MOST 2014 學術研習營 (貨幣政策與匯率動態)

貨幣政策與匯率動態

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Outline

Measuring Monetary Policy

(1) Conventional Naive Measure:

- Money Supply (Friedman and Schwartz)
  - ⋆ In Friedman and Schwartz (1963) there are a few examples where changes in the money supply are clearly exogenous (i.e., they are not caused by changes in output).
  - ⋆ Example: The increase in reserve requirements in 1936-7 so that the Federal Reserve could improve its control of the money supply. This reduced the rate of money growth and led to a severe recession in 1937-8.
- Short-run Interest Rate

Problem: mixture of exogenous and endogenous shocks

Measuring Monetary Policy

(2) Narrative Approach (Romer and Romer dates)

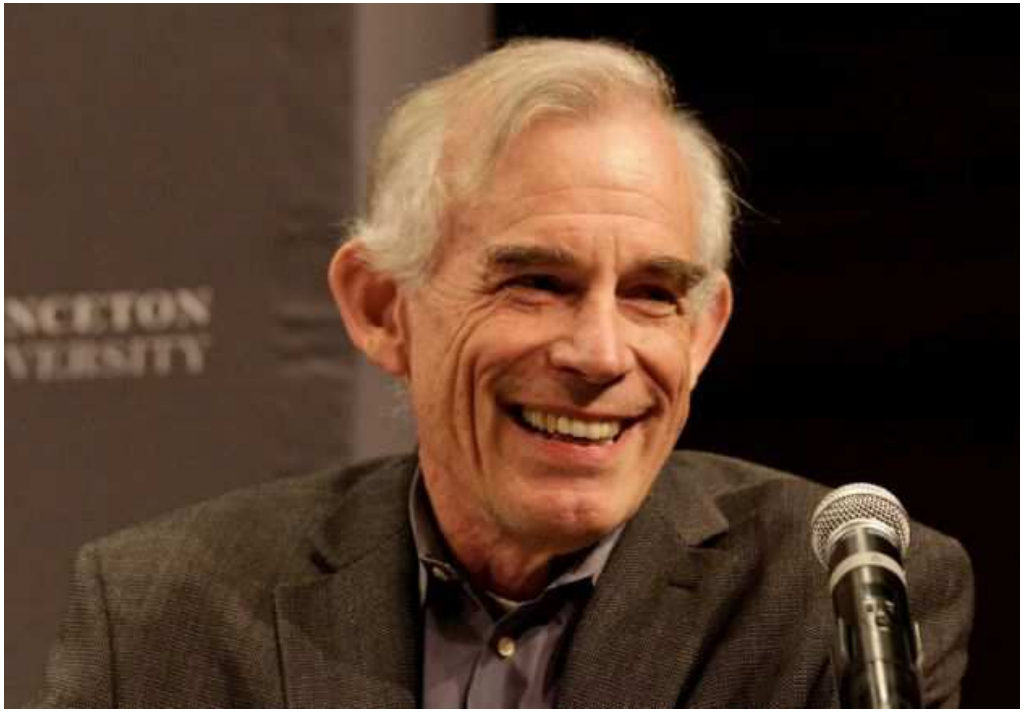
- Romer and Romer (1989, NBER Macro) Romer and Romer (1994, JME), Romer and Romer (2004, AER)
- Based on Federal Reserve documents, six times are identified that the Fed appeared to shift to tighter monetary policy not in response to real activities.
- Problem: indeed exogenous?
- See the critiques by Leeper (1997, JME)

Measuring Monetary Policy

(3) VAR Approach

- Exogenous/unanticipated shocks
- VAR Models are now used as a central tool in empirical macroeconomics.
- Sims (1980, Econometrica) provided a new macro-econometric framework that held great promise.
  - ★ Christiano (2012) " Christopher A. Sims and Vector Autoregressions " *Scandinavian Journal of Economics*

Christopher Sims



- Christopher A. Sims (1942–), Princeton University. Nobel Laureate (2011)

VAR Models

Types of VAR:

1. Reduced-form VAR (simply, VAR)
2. Structural VAR (SVAR)
   - Recursive VAR, Semi-structural VAR
   - Non-recursive VAR, Structural VAR

Structural VAR

- Given $y_t \in \mathbb{R}^k$, the SVAR(p) model is

$$y_t = D_0 y_t + D_1 y_{t-1} + \cdots + D_p y_{t-p} + B e_t$$

$$e_t \sim^{i.i.d.} (0, I) \quad \text{structural shock}$$

(a) Note that there exist contemporary effects (D_0 matrix)
(b) $[D_0]_{jj} = 0, \quad j = 1, \ldots, k$ (standardization)
(c) B diagonal matrix (orthogonalization condition)
(d) The restrictions on D_0 depend on economic theory

Structural VAR

- Given SVAR,

$$y_t = D_0 y_t + D_1 y_{t-1} + \cdots + D_p y_{t-p} + B e_t, \quad e_t \sim^{i.i.d.} (0, I)$$

