Macroeconometrics

Lecture 15 Modeling effects of monetary policy

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A small-open economy model revisited

Modeling effects of monetary policy in the US

**Modeling effects of monetary policy in the US
– extended analysis**

Materials:

A zip file `L15 mcxs-all.zip` for the reproduction of the results

Objectives.

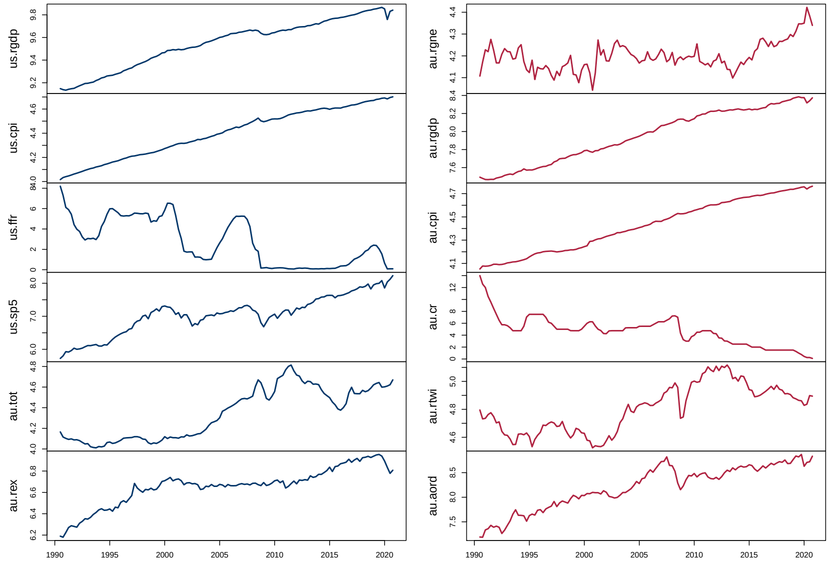
- To present the outcomes of Waggoner & Zha (2003) estimation algorithm
- To work with a variation on the small-open economy model
- To investigate the effects of the monetary policy shock in the U.S.

Learning outcomes.

- Implementing rotations in the estimation outcomes
- Specifying classical monetary policy models
- Emphasising prior specification sensitivity

A small-open economy model revisited

SVAR Model of the Australian Economy



SVAR Model of the Australian Economy

$$\begin{bmatrix} B_{0.11} & \mathbf{0}_{6\times 6} \\ B_{0.21} & B_{0.22} \end{bmatrix} \begin{bmatrix} y_t^f \\ y_t^d \end{bmatrix} = \begin{bmatrix} b_{0.1} \\ b_{0.2} \end{bmatrix} + \begin{bmatrix} B_{1.11} & B_{1.12} \\ B_{1.21} & B_{1.22} \end{bmatrix} \begin{bmatrix} y_{t-1}^f \\ y_{t-1}^d \end{bmatrix} + \dots + \begin{bmatrix} u_t^f \\ u_t^d \end{bmatrix}$$

$$y_t^{f\prime} = \begin{bmatrix} rgdp_t & cpi_t & FFR_t & sp500_t & tot_t & rex_t \end{bmatrix}$$

$$y_t^{d\prime} = \begin{bmatrix} rgne_t & rgdp_t & cpi_t & CR_t & rtwi_t & aord_t \end{bmatrix}$$

$$u_t^{f\prime} = \begin{bmatrix} u_{1.t} & u_{2.t} & u_{3.t}^{us.mps} & u_{4.t} & u_{5.t} & u_{6.t} \end{bmatrix}$$

$$u_t^{d\prime} = \begin{bmatrix} u_{7.t} & u_{8.t} & u_{9.t} & u_{10.t}^{au.mps} & u_{11.t} & u_{12.t} \end{bmatrix}$$

Foreign block.
$rgdp_t$ – real GDP, cpi_t – CPI, FFR_t – federal funds rate, $sp500_t$ – S&P 500 index, tot_t – Australian terms of trade, rex_t – Australian real export

