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

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This paper

- 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)

Background

- 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.

Background

- 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 Eliasz (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
  - Hamilton (1983,1996,2001,2003,2008)
  - Bernanke, Gertler and Watson (1997,2004)
  - 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)

$$X_t = \Lambda C_t + e_t, \tag{1}$$

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

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

where

$$C_t = \begin{bmatrix} \Delta prod_t \\ rea_t \\ rpo_t \\ F_t \\ R_t \end{bmatrix}, \tag{3}$$

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 $\widehat{F}_t$ 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 $\widehat{F}_t$ using standard methods.

Estimation

- 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 $\widehat{\lambda}_Y^{(0)}$
  - Compute $\widetilde{X}_t^{(0)} = X_t - \widehat{\lambda}_Y^{\prime(0)} Y_t$
  - Estimate $F_t^{(1)}$ as the first K PC of $\widetilde{X}_t^{(0)}$
  - Repeat the procedure multiple times

Data set

- 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 $Var(X_{it}) = 1$

Identification

Equation (2) has the following moving average representation

$$C_t = B(L) u_t, \tag{4}$$

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

$$C_t = B(L) S\varepsilon_t = D(L)\varepsilon_t \tag{5}$$

where $B(L)S = D(L)$

Identification

To orthogonalise the shocks we follow the standard in the literature and order the vector of shocks recursively by using the Cholesky decomposition.

$$C_t = \begin{bmatrix} \Delta prod_t \\ rea_t \\ rpo_t \\ F_t \\ R_t \end{bmatrix} = B(L) \begin{bmatrix} S_{11} & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{OS} \\ \varepsilon_t^{GD} \\ \varepsilon_t^{OD} \\ \varepsilon_t^{F} \\ \varepsilon_t^{MP} \end{bmatrix} \tag{6}$$

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.

