The macroeconomic effects of oil supply news: Evidence from OPEC announcements

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Introduction
Motivation

- Recent turbulences in the oil market have sparked **renewed interest** in the question of how **oil prices** affect the **macroeconomy**
Motivation

• Answering this question is **challenging** because
  • Oil prices are **endogenous**
  • Not all oil price shocks are **alike**

• The literature has focused on **oil supply** and **demand**

• Less attention has been devoted to **oil market expectations**
  • Mainly because identifying shocks to expectations is **difficult**
This paper

- Propose a novel approach to identify a shock to **oil supply expectations**, exploiting **institutional features of OPEC** and **high-frequency data**
  - Isolate exogenous variation in oil price by looking at how oil futures prices change around **OPEC announcements**
  - Use as an *instrument* in an oil market VAR to identify oil market shock
- Shock is best thought of as a **news shock** about future **oil supply**
• Oil supply news leads to an immediate increase in oil prices, a gradual fall in oil production, a significant increase in oil inventories and a fall in global activity

• This has consequences for the US economy: industrial production falls and consumer prices rise significantly

• Also leads to higher inflation expectations and a depreciation of the dollar but has no effect on uncertainty
I provide new insights to the debate on the drivers of oil price fluctuations and their effects on the macroeconomy.

- New source of information and identification strategy to shed light on the role of supply expectations.
- News about oil supply have powerful effects even if current oil production does not move $\Rightarrow$ strong channel operating through supply expectations.
Related literature

- **Macroeconomic effects of oil market shocks**: Hamilton (2003); Kilian (2009); Baumeister and Peersman (2013); Kilian and Murphy (2012, 2014); Juvenal and Petrella (2015); Antolín-Díaz and Rubio-Ramírez (2018); Caldara, Cavallo, and Iacoviello (2019); Baumeister and Hamilton (2019)

- **High-frequency identification of MP shocks**: Kuttner (2001); Gürkaynak, Sack, and Swanson (2005); Gertler and Karadi (2015); Nakamura and Steinsson (2018)

- **Event studies on OPEC announcements**: Draper (1984); Loderer (1985); Demirer and Kutan (2010); Lin and Tamvakis (2010), Loutia, Mellios, and Andriosopoulos (2016)

- **News and business cycles**: Barsky and Sims (2011); Beaudry and Portier (2014); Ramey (2011); Leeper, Walker, and Yang (2013); Arezki, Ramey, and Sheng (2017); Gambetti and Moretti (2017)
Identification
Oil market has a peculiar structure

- Market dominated by big player, OPEC, that reveals information about future supply in lumpy way
- Very liquid futures markets for oil

This motivates the use of high-frequency identification techniques

Idea: Identify oil supply surprises from changes in oil futures prices in tight window around OPEC announcements

Similar to high-frequency identification of monetary policy shocks
OPEC announcement

Having reviewed the oil market outlook, including the overall demand/supply expectations for the year 2007, in particular the first and second quarters, as well as the outlook for the oil market in the medium term, the Conference observed that market fundamentals clearly indicate that there is more than ample crude supply, high stock levels and increasing spare capacity. […]

In view of the above, the Conference decided to reduce OPEC production by a further 500,000 b/d, with effect from 1 February 2007, in order to balance supply and demand.

Source: Announcement from the 143rd meeting of the OPEC conference (14 Dec 2006)
Market reaction

Figure 1: Oil futures prices (1-month WTI crude) around announcement on 14 December 2006
Construction of oil supply surprises

- Collected **OPEC press releases** for the period 1983-2017
  - Total of 119 announcements
- Compute **oil supply surprises**:

  \[
  \text{Surprise}_{t,d}^h = F_{t+h,d} - F_{t+h,d-1},
  \]

  where \( F_{t+h,d} \) is log settlement price of \( h \)-month ahead WTI crude contract on announcement day \( d \) in month \( t \)
- Aggregate surprises to **monthly** series

  \[
  \text{Surprise}_t^h = \begin{cases} 
  \text{Surprise}_{t,d}^h & \text{if one announcement} \\
  \sum_i \text{Surprise}_{t,d_i}^h & \text{if multiple announcements} \\
  0 & \text{if no announcements}
  \end{cases}
  \]
Figure 2: Oil supply surprise series constructed from changes in oil futures prices (6-month WTI crude) around OPEC announcements
Oil supply surprise series