Australian block.
$rgne_t$ – real gross national expenditure, $rgdp_t$ – real GDP, cpi_t – CPI, CR_t – cash rate, $rtwi_t$ – real trade weighted index, $aord_t$ – All Ordinaries Index

Shocks of interest.
$u_{10.t}^{au.mps}$ – Australian monetary policy shock
$u_{3.t}^{us.mps}$ – US monetary policy shock

SVAR Model of the Australian Economy

$$\begin{bmatrix} B_{0.11} & \mathbf{0}_{6\times6} \\ B_{0.21} & B_{0.22} \end{bmatrix} \begin{bmatrix} y_t^f \\ y_t^d \end{bmatrix} = \begin{bmatrix} b_{0.1} \\ b_{0.2} \end{bmatrix} + \begin{bmatrix} B_{1.11} & B_{1.12} \\ B_{1.21} & B_{1.22} \end{bmatrix} \begin{bmatrix} y_{t-1}^f \\ y_{t-1}^d \end{bmatrix} + \cdots + \begin{bmatrix} u_t^f \\ u_t^d \end{bmatrix}$$

SVAR for a small-open economy

$B_{0.11}$ – identification of foreign shocks: lower-triangular matrix

$B_{0.22}$ – identification of domestic shocks: lower-triangular matrix

$B_{0.12} = \mathbf{0}_{6\times6}$ – small-open economy assumption

$B_{l.12} = \mathbf{0}_{6\times6}$ – small-open economy assumption (not imposed)

$B_{0.21}$ – small-open economy assumption: foreign shocks affect domestic variables

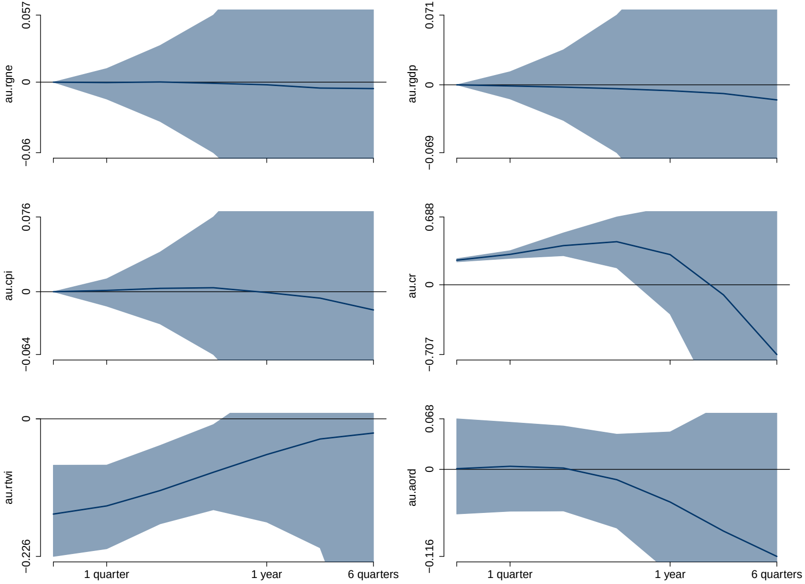
SVAR Model of the Australian Economy

$$\begin{bmatrix} B_{0.11} & \mathbf{0}_{6\times 6} \\ B_{0.21} & B_{0.22} \end{bmatrix} \begin{bmatrix} y_t^f \\ y_t^d \end{bmatrix} = \begin{bmatrix} b_{0.1} \\ b_{0.2} \end{bmatrix} + \begin{bmatrix} B_{1.11} & B_{1.12} \\ B_{1.21} & B_{1.22} \end{bmatrix} \begin{bmatrix} y_{t-1}^f \\ y_{t-1}^d \end{bmatrix} + \dots + \begin{bmatrix} u_t^f \\ u_t^d \end{bmatrix}$$

