Oil Price Shocks and Monetary Policy in a Data-Rich Environment

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Objective: Increase our understanding of the role of different types of oil price shocks for the U.S. macro economy and monetary policy.

- Characterize the transmission mechanism of these shocks.

- Take into account the full interaction between oil market, macro economy and policy.

- Modeling framework: Factor Augmented VAR (FAVAR)
Common approach: Model oil prices as exogenous to macroeconomic aggregates.

- Implicit assumption that oil price innovations are interpreted as oil supply shocks.

Recently this view has been challenged by Barsky and Kilian (2002, 2004) and Kilian (2009).

Two problems with the common approach:

- Reverse causality from macro aggregates.
- Price of oil is driven by both supply and demand shocks.

The effect on the real price of oil and macroeconomic variables may depend on the underlying cause of the price increase.
Kilian (2009) proposes a SVAR with 3 types of oil price shocks.

Variables: Global oil production, global real economic activity index, real price of oil.

Identifying restrictions

- Crude oil supply shock
  - All shocks that affect oil production within a month.

- Aggregate demand shock
  - All remaining shocks that affect the global real economic activity index within a month.

- Oil-specific demand shock
  - All other shocks to the price of oil.
Motivation

- **Shortcomings for study macroeconomic effects**
  - Do not study the interaction between oil market, U.S. macro economy and monetary policy
  - This is important for understanding the full transmission mechanism of these shocks to the macro economy

- Extend the model in Kilian (2009) to include Bernanke, Boivin and Eliaasz (2005).
  - Will account for full simultaneity between oil market, the macro economy and policy.
Findings

- The different oil price shocks have different effect on U.S. macro economy and monetary policy
- Simultaneity is important
- Oil demand shocks are more important than oil supply shocks
- The origin of the oil demand shock is important.
Related Literature

- **Oil - macro literature**
  - Kilian (2008a, b, 2009a)
  - Baumeister and Peersman (2012)
  - Kilian and Park (2009), Kilian and Lewis (2011)
  - Peersman and Van Robeys (2009, 2010)
  - Kilian and Vigfusson (2011a, b)

- **FAVAR literature**
  - Bernanke, Boivin and Eliasz (2005)
  - Boivin, Giannoni and Mojon (2008)
  - Boivin, Giannoni and Mihov (2009)
Outline

- Model
- Data and model specification
- Empirical results
- Conclusion
FAVAR model

- Idea: Estimate common factors ($C_t$) from large data set
  - $C$’s have pervasive effects potentially on all indicators

- Augments standard VAR with extra information

- Not necessary to define measures for diffuse concepts

- Can decompose each series into common and series-specific components

- Can trace out the response of all data series to macro disturbances
  - Broader picture of the effect of the shock
  - More complete check on the plausibility of identification scheme
FAVAR model

Assume that the state of the economy can be summarized by a $K \times 1$ vector $C_t$ (Observation equation)

$$X_t = \Lambda C_t + e_t,$$  \hspace{1cm} (1)

The dynamics of the common factors is modeled as a VAR (Transition equation)

$$C_t = \Phi (L) \, C_{t-1} + u_t,$$ \hspace{1cm} (2)

where

$$C_t = \begin{bmatrix}
\Delta prod_t \\
\text{rea}_t \\
\text{rpo}_t \\
F_t \\
R_t
\end{bmatrix},$$ \hspace{1cm} (3)
Estimation

- Estimated in a two step procedure similar to Boivin, Giannoni and Mihov (2009):

  - **Step 1:** Estimate factors, $F_t$, by Principal Components (PC) of $X_t$
    - Consistent estimate of $F_t$
    - Add observable factors $Y_t = [\Delta prod_t, rea_t, rpo_t, R_t]'$
    - Obtain $\hat{F}_t$ by extracting out the effect of $Y_t$ on $C_t$
      - Guarantees the estimated latent factors to recover dimensions of the common dynamics not captured by the four observable variables
    - Obtain loadings by OLS regression on the observation equation

  - **Step 2:** Estimate a VAR in $Y_t$ and $\hat{F}_t$ using standard methods.
Start with initial estimate of $F_t$, denoted by $F_t^{(0)}$ and obtained as the $K$ first PC of $X_t$

Iterate through the following steps:

- Regress $X_t$ on $F_t^{(0)}$ and the observed factors $Y_t = [\Delta prod_t, rea_t, rpo_t, R_t]'$. We obtain $\hat{\lambda}_Y^{(0)}$
- Compute $\tilde{X}_t^{(0)} = X_t - \hat{\lambda}_Y^{(0)} Y_t$
- Estimate $F_t^{(1)}$ as the first $K$ PC of $\tilde{X}_t^{(0)}$
- Repeat the procedure multiple times
111 monthly variables for the U.S. economy, similar to Bernanke, Boivin and Eliasz (2005)

- 110 Macroeconomic indicators
- Fed funds rate
- 3 "Oil related" variables.