- Accords well with narrative accounts on **historical episodes**
- No evidence for autocorrelation
- Not forecastable by macroeconomic or financial variables
- Uncorrelated with measures of **other structural shocks** (e.g. global demand or uncertainty shocks)
Econometric framework
• **Oil supply surprise series** has good properties but is likely only imperfect shock measure

• **Solution:** use the series as an *instrument* in proxy VAR to identify *oil supply news shock*
  - Allows for *measurement error* in the instrument
  - Can trace out responses of financial and macro variables jointly
Proxy VAR

• Structural VAR

\[ y_t = b + B_1 y_{t-1} + \cdots + B_p y_{t-p} + S\varepsilon_t, \quad \varepsilon_t \sim N(0, \Omega) \]

• Identification based on external instruments (Stock and Watson, 2012; Mertens and Ravn, 2013)
  • **External instrument:** variable *correlated* with the **shock of interest** but *not* with the **other shocks**

\[ \mathbb{E}[z_t \varepsilon_{1,t}] = \alpha \neq 0 \quad \text{(Relevance)} \]
\[ \mathbb{E}[z_t \varepsilon_{2:n,t}] = 0, \quad \text{(Exogeneity)} \]

• Use **oil supply surprise series**, \( \text{Surprise}^h_t \), as external instrument, \( z_t \), for **oil price**
**Model specification**

- $y_t$ includes real oil price, world oil production, world oil inventories, world industrial production, US IP, US CPI
- Identification sample: 1983M2-2017M12
- VAR is estimated in (log) levels
- Lag order: $p = 13$
Results
Table 1: Strength of the instrument

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>1M</th>
<th>2M</th>
<th>3M</th>
<th>6M</th>
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<tr>
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<td>0.950</td>
<td>0.998</td>
<td>1.035</td>
<td>1.093</td>
<td>1.128</td>
<td>1.134</td>
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<tr>
<td>F-stat</td>
<td>26.81</td>
<td>25.05</td>
<td>25.49</td>
<td>25.61</td>
<td>24.24</td>
<td>24.06</td>
<td>15.55</td>
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<tr>
<td>F-stat (robust)</td>
<td>13.21</td>
<td>11.87</td>
<td>12.06</td>
<td>12.14</td>
<td>11.57</td>
<td>11.64</td>
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<tr>
<td>$R^2$</td>
<td>4.97</td>
<td>4.66</td>
<td>4.73</td>
<td>4.76</td>
<td>4.51</td>
<td>4.48</td>
<td>2.94</td>
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<tr>
<td>$R^2$ (adjusted)</td>
<td>4.78</td>
<td>4.47</td>
<td>4.55</td>
<td>4.57</td>
<td>4.33</td>
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<td>515</td>
<td>515</td>
<td>515</td>
<td>515</td>
<td>515</td>
</tr>
</tbody>
</table>

Notes: First-stage regressions of oil price residual on proxies. F-stats above 10 indicate strong instruments.

• High-frequency surprises are **strong instruments** for oil price
Baseline results

Figure 3: IRFs to oil supply news shock (one sd). Dashed lines are 90% CIs.
Baseline results

- Shock leads to a large, **immediate increase** in oil prices, **sluggish fall** in oil production and significant **increase** in oil inventories
  \[\Rightarrow\] **consistent** with interpretation of a **news shock** about oil supply
- Global activity falls persistently
- This has consequences for the **U.S. economy**:
  - Industrial production **falls** and consumer prices **rise** significantly
- Changes in **oil supply expectations** have **powerful effects** even if current oil production does not move
Figure 4: Historical decomposition. Dashed lines are 90% CIs.

- **Oil supply news** have contributed meaningfully to historical variations in oil price.
- Events in the Middle East affect the oil price not only through *current* supply but also changes in *supply expectations*.
To get a better understanding on how the shock propagates, study the effects on a wide range of financial and macroeconomic variables.