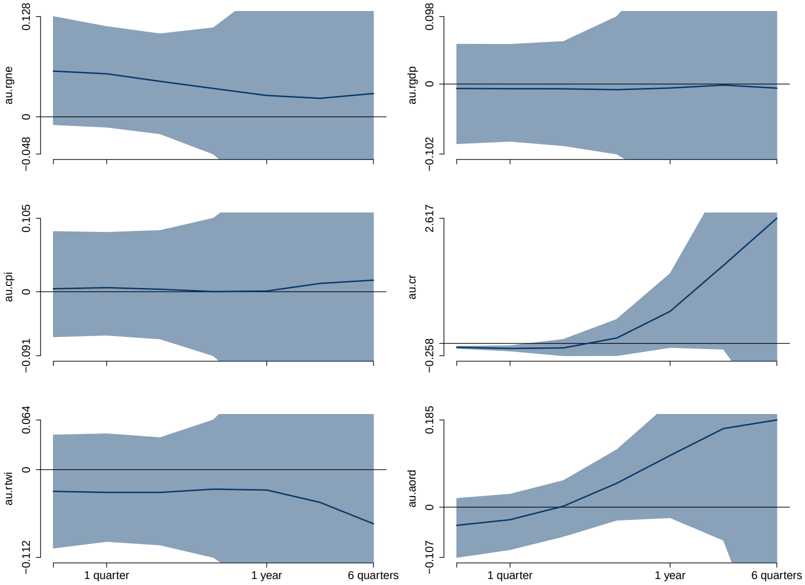
SVAR for a small-open economy

- The model was estimated using Waggoner & Zha (2003) algorithm
- $\underline{B}$ and $\underline{\Omega}$ prior matrices are set the same way as the RF Minnesota prior with $\kappa_1 = \kappa_2 = 1$, $\kappa_3 = 0.95$
- $\underline{S} = \kappa_4 I_N$ and $\kappa_4 = 1$, $\underline{\nu} = N$ which make the generalized-normal prior for B_0 set to $\mathcal{N}(\mathbf{0}_N, I_N)$
- The results are sensitive to the specification of κ_1 and κ_4
- The Gibbs sampler for B_0 used $S_1 = 100$ draws in the burin-in and $S_2 = 5000$ in the final sampler
- The potential extensions include: estimation of prior hyper-parameters and heteroskedasticity of the structural shocks

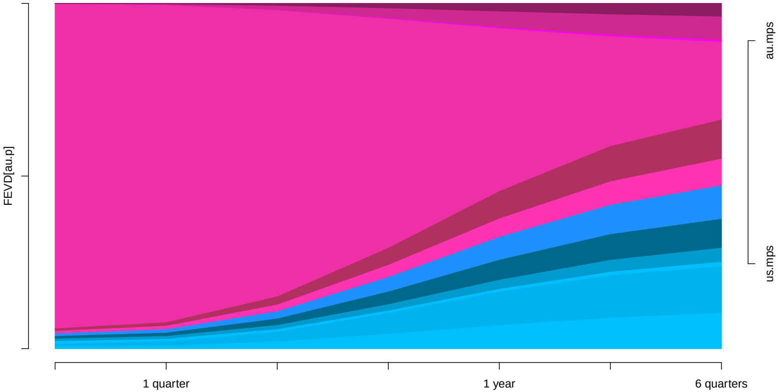
IRFs of domestic sector to $u_{10.t}^{au.mps}$



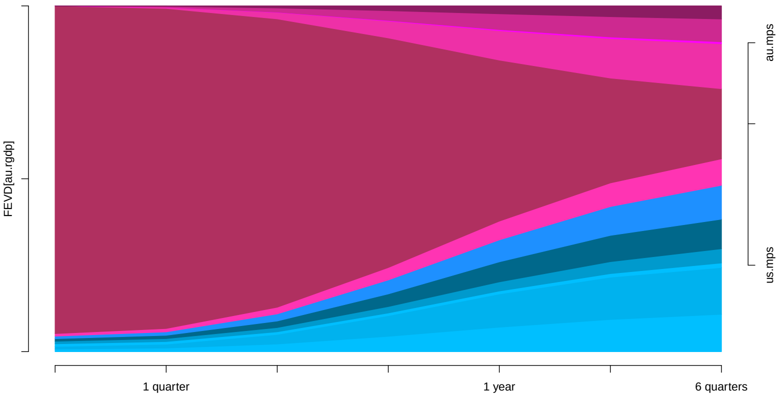
IRFs of domestic sector to $u_{3.t}^{us.mps}$