- With a few more manipulations, we obtain a reduced-form VAR

$$y_t = \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + \varepsilon_t$$

where $\Phi_j \equiv (I - D_0)^{-1} D_j$ and $\varepsilon_t \equiv (I - D_0)^{-1} B e_t$

Identification

- SVAR vs. VAR

$$y_t = D_0 y_t + D_1 y_{t-1} + \cdots + D_p y_{t-p} + B e_t$$

$$y_t = \Phi_1 y_{t-1} + \cdots + \Phi_p y_{t-p} + \varepsilon_t$$

  - Our goal is to identify $\{D_0, D_1, \ldots, D_p\}$ and B from $\{\Phi_1, \Phi_2, \ldots, \Phi_p\}$ and Σ_ε
  - Note that

$$D_j = (I - D_0)\Phi_j, \quad j = 1, \ldots, p$$

    the identification can be achieved by

$$\varepsilon_t = (I - D_0)^{-1} B e_t$$

Identification

- From $\varepsilon_t = (I - D_0)^{-1} B e_t$,

$$E(\varepsilon_t \varepsilon_t') = (I - D_0)^{-1} B E(e_t e_t') B' (I - D_0)^{-1'}$$

- That is,

$$\Sigma_\varepsilon = (I - D_0)^{-1} B B' (I - D_0)^{-1'}$$

  - $\frac{k(k-1)}{2} + k$ parameters can be identified from Σ_ε
  - On the other hand, we need to identify $2k^2$ parameters in D_0 and B
  - Thus, the difference is $\frac{k(3k-1)}{2}$

Identification

- Recall that
  - (a) B is diagonal (structural shocks are uncorrelated to each other).
  - (b) Standardization: $[D_0]_{jj} = 0, \quad j = 1, \ldots, k$

- These conditions imply

$$\underbrace{k^2 - k}_{\text{by}(a)} + \underbrace{k}_{\text{by}(b)}$$

We still need to identify

$$\frac{k(3k-1)}{2} - (k^2 - k) - k = \frac{k(k-1)}{2}$$

Identification

- How to obtain $\frac{k(k-1)}{2}$ conditions?
  - short-run restriction
    (a) recursive (semi-structural)
    (b) economic theory/institutional knowledge (structural)
  - long-run restriction
- See:
  - Sims (1980, Econometrica)
  - Bernanke (1986, Carnegie-Rochester Conference Series on Public Policy)
  - Blanchard and Quah (1989, AER)

Monetary Policy and VAR

Puzzles in Previous Studies

A conventional SVAR: (Y, P, M, R) with structural shocks (e_y, e_p, e_M, e_R)

- Is the monetary shock e_M or e_R?
- Two puzzles:
  - Liquidity Puzzle ($e_M \Rightarrow R$)

	Theory	Evidence
$M_t^s \uparrow$	$R_t \downarrow$	$R_t \uparrow$

  - Price Puzzle ($e_R \Rightarrow P$)

	Theory	Evidence
$R_t \uparrow$	$P_t \downarrow$	$P_t \uparrow$

Monetary Policy and VAR

More Sophisticated Structure: Reserve Market.

- Bernanke and Blinder (1992, AER): Federal Funds Rates
- Christiano and Eichenbaum (1992): Non-borrowed Reserves
- Strongin (1995, JME): Non-borrowed Reserves/Total Reserves
- Cosimano and Sheehan (1994, JMacro): Borrowed Reserves
- Bernanke and Mihov (1998, QJE) consider all of the above models

Bernanke and Mihov (1998)

Consider a 6-Variable SVAR

- Macroeconomic Variables
  - real GDP
  - GDP deflator
  - commodity prices
- Policy Variables
  - total bank reserves
  - non-borrowed reserves
  - federal funds rates

Identification in Bernanke and Mihov (1998)

- Let

$$Y_t = \begin{bmatrix} \text{Real GDP} \\ \text{GDP deflator} \\ \text{Commondity Price} \end{bmatrix}, \qquad P_t = \begin{bmatrix} TR_t \\ NBR_t \\ FF_t \end{bmatrix}$$

- Consider a SVAR

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=0}^{k} C_i P_{t-i} + A^y v_t^y$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} G_i P_{t-i} + A^p v_t^p$$

- Bernanke and Mihov (1998) assume $C_0 = \mathbf{0}$

Identification in Bernanke and Mihov (1998)

- We can estimate a reduced form VAR

$$Y_t = \sum_{i=1}^{k} H_i^y Y_{t-i} + \sum_{i=1}^{k} H_i^p P_{t-i} + \varepsilon_t^y$$

$$P_t = \sum_{i=0}^{k} J_i^y Y_{t-i} + \sum_{i=1}^{k} J_i^p P_{t-i} + \varepsilon_t^p$$

where

$$\varepsilon_t^p = (I - G_0)^{-1} A^p v_p \quad \text{or} \quad (I - G_0) \begin{bmatrix} \varepsilon_t^{TR} \\ \varepsilon_t^{NBR} \\ \varepsilon_t^{FF} \end{bmatrix} = A^p \begin{bmatrix} v_t^d \\ v_t^b \\ v_t^s \end{bmatrix}$$