Implemented by augmenting baseline VAR by one variable at a time and computing impulse response.
Oil supply news lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
News versus uncertainty

Figure 5: Expectations and uncertainty measures
Oil supply news lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
Figure 6: Core CPI and CPI components
Oil supply news lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
Figure 7: Activity and labor market indicators
Oil supply news lead to

- higher oil price and inflation expectations, but do not affect uncertainty
- higher consumer prices, even after excluding energy
- lower economic activity, broadly defined
- depreciation of dollar and deterioration of terms of trade and trade balance
Figure 9: Exchange rates and trade
### Table 2: Forecast error variance decomposition

<table>
<thead>
<tr>
<th>Global variables and exchange rates:</th>
<th>Oil price</th>
<th>Oil production</th>
<th>Oil inventories</th>
<th>World IP</th>
<th>NEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.73</td>
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<td>0.04</td>
<td>0.05</td>
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<td>[0.23, 0.90]</td>
<td>[0.00, 0.03]</td>
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<td>12</td>
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<td>24</td>
<td>0.39</td>
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<td>0.02</td>
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<td>[0.00, 0.12]</td>
<td>[0.05, 0.56]</td>
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<td>48</td>
<td>0.37</td>
<td>0.14</td>
<td>0.24</td>
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<tr>
<td></td>
<td>[0.12, 0.62]</td>
<td>[0.05, 0.30]</td>
<td>[0.04, 0.56]</td>
<td>[0.01, 0.20]</td>
<td>[0.05, 0.49]</td>
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**Notes:** The table shows the forecast error variance decomposition at horizons 0, 6, 12, and 24 months together with 90% CIs.
Table 2: Forecast error variance decomposition cont.

<table>
<thead>
<tr>
<th>U.S. variables:</th>
<th>IP</th>
<th>CPI</th>
<th>FFR</th>
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<th>TOT</th>
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<td>0</td>
<td>0.07</td>
<td>0.11</td>
<td>0.01</td>
<td>0.00</td>
<td>0.13</td>
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<td></td>
<td>[0.00, 0.33]</td>
<td>[0.00, 0.48]</td>
<td>[0.00, 0.05]</td>
<td>[0.00, 0.02]</td>
<td>[0.00, 0.39]</td>
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<td>12</td>
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<td>0.00</td>
<td>0.01</td>
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<td>[0.12, 0.64]</td>
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<td>24</td>
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<td></td>
<td>[0.01, 0.29]</td>
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<td>[0.01, 0.10]</td>
<td>[0.12, 0.56]</td>
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<td>48</td>
<td>0.20</td>
<td>0.14</td>
<td>0.04</td>
<td>0.03</td>
<td>0.33</td>
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<td>[0.03, 0.43]</td>
<td>[0.01, 0.10]</td>
<td>[0.01, 0.08]</td>
<td>[0.12, 0.54]</td>
</tr>
</tbody>
</table>

Notes: The table shows the forecast error variance decomposition at horizons 0, 6, 12, and 24 months together with 90% CIs.

- Shock contributes meaningfully to economic activity and prices.
Perform a battery of robustness tests

- **Identification**: Informationally robust instrument, futures contract, announcement type, two-shock proxy VAR, placebo
  
  ▶ Details on identification

- **Model specification**: variable selection, lag order, deterministics
  
  ▶ Details on specification

- **Sample period**: excluding 70s, pre-Great Recession, pre-Shale oil revolution
  
  ▶ Sub-sample analysis

⇒ Results turn out to be robust
Conclusion
Conclusion

- Propose a novel approach to identify oil supply news shocks, combining HFI literature with traditional oil market VARs
- Evidence for a strong channel operating through supply expectations
- Provides new insights to the debate on the drivers of oil price fluctuations and their effects on the macroeconomy
- Underlines the potential of the high-frequency identification approach
Thank you!
Institutional background

• **OPEC** is an intergovernmental organization of *oil producing nations*
  • Accounts for about **44%** of *world oil production*
  • Founded in 1960 by Iran, Iraq, Saudi Arabia and Venezuela