Forecast error variance decomposition of $au.cpi_{t+h|t}$



Forecast error variance decomposition of $au.rgdp_{t+h|t}$



SVAR Model of the Australian Economy

$$\begin{bmatrix} B_{0.11} & \mathbf{0}_{6\times 6} \\ B_{0.21} & B_{0.22} \end{bmatrix} \begin{bmatrix} y_t^f \\ y_t^d \end{bmatrix} = \begin{bmatrix} b_{0.1} \\ b_{0.2} \end{bmatrix} + \begin{bmatrix} B_{1.11} & B_{1.12} \\ B_{1.21} & B_{1.22} \end{bmatrix} \begin{bmatrix} y_{t-1}^f \\ y_{t-1}^d \end{bmatrix} + \dots + \begin{bmatrix} u_t^f \\ u_t^d \end{bmatrix}$$

$$y_t^{f\prime} = \begin{bmatrix} rgdp_t & cpi_t & FFR_t & sp500_t & tot_t & rex_t \end{bmatrix}$$
$$y_t^{d\prime} = \begin{bmatrix} rgne_t & rgdp_t & cpi_t & CR_t & rtwi_t & aord_t \end{bmatrix}$$

Shocks of interest.

u_t^f – foreign shocks

u_t^d – domestic shocks

Objective.

To identify to what extent the foreign shocks determine the business cycle in Australia jointly

SVAR Model of the Australian Economy

$$\begin{bmatrix} B_{0.11} & \mathbf{0}_{6\times 6} \\ B_{0.21} & B_{0.22} \end{bmatrix} \begin{bmatrix} y_t^f \\ y_t^d \end{bmatrix} = \begin{bmatrix} b_{0.1} \\ b_{0.2} \end{bmatrix} + \begin{bmatrix} B_{1.11} & B_{1.12} \\ B_{1.21} & B_{1.22} \end{bmatrix} \begin{bmatrix} y_{t-1}^f \\ y_{t-1}^d \end{bmatrix} + \dots + \begin{bmatrix} u_t^f \\ u_t^d \end{bmatrix}$$

SVAR for a small-open economy.

B_{11}, B_{22} – unrestricted

$B_{12} = \mathbf{0}_{6\times 6}$ – small-open economy assumption

$B_{0.21}$ – small-open economy assumption: unrestricted

Identification.

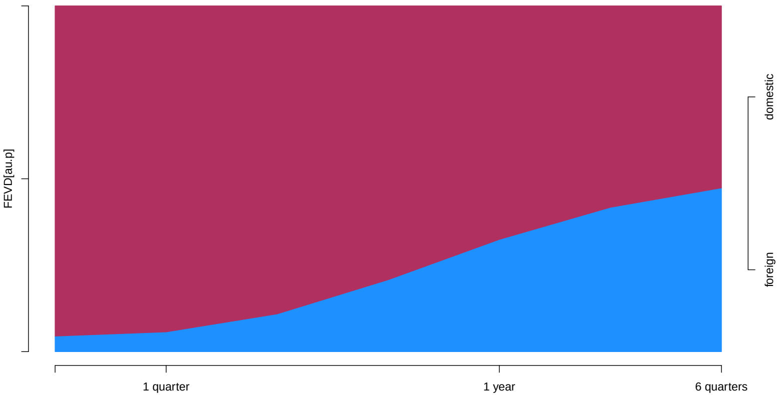
The model is identified up to a block diagonal rotation matrix

$$Q = \begin{bmatrix} Q_1 & \mathbf{0}_{6\times 6} \\ \mathbf{0}_{6\times 6} & Q_2 \end{bmatrix}$$