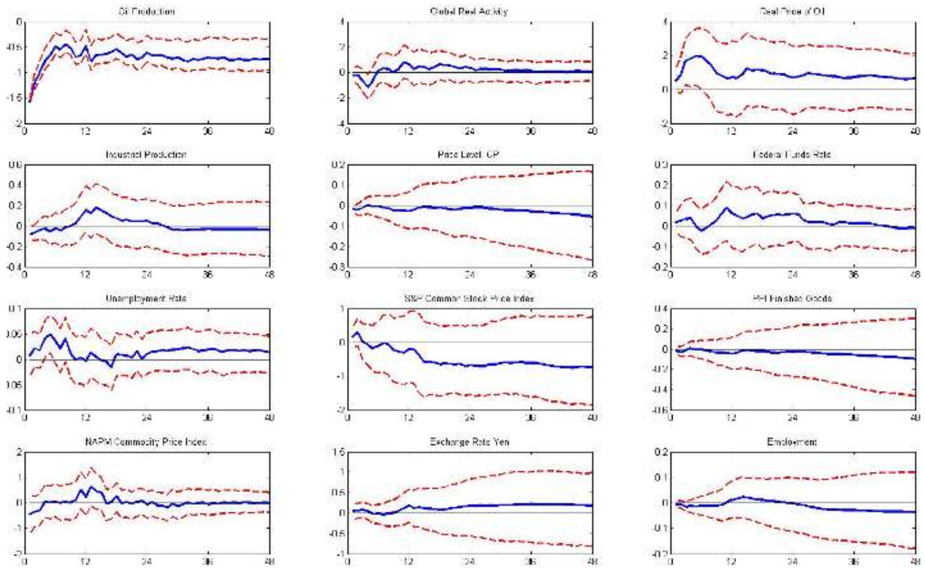
Impulse response

- 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

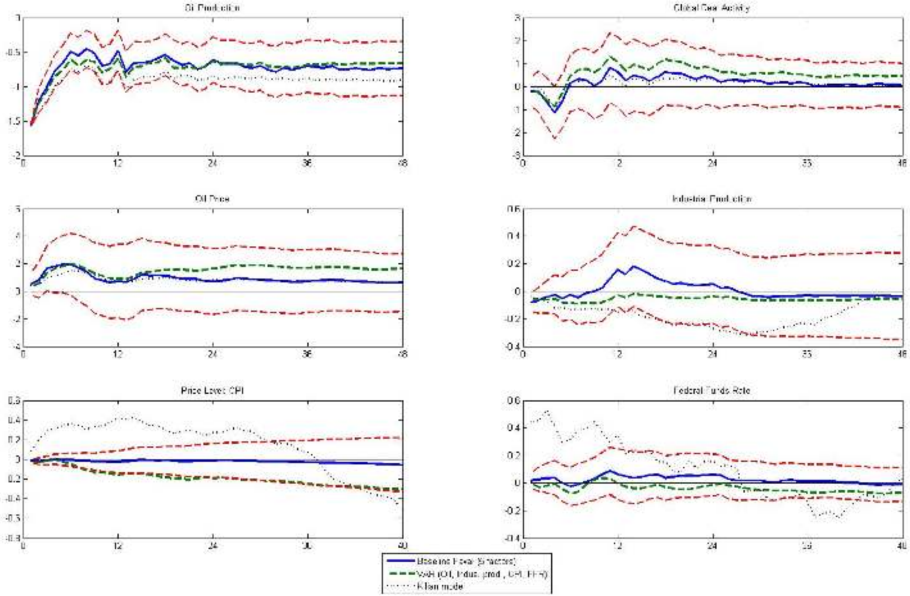
$$x_{it} = \Lambda_i' C_t + e_{it}, \tag{7}$$

