Time-Varying Effects of Oil Supply Shocks on the US Economy

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Motivation

Nominal and real price of crude oil

- 1973/74 Arab-Israeli war and oil embargo
- 1979 Iranian revolution
- 1980 Iran-Iraq war
- 1986 oil price collapse
- 1990/91 Persian Gulf war
- 1999 concerted action by OPEC and non-OPEC countries
- 2002 general strikes in Venezuela
- 2003 Iraq war
- 2002 general strikes in Venezuela
- 2003 Iraq war

Real oil price
Nominal oil price


$/barrel
Motivation

• Relationship of oil with the macroeconomy
  – Reduction in spending ➔ recession
  – Firms pass on cost increase to consumer prices ➔ inflation
  – BUT relationship has not been stable over time

• Oil price shocks = oil supply shocks?
  – Reduction of oil supply due to war activities
  – BUT also: higher demand for oil due to booming economy
  – Different effects on the macroeconomy

• This paper further investigates the importance of oil supply shocks when time variation is accounted for
Why time variation?

• Structural transformations of the crude oil market since the 1970s
  – Relative importance of driving forces behind oil price movements has changed
    • Barsky and Kilian (2002)
    • Kilian (2009)
  – Global capacity utilization rates in crude oil production have not been constant over time
    • Kilian (2006)
  – Dramatic rise in oil price volatility since 1986
    • Lee, Ni and Ratti (1995)
    • Federer (1996)
Why time variation?

• Macroeconomic structure has changed over time
  – Improved monetary policy
    • Bernanke, Gertler and Watson (1997)
    • Blanchard and Gali (2007)
  – More flexible labor markets
    • Blanchard and Gali (2007)
  – Share and role of oil in the economy
    • Bernanke (2006)
    • Edelstein and Kilian (2009)

→ alter the way the economy reacts to shocks
Contribution

- Multivariate time-varying parameters Bayesian vector autoregression (TVP-BVAR) with stochastic volatility to model time variation
  

- Previous empirical approaches
  - Sample split (Edelstein and Kilian 2009, Herrera and Pesavento 2009)
  - Bivariate VARs over moving time windows (Blanchard and Gali 2007)

- TVP-BVAR should capture smooth transitions in the propagation mechanism of oil shocks without imposing a specific breakpoint

- Stochastic volatility models changes in the magnitude of structural shocks and their immediate impact
Empirical model

- TVP-BVAR with global oil production, real crude oil price, US real GDP and US CPI

\[ y_t = c + B_{1,t} y_{t-1} + \ldots + B_{p,t} y_{t-p} + u_t \equiv X_t' \theta + u_t \]

\[ u_t \sim N(0, \Omega_t) \quad \Omega_t = A_t' H_t(A_t')' \]

- First differences, 4 lags
- 1947Q1-2006Q2 (first 20 years as a training sample)
- Estimated with Bayesian methods (MCMC algorithm)
Empirical model

- Drifting coefficients capture time variation in the propagation mechanism

\[ \theta_t = \theta_{t-1} + \nu_t \quad \nu_t \sim N(0, Q) \]

- Heteroskedasticity of the shocks and time variation in the simultaneous relationships between the variables

\[
A_t = \begin{bmatrix}
1 & 0 & 0 & 0 \\
\alpha_{21,t} & 1 & 0 & 0 \\
\alpha_{31,t} & \alpha_{32,t} & 1 & 0 \\
\alpha_{41,t} & \alpha_{42,t} & \alpha_{43,t} & 1 \\
\end{bmatrix}
\quad H_t = \begin{bmatrix}
h_{1,t} & 0 & 0 & 0 \\
0 & h_{2,t} & 0 & 0 \\
0 & 0 & h_{3,t} & 0 \\
0 & 0 & 0 & h_{4,t} \\
\end{bmatrix}
\]

\[
\alpha_t = \alpha_{t-1} + \xi_t \quad \xi_t \sim N(0, S)
\]

\[
\ln h_{i,t} = \ln h_{i,t-1} + \sigma_i \eta_{i,t} \quad \eta_{i,t} \sim N(0,1)
\]
Contribution