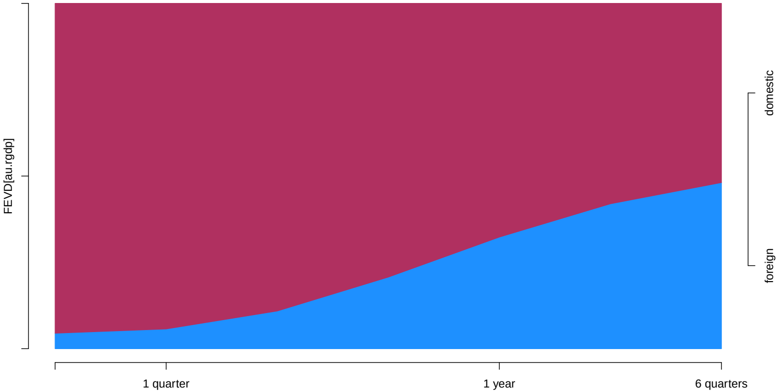
Q_1, Q_2 – 6×6 rotation matrices (drawn from Haar distribution)

The model has been estimated by premultiplying every draw of matrices B_0 and B_+ by the corresponding draw of matrix Q

Forecast error variance decomposition of $au.cpi_{t+h|t}$

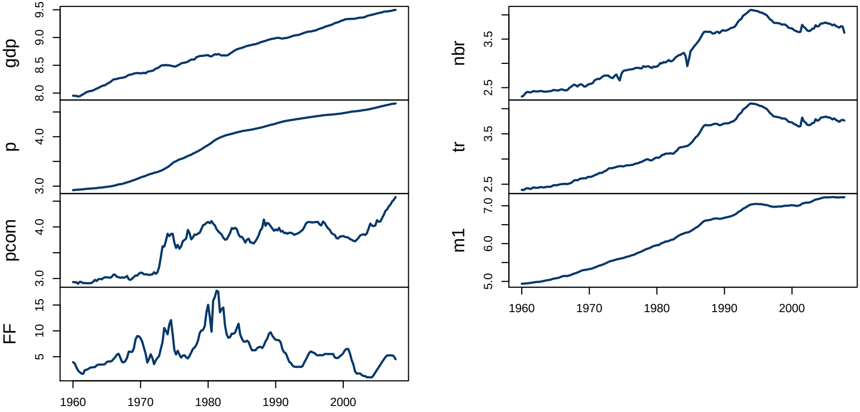


Forecast error variance decomposition of $au.rgdp_{t+h|t}$



Modeling effects of monetary policy in the US

Modeling effects of monetary policy: data



Quarterly data from 1961 Q2 to 2007 Q4.

$rgdp_t$ – real GDP, p_t – GDP price deflator, $pcom_t$ – commodity price index, FF_t – federal funds rate, nbr_t – non-borrowed reserves, tr_t – total reserves, m_t – monetary aggregate M1

Modeling effects of monetary policy: models

$$B_0 y_t = b_0 + B_1 y_{t-1} + \cdots + B_p y_{t-p} + u_t$$

$$u_t | s_t \sim \mathcal{N}\left(\mathbf{0}_N, I_N\right)$$

SVAR for a small-open economy

- The model was estimated using Waggoner & Zha (2003) algorithm
- $\underline{B}$ and $\underline{\Omega}$ prior matrices are set the same way as the RF Minnesota prior with $\kappa_1 = 0.1$, $\kappa_2 = 10$, and $\kappa_3 = 1$
- $\underline{S} = \kappa_4 I_N$ and $\kappa_4 = 10$, $\underline{\nu} = N$ which make the generalized-normal prior for B_0 set to $\mathcal{N}(\mathbf{0}_N, 10 I_N)$
- The results are sensitive to the specification of κ_1 and κ_4
- The Gibbs sampler for B_0 used $S_1 = 100$ draws in the burin-in and $S_2 = 5000$ in the final sampler
- The potential extensions include: estimation of prior hyper-parameters and heteroskedasticity of the structural shocks

Modeling effects of monetary policy: models

FF policy shock by Bernanke & Blinder (1992, AER), Sims (1992, EER)

$$
\begin{bmatrix}
a_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 \\
a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 \\
a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 & 0 \\
a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 & 0 \\
a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & 0 \\
a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77}
\end{bmatrix}
\begin{bmatrix}
rgdp_t \\ p_t \\ pcom_t \\ FF_t \\ nbr_t \\ tr_t \\ m_t
\end{bmatrix}
$$