• Supreme authority is the **OPEC conference**, consisting of delegations headed by oil ministers of member countries
  • Meets *several times a year* to agree on *oil production plans*, including *production quotas* for the organization and its members
  • Decisions of the conference take the form of an *announcement*, issued shortly after the meeting
Institutional background

- **Crude oil** is an *internationally* traded commodity ⇒ **liquid futures markets**
- Most widely traded contracts: WTI crude and Brent crude futures
- Focus on **WTI crude**
  - First traded futures on crude oil, **longest history** (started trading in 1983)
  - Most *liquid* and largest volume market for crude oil (currently trading nearly 1.2 million contracts a day)
  - Relevant benchmark for the US
Surprise series: autocorrelation

Figure 10: The autocorrelation function of the oil supply surprise series
### Table 4: Granger causality tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Instrument</td>
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<td>Oil price</td>
<td>0.4835</td>
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<tr>
<td>World oil production</td>
<td>0.6901</td>
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<tr>
<td>World oil inventories</td>
<td>0.6664</td>
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<tr>
<td>World industrial production</td>
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<td>US industrial production</td>
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<td>US CPI</td>
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<td>Fed funds rate</td>
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<td>S&amp;P 500</td>
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<td>Geopolitical risk</td>
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<td>Joint</td>
<td>0.6344</td>
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## Surprise series: correlation with other shocks

<table>
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<th>Shock</th>
<th>Source</th>
<th>( \rho )</th>
<th>p-value</th>
<th>( n )</th>
<th>Sample</th>
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<tr>
<td><strong>Panel A: Oil shocks</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Oil price</td>
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<td>0.18</td>
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<td>Oil supply</td>
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<td>369</td>
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<td>Caldara, Cavallo, and Iacoviello (2019)</td>
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<td>0.77</td>
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<td>Kilian (2009)</td>
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<td>Oil-specific demand</td>
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<td><strong>Panel B: Other shocks</strong></td>
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<td>Productivity</td>
<td>Basu, Fernald, and Kimball (2006)</td>
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<td>0.74</td>
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<td>Baker, Bloom, and Davis (2016)</td>
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<td>Financial</td>
<td>Gilchrist and Zakrajšek (2012)</td>
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<td>Bassett et al. (2014)</td>
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<td>Fiscal policy</td>
<td>Romer and Romer (2010)</td>
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<td>1974Q1-2007Q4</td>
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<td>Ramey (2011)</td>
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<td>Fisher and Peters (2010)</td>
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### Table 5: Data description and sources

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<thead>
<tr>
<th>Identifier</th>
<th>Variable name</th>
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<tr>
<td><strong>Instrument</strong></td>
<td></td>
<td></td>
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<tr>
<td>NCLC.0h (PS)</td>
<td>WTI crude $h$th contract (settlement price)</td>
<td>Datastream</td>
</tr>
<tr>
<td>NCLC.0h (VM)</td>
<td>WTI crude $h$th contract (traded volume)</td>
<td>Datastream</td>
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<td><strong>Baseline variables</strong></td>
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<td>WTISPLC</td>
<td>WTI spot crude oil price, deflated by US CPI</td>
<td>FRED</td>
</tr>
<tr>
<td>EIA1955</td>
<td>World oil production</td>
<td>Datastream</td>
</tr>
<tr>
<td>OILINV</td>
<td>OECD oil inventories (proxy)</td>
<td>Kilian &amp; Murphy</td>
</tr>
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<td>OECD+6IP</td>
<td>IP of OECD and 6 major countries</td>
<td>Baumeister &amp; Hamilton</td>
</tr>
<tr>
<td>INDPRO</td>
<td>US industrial production index</td>
<td>FRED</td>
</tr>
<tr>
<td>CPIAUCSL</td>
<td>US CPI for all urban consumers: all items</td>
<td>FRED</td>
</tr>
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Figure 11: Series included in the VAR over the sample period 1974-2015
Inflation expectations

- **Differential** effects between **households** and **professional forecasters**
- Response of SPF expectations **much weaker**, in line with recent literature on role of oil prices and expectations in inflation dynamics (Coibion, Gorodnichenko, and Kamdar, 2018; Hasenzagl et al., 2018)