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

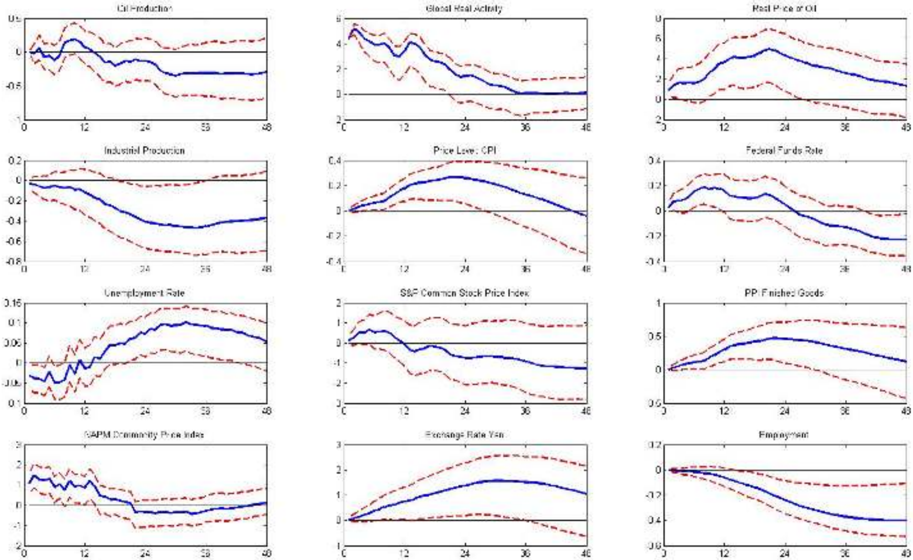
Oil Supply Shock - FAVAR



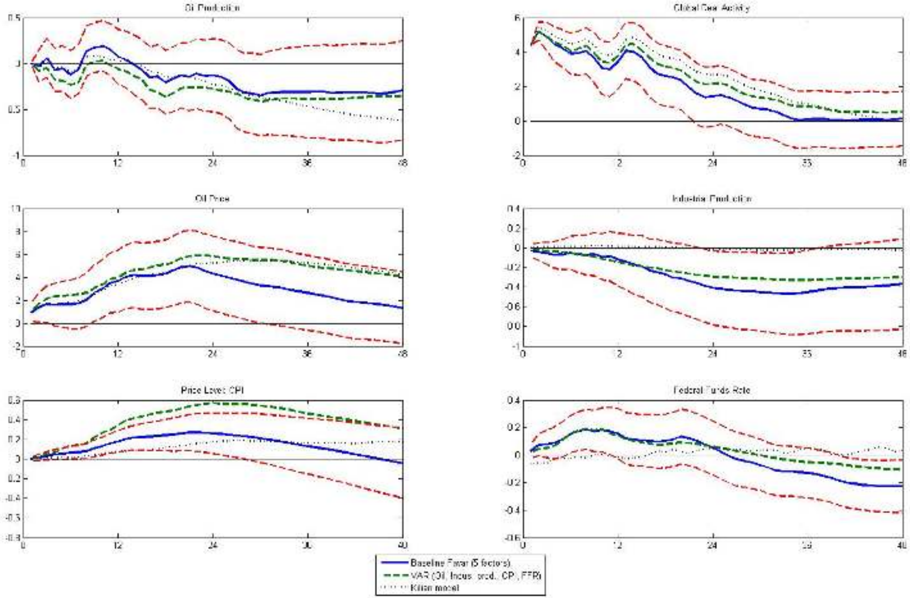
Oil Supply Shock - Comparison



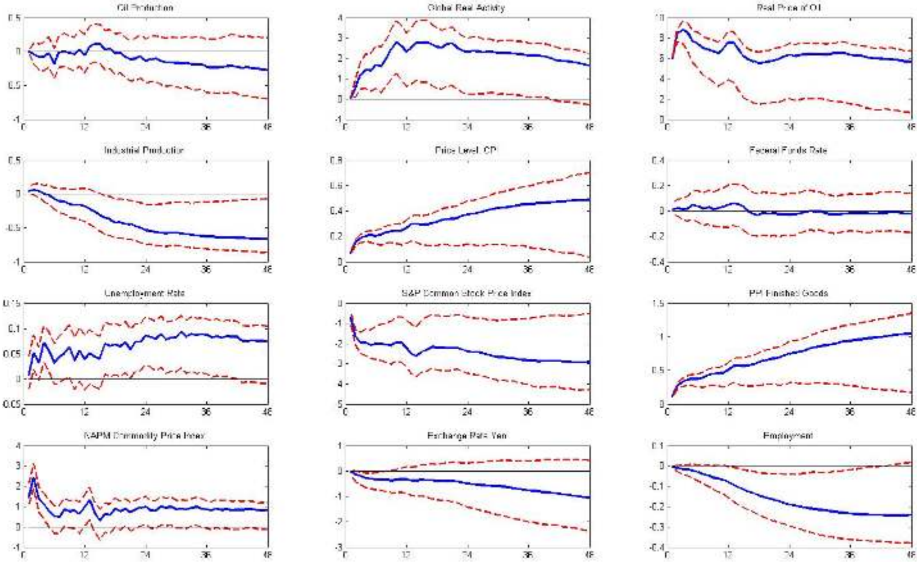
Aggregate Demand Shock - FAVAR



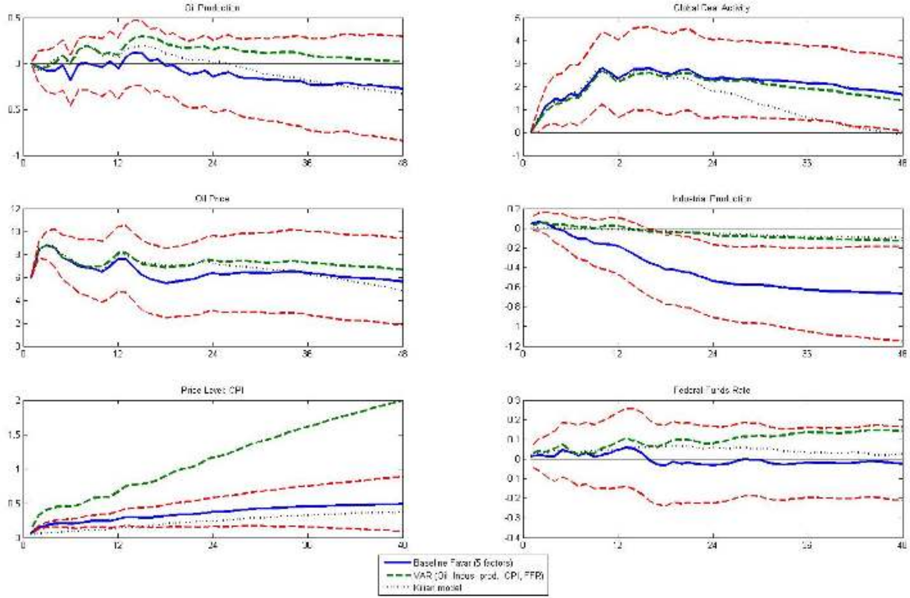
Aggregate Demand Shock - Comparison