Modeling effects of monetary policy: models

NBR policy shock by Christiano & Eichenbaum (1992)

$$\begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & 0 & 0 \\ a_{51} & a_{52} & a_{53} & 0 & a_{55} & 0 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77} \end{bmatrix} \begin{bmatrix} rgdp_t \\ p_t \\ pcom_t \\ FF_t \\ nbr_t \\ tr_t \\ m_t \end{bmatrix}$$

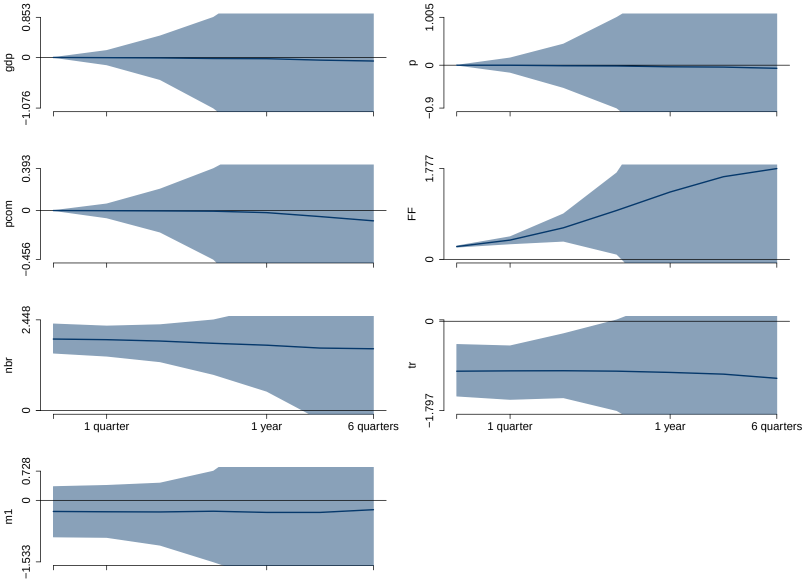
Modeling effects of monetary policy: models

NBR/TR policy shock by Strongin (1995, JME)

$$\begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} & 0 \\ a_{51} & a_{52} & a_{53} & 0 & a_{55} & a_{56} & 0 \\ a_{61} & a_{62} & a_{63} & 0 & 0 & a_{66} & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77} \end{bmatrix} \begin{bmatrix} rgdp_t \\ p_t \\ pcom_t \\ FF_t \\ nbr_t \\ tr_t \\ m_t \end{bmatrix}$$

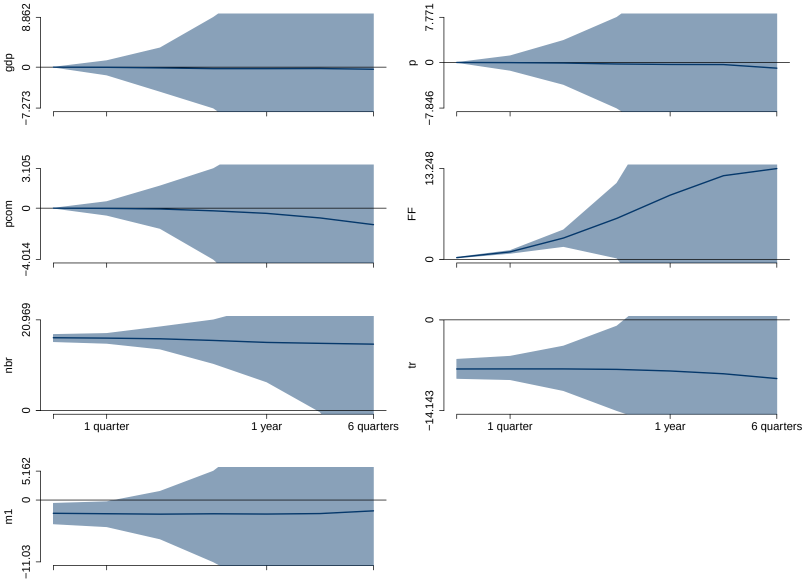
Modeling effects of monetary policy: models