• New method to identify exogenous oil supply shocks
  – All variations in oil prices are exogenous oil supply shocks
    • Barsky and Kilian (2002)
    • Kilian (2006)
  – Oil production shortfalls in the wake of political crises and military conflicts
    • Hamilton (2003)
    • Kilian (2006)
  – Recursive identification: vertical oil supply curve
    • Kilian (2009)
Identification

• Sign restrictions from a simple supply and demand model of the crude oil market

  – Oil supply shocks move oil prices and oil production in opposite direction

  – Supply and demand shocks can affect oil production and prices immediately and this impact can change over time
Results

- Effect of typical (one standard deviation) oil supply shock on the macroeconomy
Results

• Typical (one standard deviation) oil supply shock
  – Significant impact on economic activity and inflation
  – Impact has not dramatically changed over time
    • In contrast with most existing evidence
  – How can we explain this?
Results

- Effect of a typical (one standard deviation) oil supply shock in the oil market
Results

• Typical (one standard deviation) oil supply shock
  – Considerable time variation in oil market dynamics
    • smaller impact on oil production
    • greater effect on the real price of crude oil
    • difference is statistically significant
  – What does this mean?
Results

• Typical (one standard deviation) oil supply shock
  – Combination of greater price response and smaller quantity reaction
  – Oil demand curve must have become steeper (less elastic) over time
Results

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  – Oil demand curve must have become steeper (less elastic) over time
Results

• Consequences for comparisons over time
  – A similar shift of **crude oil prices** (e.g. 10 percent rise)
  – more moderate impact on output over time: consistent with existing evidence
Results

• Consequences for comparisons over time
  – A similar shift of crude oil prices (e.g. 10 percent rise)
  • Comparison cannot really be made because a different underlying supply shock is considered
    – A constant slope of oil demand curve is implicitly assumed
Results

- Consequences for comparisons over time
  - A similar shift of oil production (e.g. 1 percent shortfall)
    - much stronger impact over time
Results

• Why are we currently not confronted with same macroeconomic conditions of 1970s?
  – Adverse oil supply shocks explain little of the Great Inflation
Results

- Why are we currently not confronted with same macroeconomic conditions of 1970s?
  - Significant but non-exclusive contribution to 1974/75 and 1990s recessions
Results

• Why are we currently not confronted with same macroeconomic conditions of 1970s?
  – Current oil prices are more demand driven
Why a less elastic oil demand curve?

• High oil prices of 1970s caused industries to switch away from oil to other sources of energy

• Cost share of crude oil in total expenditures has decreased

• Higher share of developing countries in global oil demand
Why a less elastic oil demand curve?

- Capacity utilization rates of crude oil production: close to full capacity can lead to relative higher share of (less elastic) precautionary oil demand
  - Signals tightness in the market which affects demand behavior
Robustness

• Very robust for several alternative variables, specifications and timing of sign restrictions
  – e.g. adding interest rate, using GDP deflator or unemployment
  – Always a steeper oil demand curve over time

• Model properties: time-varying parameter methodology
  – Splitting sample in two sub-periods and use sign restrictions

Oil quantity

Oil price
Robustness

- Model properties: identification strategy
  - TVP-BVAR but using Choleski decomposition (Kilian 2009)

BUT less appropriate in a quarterly framework
Conclusions

• Remarkable structural change in the oil market over time
  – “Typical” oil supply shock is characterized by a much smaller impact on world oil production and a greater effect on the real price of crude oil over time
    • Steepening of the oil demand curve (less elastic oil demand) is the only possible explanation for this stylized fact
  – The contribution of oil supply shock to real oil price fluctuations has decreased over time
    • Current oil prices are more demand driven

• The role of supply shocks in explaining the macroeconomy
  – Significant but non-exclusive role in 1974/75 and early 1990s recessions
  – Minor importance in the 1980/81 and millennium slowdowns
  – Explain little of the Great Inflation