Oil-Specific Demand Shock - FAVAR



Oil-Specific Demand Shock - Comparison



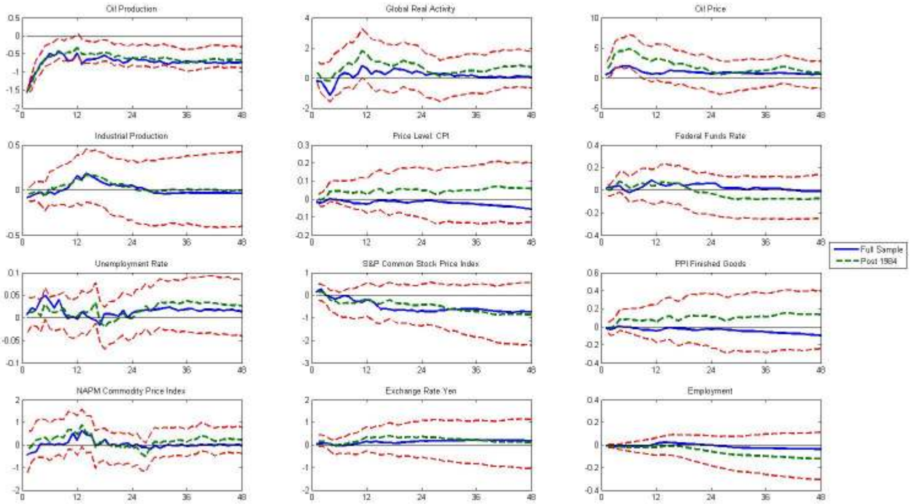
Summing up results

- 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.

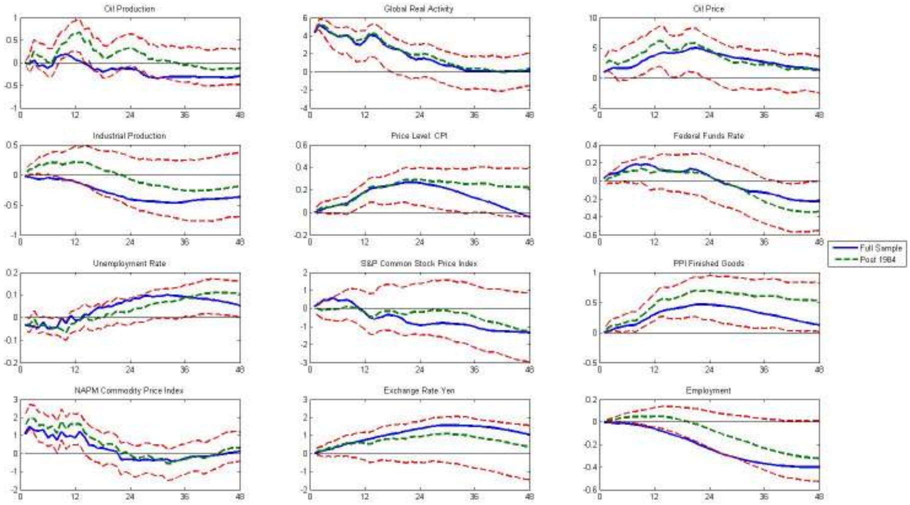
Robustness checks

- Different number of factors
- Different lag length
- Post 1984
- Alternative identification
- Alternative transformation