FF policy shock by Bernanke & Blinder (1992, AER), Sims (1992, EER)



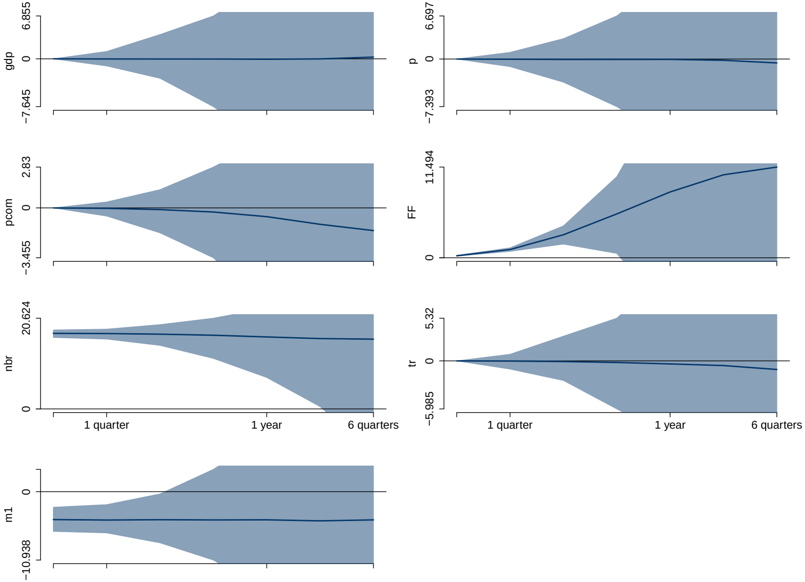
Modeling effects of monetary policy: models

NBR policy shock by Christiano & Eichenbaum (1992)



Modeling effects of monetary policy: models

NBR/TR policy shock by Strongin (1995, JME)



Modeling effects of monetary policy in the US

Extended analysis

Not Examinable

In reference to:

Christiano, Eichenbaum, & Evans (1999, HM)
Ramey (2016, HM)

as well as:

Normandin, Phaneuf (2004, JME)
Lanne, Lütkepohl (2008, JEDC)
Woźniak & Droumaguet (2019)

Heteroskedastic Structural Vector Autoregressions

$$B_0 y_t = b_0 + B_1 y_{t-1} + \cdots + B_p y_{t-p} + u_t$$

$$u_t | s_t \sim \mathcal{N}\left(\mathbf{0}_N, \operatorname{diag}\left(\lambda_{s_t}\right)\right)$$

$B_{0.n} = b_n V_n$ – restrictions for rows

$\sum_{s_t=1}^{M} \lambda_{n.s_t} = 1$ – standardization

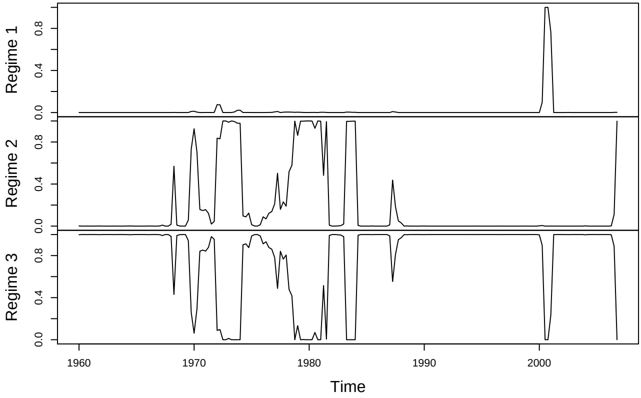
$s_t = m \in \{1, \ldots, M\}$ – Markov process