Period: January 1974 to June 2008

All variables in $X_t$ are transformed to induce stationarity and normalized to have $E(X_{it}) = 0$ and $Var(X_{it}) = 1$
Equation (2) has the following moving average representation

\[ C_t = B(L) u_t, \quad (4) \]

Assume that the reduced form innovations \((u_t)\) can be written as linear combinations of the underlying orthogonal structural disturbances \((\varepsilon_t)\), i.e. \(u_t = S\varepsilon_t\). We then get the following Structural MA representation

\[ C_t = B(L) S\varepsilon_t = D(L)\varepsilon_t \quad (5) \]

where \(B(L)S = D(L)\)
To orthogonalise the shocks we follow the standard in the literature and order the vector of shocks recursively by using the Cholesky decomposition.

\[
C_t = \begin{bmatrix}
\Delta prod_t \\
\text{reat}_t \\
\text{rpo}_t \\
F_t \\
R_t
\end{bmatrix} = B(L)
\begin{bmatrix}
S_{11} & 0 & 0 & 0 & 0 \\
S_{21} & S_{22} & 0 & 0 & 0 \\
S_{31} & S_{32} & S_{33} & 0 & 0 \\
S_{41} & S_{42} & S_{43} & S_{44} & 0 \\
S_{51} & S_{52} & S_{53} & S_{54} & S_{55}
\end{bmatrix}
\begin{bmatrix}
\varepsilon^\text{OS}_t \\
\varepsilon^\text{GD}_t \\
\varepsilon^\text{OD}_t \\
\varepsilon^F_t \\
\varepsilon^\text{MP}_t
\end{bmatrix}
\] (6)
Model Specification

- Number of factors must be chosen exogenously
  - Bai and Ng (2002) criterion
  - Choose as few factors as possible without affecting results.
  - I choose $K = 5$ (similar to BGM)

- I choose 13 lags when estimating Equation (2)

- I check for robustness
Exercise

- Study the effect of different types of oil price shocks on U.S. economy

- FAVAR model
  - Impulse responses
  - Variance decomposition

- Compare impulse responses for selected variables
  - Kilian model
  - Standard monetary SVAR with oil

- Oil market shocks
  - Normalized to have a positive effect on the real price of oil.
  - One standard deviation structural shocks.
Advantage of FAVAR: Can analyze responses to a large number of variables with minimal identifying restrictions

Equation (1) implies that each variable in $X_t$ can be written as

$$x_{it} = \Lambda_i' C_t + e_{it}, \quad (7)$$

Each variable in $X_t$ is allowed to react contemporaneously to all structural shocks despite the recursive ordering in equation (2)
Oil Supply Shock - FAVAR

- Oil Production
- Global Real Activity
- Real Price of Oil
- Industrial Production
- Price Level, CPI
- Federal Funds Rate
- Unemployment Rate
- S&P Common Stock Price Index
- PPI Finished Goods
- NAPM Commodity Price Index
- Exchange Rate Yen
- Employment
Aggregate Demand Shock - FAVAR

- Oil Production
- Global Real Activity
- Real Price of Oil
- Industrial Production
- Price Level: CPI
- Federal Funds Rate
- Unemployment Rate
- S&P Common Stock Price Index
- PPI Finished Goods
- NAPM Commodity Price Index
- Exchange Rate Yen
- Employment
Aggregate Demand Shock - Comparison

Oil Production

Global Real Activity

Oil Price

Industrial Production

Price Level: CPI

Federal Funds Rate

Baseline Favour (5 factors)
- VAR (Oil, Indus prod., CPI, FFR)
- Kilian model
Oil-Specific Demand Shock - FAVAR

- Oil Production
- Global Real Activity
- Real Price of Oil
- Industrial Production
- Price Level: CPI
- Federal Funds Rate
- Unemployment Rate
- S&P Common Stock Price Index
- PPI Finished Goods
- NAPM Commodity Price Index
- Exchange Rate Yen
- Employment
Oil-Specific Demand Shock - Comparison

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BI 2012 24 / 32
Summing up results

- Oil supply shock
  - Small negative effect on the real economy, prices almost unaffected.
  - Negligible effects on monetary policy.

- Aggregate demand shock
  - Large persistent effect on all prices.
  - Delayed negative effect on real economy.
  - Monetary tightening.

- Oil-specific demand shock
  - Large positive effect on all prices.
  - Immediate negative effect on real economy.
Robustness checks

- Different number of factors
- Different lag length
- Post 1984
- Alternative identification
- Alternative transformation
Post 1984 Oil Supply Shock
Post 1984 Global Demand Shock

- Oil Production
- Global Real Activity
- Oil Price
- Industrial Production
- Price Level CPI
- Federal Funds Rate
- Unemployment Rate
- S&P Common Stock Price Index
- PPI Finished Goods
- NAPM Commodity Price Index
- Exchange Rate Year
- Employment
Post 1984 Oil-specific Demand Shock
I find important differences in both the response of macroeconomic variables and monetary policy to the different type of oil shocks.

- The simultaneity between macro variables and policy is important.

- Oil demand shocks are more important than oil supply shocks

- The cause behind the movements in the oil price is important.
Monetary Policy Shock - FAVAR

- Oil Production
- Global Real Activity
- Real Price of Oil
- Industrial Production
- Price Level: CPI
- Federal Funds Rate
- Unemployment Rate
- S&P Common Stock Price Index
- PPI Finished Goods
- NAPM Commodity Price Index
- Exchange Rate Yen
- Employment
Post 1984 Monetary Policy Shock - FAVAR