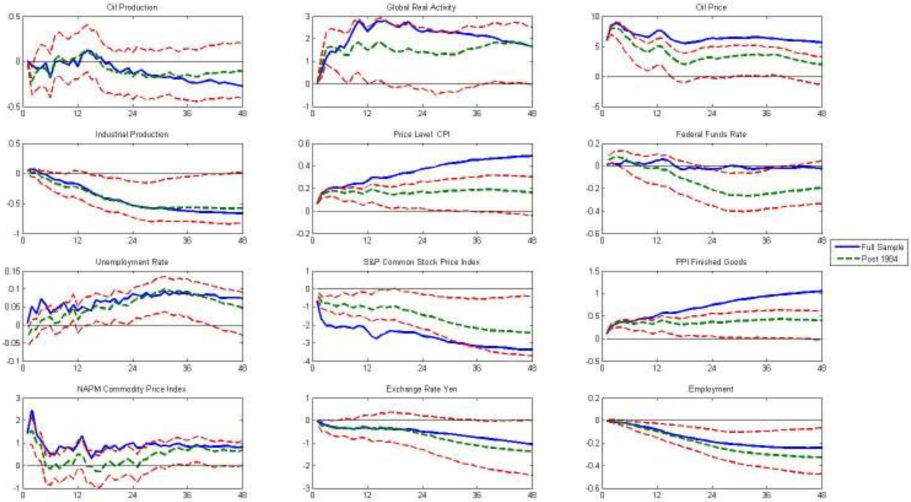
Post 1984 Oil Supply Shock



Post 1984 Global Demand Shock



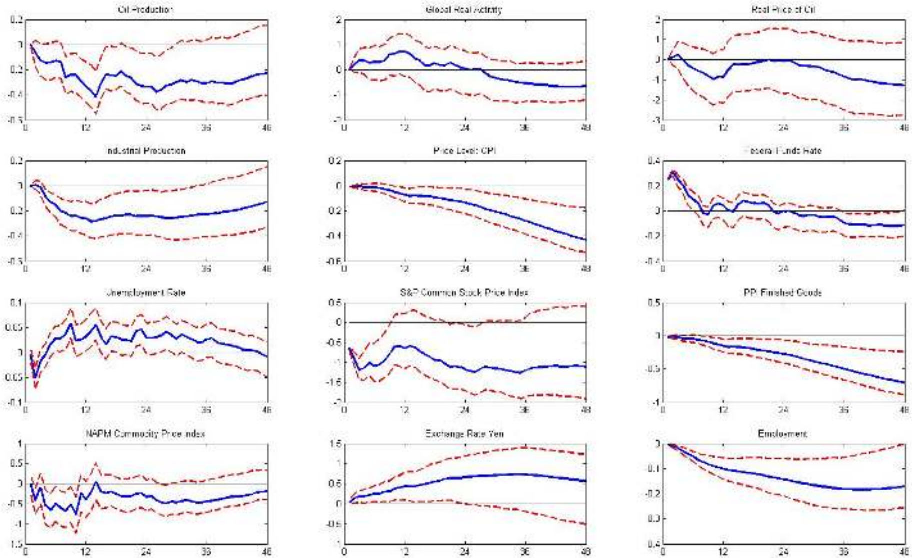
Post 1984 Oil-specific Demand Shock



Conclusion

- 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



Post 1984 Monetary Policy Shock - FAVAR