$\mathbf{P}$ – transition matrix

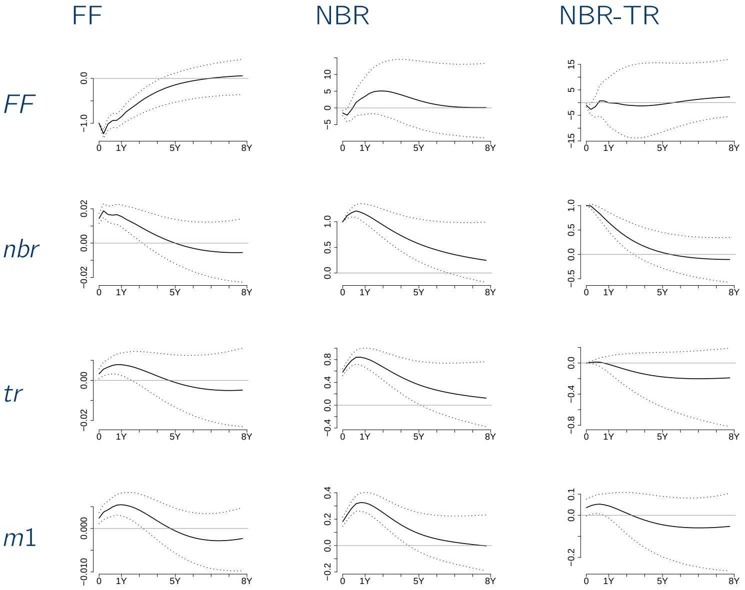
$(\kappa_1, \kappa_2, \kappa_4)$ – estimated hyper-parameters

Volatility of Structural Shocks

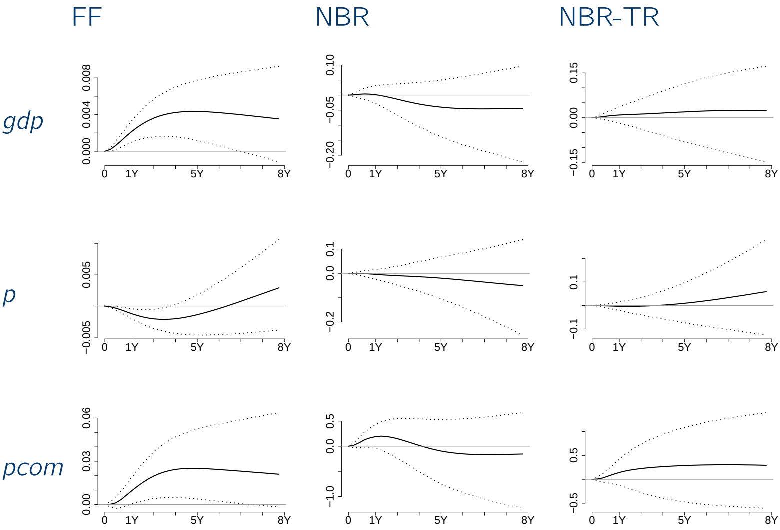
Marginal posterior state probabilities: $\Pr[s_t|\mathbf{y}]$



Monetary Policy Models for U.S. Data



Monetary Policy Models for U.S. Data



Identification Through Heteroskedasticity

Heteroskedasticity.
Let there be 2 covariance matrices associated with data:

$$\Sigma_1, \quad \text{and} \quad \Sigma_2$$

Contemporaneous effects matrix.
All N^2 elements of matrix B_0 are identified:

$$\Sigma_1 = B_0^{-1} \text{diag}(\lambda_1) B_0^{-1\prime}$$
$$\Sigma_2 = B_0^{-1} \text{diag}(\lambda_2) B_0^{-1\prime}$$

Identification Through Heteroskedasticity

Heteroskedasticity.
Let there be M covariance matrices associated with data:

$$\Sigma_m = B_0^{-1}\text{diag}(\lambda_m)B_0^{-1'}$$

Contemporaneous effects matrix.
All N^2 elements of matrix B_0 are identified.

Just-identifying restrictions in the homoskedastic case **over identify the system in the heteroskedastic** one.

These restrictions can be tested!

Monetary Policy Models for U.S. Data

M	Unrestricted	FF model	NBR model	NBR-TR model
		Markov-switching heteroskedasticity		
2	2577.3	2655.2	2653.4	**2660.1**
3	2660.6	2710.0	2708.2	**2731.4**

Reported values: $\ln p(\mathbf{y}|\mathcal{M}_i)$

References

Bernanke & Blinder (1992) The Federal Funds Rate and the Channels of Monetary Transmission American Economic Review

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