**Figure 12:** Inflation expectations
Figure 13: Monetary policy and financial variables

- No significant effects on **monetary policy** and **financial conditions**
- Significant fall of **stock market index**
Economic activity

Figure 14: Consumption expenditures
• Do announcements only contain news about future supply?
  • For interpretation, it is crucial that they do not contain new information about other factors, e.g. global oil demand

• To mitigate this concern, construct informationally robust instrument, akin to Romer and Romer (2004) refinement of monetary policy shocks
Informationally robust instrument

Two steps

- Collect OPEC’s global demand forecasts published in OPEC oil market reports
- Construct refined instrument as residual of the following regression

\[
\text{Surprise}_m = \alpha_0 + \sum_{j=-1}^{2} \theta_j F_m^{OPEC} y_{q+j} + \sum_{j=-1}^{2} \varphi_j [F_m^{OPEC} y_{q+j} - F_{m-1}^{OPEC} y_{q+j}] + IRS_m
\]
Figure 15: Refined, informationally robust surprise series
Ordinary announcements

• Large part of the OPEC meetings were extraordinary meetings, scheduled in response to macroeconomic or geopolitical developments
⇒ Potential endogeneity problem

• As robustness, only use ordinary meetings
Figure 16: Ordinary announcements only

First stage regression: F: 11.56, robust F: 5.33, $R^2$: 2.20%, Adjusted $R^2$: 2.01%
Figure 17: Sample of placebo instruments
News and surprise shocks

- Is the instrument \textit{only correlated} with oil supply \textit{news shock}? Or does it also capture conventional, \textit{unanticipated supply shocks}?
  \textit{⇒ Exogeneity assumption} might be violated
- To mitigate this concern, \textbf{identify an oil supply surprise and news shock \textit{jointly}}, using Kilian’s (2008) exogenous supply shock measure and my oil supply surprise series
  - \textbf{Additional identifying assumption}: oil supply news shock does \textit{not} affect oil production \textit{on impact}
News and surprise shocks

Figure 18: Oil supply surprise and news shocks
Futures contracts

- A crucial choice was the maturity of the futures contract
  - As a benchmark, used 6-month contract
- Are results robust to using other maturities?
Figure 19: Different maturities of futures contracts
Futures contracts

• Since the **shale oil revolution**, WTI has become less representative for the global price of oil

• Are the results robust to using **Brent** instead?
Futures contracts

First stage regression: F: 11.47, robust F: 7.22, $R^2$: 2.19%, Adjusted $R^2$: 2.00%

Figure 20: Brent spot and futures prices
Model specification: variables

Figure 21: Kilian’s (2009) global activity indicator

First stage regression: F: 23.30, robust F: 14.86, $R^2$: 4.66%, Adjusted $R^2$: 4.46%
Model specification: variables

Figure 22: Refiner acquisition costs as oil price indicator
Model specification: lags

Figure 23: Lag order: 24 lags

First stage regression: F: 21.01, robust F: 12.09, $R^2$: 4.02%, Adjusted $R^2$: 3.83%
Model specification: lags

First stage regression: F: 21.17, robust F: 9.69, $R^2$: 3.96%, Adjusted $R^2$: 3.78%

Figure 24: Lag order: 6 lags
Model specification: stationary VAR

First stage regression: F: 22.91, robust F: 12.29, $R^2$: 4.27%, Adjusted $R^2$: 4.09%

**Figure 25:** Stationary VAR
Model specification: deterministics

Figure 26: Deterministics: linear trend
Model specification: frequency

![Graphs of various economic indicators](image)

**First stage regression:** F: 9.16, robust F: 5.98, $R^2$: 5.14%, Adjusted $R^2$: 4.58%

**Figure 27:** Quarterly data
Sub-sample analysis: pre Great Recession

Figure 28: Exclude Great Recession period
Sub-sample analysis: pre shale oil

First stage regression: $F: 28.93$, robust $F: 19.35$, $R^2$: 6.32%, Adjusted $R^2$: 6.10%

Figure 29: Exclude shale oil revolution
Sub-sample analysis: post 70s

Figure 30: Exclude the 1970s