DRILL-BIT PARITY:
SUPPLY-SIDE LINKS IN OIL & GAS MARKETS

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Motivation: A Regime Change
Demand to Supply

$\text{$/MMBTU}$

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WTI Prompt Month
Henry Hub Prompt Month
EIA NGL Composite Price
Motivation: A Regime Change
Demand to Supply

Oil Directed Rigs
Gas Directed Rigs
Oil & Gas Market Integration

- Traditional focus on demand-side
  - Marginal benefit
  - Burner-tip parity
    \[ P_{HH,t} = T + \frac{P_{BT,t}}{P_{WTI,t}} \frac{1}{E_{BT}} P_{WTI,t} \]

- We focus on two potential supply-side connections
  - Competition for inputs
    - Drilling rigs, specialized labor
  - Associated-commodity flows
    - Gas from oil wells, oil & oil substitutes from gas wells
Theoretical Model

- Representative firm allocates rigs towards natural gas wells or crude oil wells to maximize profits
  - Associated commodity parameters
  - Cost spillovers

\[
\text{Profit}_t = P_{o,t} f_{o,t} + P_{g,t} f_{g,t} - C(d_{o,t} + d_{g,t}, d_{o,t}, d_{g,t}, a_o d_g, a_g d_o)
\]

\[
\frac{\partial f_{g,t}}{\partial t} = d_{g,t} - r_g f_{g,t} + a_g d_{o,t}
\]
Theoretical Results

- Interested in cross-commodity price shocks
  - e.g., How does oil-price shock affect gas drilling, gas flow (supply), and prices?

- Analyze supply-side links separately
  - If input-competition (cost-spillover) is only link:
    - Oil-price shock leads to: less gas drilling, less gas supply, higher gas price
    - Converging prices
  - If associated-commodity is only link:
    - Oil price shock leads to: ambiguous gas drilling effect, increases gas supply, and decreases gas price
    - Ambiguity in drilling results from two effects
      - Lower gas price due to associated gas
      - Higher value of associated oil from oil wells
    - Possibly diverging prices
Empirical Strategy

- Isolate supply-side links by looking at drilling in five basins with oil and gas production
  - Anadarko (OK and TX), Chautauqua Platform (OK), East Texas Basin (TX), Fort Worth Basin (TX), Permian Basin (TX)
- Estimate own-price and cross-price elasticities using three-stage least squares
- Price instruments: Lagged Brent oil price, lagged HDDs and CDDs, lagged cumulative HDDs and CDDs
- Gas price instrument included in oil price first stage and vice versa to control for potential of demand-side links
- Monthly drilling and production from 2005 to 2016
## Empirical Results

<table>
<thead>
<tr>
<th>Basin</th>
<th>Total Wells</th>
<th>% Gas</th>
<th>% Oil</th>
<th>Gas Decline</th>
<th>Oil Decline</th>
<th>Assoc Gas</th>
<th>Assoc Oil</th>
<th>Gas Gather</th>
<th>Gas on Oil</th>
<th>Oil on Gas</th>
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<tbody>
<tr>
<td>Anadarko</td>
<td>24257</td>
<td>59.6</td>
<td>40.4</td>
<td>0.018</td>
<td>0.022</td>
<td>0.86</td>
<td>0.17</td>
<td>0.76</td>
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<td>0.44***</td>
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<td>Chautauqua</td>
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<td>47.0</td>
<td>53.0</td>
<td>0.015</td>
<td>0.013</td>
<td>0.52</td>
<td>0.046</td>
<td>0.63</td>
<td>-0.17*</td>
<td>0.29</td>
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<td>Platform</td>
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<tr>
<td>East Texas</td>
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<td>90.6</td>
<td>9.4</td>
<td>0.020</td>
<td>0.018</td>
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<td>Fort Worth</td>
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<td>84.6</td>
<td>15.4</td>
<td>0.017</td>
<td>0.022</td>
<td>0.75</td>
<td>0.042</td>
<td>0.57</td>
<td>-0.13**</td>
<td>0.31**</td>
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<td>Permian</td>
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<td>26.8</td>
<td>73.2</td>
<td>0.014</td>
<td>0.015</td>
<td>0.45</td>
<td>0.16</td>
<td>0.86</td>
<td>-0.28***</td>
<td>-0.25**</td>
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</table>
Empirical Results Summary

- Positive gas price shocks lead to less oil drilling
  - i.e., Negative gas price shocks generally lead to more oil drilling
  - Consistent with input competition (cost spillovers)
  - And/or associated oil with an inelastic oil demand curve and/or costly associated gas

- Positive oil price shocks lead to more gas drilling in most basins
  - Consistent with high value associated oil and/or elastic natural gas demand curve and/or low cost associated oil

- Positive oil price shock leads to less gas drilling in Permian basin
Conclusion

- We provide a theoretical model that highlights the roles of two supply-side links in oil and gas markets
  - Input competition
  - Associated commodity flows
- These supply-side links help explain changes in oil and gas market integration that have occurred since the onsets of the unconventional gas and oil “revolutions”
- Our empirical estimates indicate that these supply-side links are economically significant, and should be accounted for by analysts and policymakers