Shale Producers Erosion of OPEC Market Power: Captured in an Empirical Dominant Firm Model

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Is OPEC a Cartel?

Is this a good question? Let’s assume it is a cartel and see, given underlying market structure, what they might accomplish.

A better question: What are the limits on a cartel’s power? How much can OPEC affect the price of oil? How does the recent tight oil revolution change the answer to this question?

The first step is to estimate how changes in non-OPEC production affect OPEC’s ability to raise prices.
OPEC governments need astronomically high crude oil prices to prevent bankruptcy.
Price elasticity of excess demand for OPEC supply has been estimated in the past. Golombek et al., (2014) uses a 3SLS model to estimate this elasticity and OPEC’s market power. However, they do not allow for changes in those estimates over time. Rather they use quarterly data from 1986-2009 which would not capture recent changes. Other similar works:

- Huppman (2012)
- Golombek (2012)
Market or Mayhem?

Why are we confident oil markets are still dictated by rational actors rather than Saudi Arabia trying to drive shale producers out of business or animal spirits? Smith (2009) shows that markets are functioning through the financial crisis (red line).
Since the financial crisis, US production has risen.

Smith’s logic holds true over the last decade.

Figure: Data from the US Energy Information Administration.
Non-OPEC Production: 2007

Fringe Production (Regression with data from 2006-2008)

Price (USD)

Fringe Supply (mbpd)

Month

2015
2014
2012
2010
2008
2006
Non-OPEC Production: Since 2007
Market Structure: Slope of fringe supply affects OPEC.

**Figure:** OPEC faces demand $D_w - S_f$ with a slope that is minus the sum of the absolute value of $D_w$ and $S_f$'s slopes.
Market Structure: Slope of fringe supply affects OPEC.

Figure: OPEC faces demand $D_w - S_f$ with a slope that is minus the sum of the absolute value of $D_w$ and $S_f$'s slopes.
How to estimate? 3SLS.

\[ S_f = a_0 + a_1 P \]
\[ D_w = b_0 - b_1 P \]
\[ D_o = D_w - S_f = b_0 - a_0 - (b_1 + a_1) P. \]

OPEC selects the level of supply that sets marginal revenue equal to marginal cost.

\[ \frac{b_0 - a_0}{b_1 + a_1} - S_o \cdot \frac{2}{b_1 + a_1} = \frac{MC_o}{\alpha} = \frac{\bar{q} - S_o}{\bar{q} - S_o} \]

\[ S_o^* = \frac{a_0 - b_0 - 2\bar{q} \pm \sqrt{(a_0 - b_0 - 2\bar{q})^2 - 8((b_0 - a_0)\bar{q} - \alpha(a_1 + b_1))}}{4} \]
Equations to Estimate

Using a Stata’s non-linear solver for seemingly unrelated regressions, we can estimate these three equations in terms of instruments.

\[ \hat{S}_o = \frac{a_0 - b_0 - 2\bar{q} \pm \sqrt{(a_0 - b_0 - 2\bar{q})^2 - 8((b_0 - a_0)\bar{q} - \alpha(a_1 + b_1))}}{4} \]

\[ \hat{P} = \frac{b_0 - a_0}{b_1 + a_1} - \hat{S}_o \frac{1}{b_1 + a_1} \]

\[ \hat{S}_f = a_0 + a_1 \hat{P} \]

where slope of \( a_1 \) is allowed to change over time by being defined

\[ a_1 = (a_{1,P} + a_{1,share.Shale.Shale} + a_{1,horizontal.Share.Horizontal}) \]
## Instruments

<table>
<thead>
<tr>
<th>Shifter</th>
<th>Specification</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fringe Supply (horiz.)</td>
<td>$a_0$</td>
<td>1 Unplanned Disruptions, Unplanned Disruptions (lag), PPI – Directional Drilling, PPI – General Drilling</td>
</tr>
<tr>
<td>World Demand (horiz.)</td>
<td>$b_0$</td>
<td>1 China PMI yoy, US PMI yoy, Google Search: Justice, Google Search: The Justice, Avg MPG US Fleet</td>
</tr>
<tr>
<td>World Demand (slope)</td>
<td>$b_1$</td>
<td>1</td>
</tr>
<tr>
<td>OPEC Costs (non-linear)</td>
<td>$c_0$</td>
<td>alpha, OPEC Capacity</td>
</tr>
</tbody>
</table>
Results: Prices

Brent Crude Oil Prices

Price (Brent)  fitted values
Results: Fringe Production

![Graph showing Fringe Production from 2005 to 2020 with Non-OPEC Supply and fitted values.](image-url)
Results: OPEC Supply
Slopes over time?

Slope on Excess Demand for OPEC Supply

- Year: 2005 to 2020
- Slope values range from -0.36 to -0.366
## Estimates

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>t-stat</th>
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<tbody>
<tr>
<td>b1_P</td>
<td>-2.751</td>
<td>(-2.13)</td>
</tr>
<tr>
<td>a1_P</td>
<td>-0.0415</td>
<td>(-4.77)</td>
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<td>a1_share_horiz</td>
<td>0.0480</td>
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<td>a1_share_shale</td>
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<td>a0_1</td>
<td>54.26</td>
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<td>-2.142</td>
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<td>(-1.62)</td>
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<td>(-1.89)</td>
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<td>15.12</td>
<td>(2.22)</td>
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<td>b0_ggl_justice</td>
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<td>(-0.54)</td>
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<tr>
<td>b0_ggl_justice_d</td>
<td>-0.103</td>
<td>(-0.41)</td>
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<td>b0_mpg</td>
<td>16.34</td>
<td>(2.60)</td>
</tr>
<tr>
<td>alpha</td>
<td>242.8</td>
<td>(6.50)</td>
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Observations: 140

*t* statistics in parentheses
What does the real data look like?

Observed OPEC (left) and fringe (middle) supply and global demand (right)
What does the estimation look like?

Estimates for Supply, Demand and Cost Curves (2017)
OPEC governments need astronomically high crude oil prices to prevent bankruptcy.

Fiscal Breakeven for OPEC + Russia: 2016 & 2017

- Angola
- Russia
- UAE
- Saudi Arabia
- Algeria
- Iraq
- Qatar
- Kuwait
- Iran

Average Price in 2017 (51.82)

Average Price in 2016 (43.55)