55</td>
</tr>
<tr>
<td>NG9</td>
<td>1.287</td>
<td>1.059</td>
<td>1.922</td>
<td>7.09</td>
</tr>
<tr>
<td>NG10</td>
<td>1.206</td>
<td>1.003</td>
<td>2.204</td>
<td>10.753</td>
</tr>
<tr>
<td>NG11</td>
<td>1.14</td>
<td>0.965</td>
<td>2.682</td>
<td>19.763</td>
</tr>
<tr>
<td>NG12</td>
<td>1.094</td>
<td>0.947</td>
<td>2.846</td>
<td>19.726</td>
</tr>
</tbody>
</table>
We break out our event study into the three policy types that Vincenzo explained: (1) rule is announced (NOI/NOPR); (2) rule is made final (Final); (3) rule is made effective (Effective)

Define time range: events between 8/31/2010 and 3/31/2015

Define the event window: -20 to +20 days relative to the FERC announcement.

Establish criteria for selection

Calculate normal and abnormal returns for each of the contracts: use OLS with the estimation window of -20 to -80 days relative to the FERC announcement.

Estimate model parameters with data for each contract

Conduct significance test and present results

Interpret results and draw inferences and conclusions
Event Study Methodology

We used one of the most popular models in practice to calculate abnormal returns for each of the natural gas contracts with $R_{mt}$ as the index return:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \epsilon_{it}$$  \hspace{1cm} (1)

$$E[\epsilon_{it}] = 0 \quad \text{Var}[\epsilon_{it}] = (\sigma^2)_{\epsilon_i}$$  \hspace{1cm} (2)

$$AR_{it} = R_{it} - \frac{E(R_{it}, \Omega_{t-1})}{\Omega_{t-1}}$$  \hspace{1cm} (3)

where $AR_{it}$, $R_{it}$ and $\frac{E(R_{it}, \Omega_{t-1})}{\Omega_{t-1}}$ are the abnormal, actual and normal expected return at time $t$. $\Omega_{t-1}$ is the conditional information provided in period $t$. The linear model above follows assumed joint normality of returns.
Event Study Methodology

Daily Abnormal returns can be calculated in numerous ways but for this study we are going to focus on the market model. We are using the historical S&P GSCI Natural Gas Index Excess Return historically as the response variable in the regression because it has stronger historical correlation to the natural gas markets. We estimate our normal returns based on the equation below.

\[ E(NGret_T) = b_0 + b_1 \times E(SPGSNGPIndex) \] (4)
Here we are compute a test statistic to measure whether the average abnormal return for each contract for each event type is statistically different from zero at 5% level bounded by + or -1.96 for the t-stat level.
Results follow.
Average Abnormal Returns by Natural Gas contract for Effective events

(abnormal returns)

2010-09-30 2010-10-01 2011-02-25 2011-04-01 2011-04-01 2011-12-23 2012-03-27 ... Abnormal Returns by Natural Gas contract for Effective events

Soumya Kalra and Vincenzo Giordano
Average Abnormal Returns t-test results for Effective Event type

T-test results for Average Abnormal Returns for Effective Event type

(t-statistic)

2010-09-30 2010-10-01 ...

NG1 NG2 NG3 NG4 NG5 NG6 NG7 NG8 NG9 NG10 NG11 NG12

Soumya Kalra and Vincenzo Giordano |
Average Abnormal Returns by Natural Gas contract for NOI/NOPR events

(abnormal returns)
Average Abnormal Returns t-test results

NOI/NOPR

T-test results for Average Abnormal Returns for NOPR/NOI Event type
Average Abnormal Returns by Natural Gas contract for Final events

(abnormal returns)
T-test results for Average Abnormal Returns for Final Event type

(t-statistic)
Significant Policy Events

Effective:
(-) 5/31/13: Revisions to Procedural Regulations Governing Transportation by Intrastate Pipeline. → Increased costs in short term for bureaucracy.

NOI/NOPR:
(-) 12/20/12: Revisions to the Auxiliary Installations, Replacement Facilities, and Siting and Maintenance Regulations. → Increased costs in short term for bureaucracy.

Final:
(-) 1/20/11: NatGas companies should disclose amount of fuel waived, discounted or reduced as part of a negotiated rate agreement. → Increased costs in short term for bureaucracy.

▷ Regulatory events that increase bureaucratic burden on natural gas companies cause diminished returns in short term future contracts.
Further Analysis

- Regulatory events are characterized by several attributes. Further analysis on such attributes is required to better understand size and direction abnormal returns.
- Consider significant state regulation and compare it with the federal one to determine which has the most impact.
- We would posit that the event window could be broken down into an event time frame for + or - 10 days with post event window at +10 to +30 days.
- Clustering of abnormal returns.
That’s it folks!

Thank you for having us! We hope you enjoyed our presentation and please feel free to reach out to us with any questions!