Identification in Bernanke and Mihov (1998)

- Open-market operations to affect reserve market
- Reserve Market

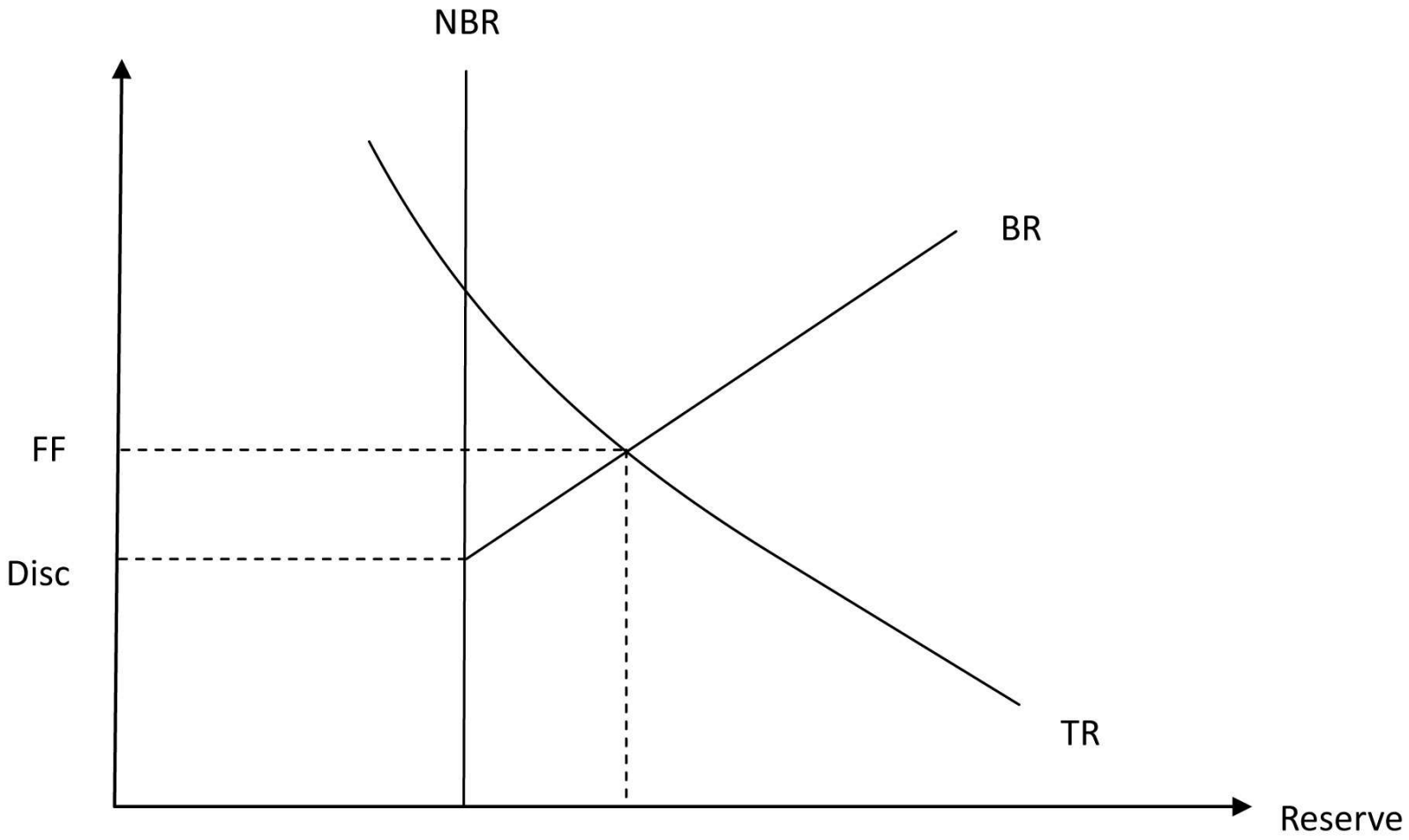
$$\varepsilon_t^{TR} = -\alpha\varepsilon_t^{FF} + v_t^d, \tag{1}$$

$$\varepsilon_t^{BR} = \beta(\varepsilon_t^{FF} - \varepsilon_t^{DISC}) + v_t^b, \tag{2}$$

$$\varepsilon_t^{NBR} = \phi^d v_t^d + \phi^b v_t^b + v_t^s. \tag{3}$$

$$\varepsilon_t^{TR} = \varepsilon_t^{BR} + \varepsilon_t^{NBR} \tag{4}$$

Reserve Market



Identification in Bernanke and Mihov (1998)

- Assume $\varepsilon_t^{DISC} = 0$,

$$\underbrace{\begin{bmatrix} 1 & 0 & \alpha \\ 1 & -1 & -\beta \\ 0 & 1 & 0 \end{bmatrix}}_{I - G_0} \begin{bmatrix} \varepsilon_t^{TR} \\ \varepsilon_t^{NBR} \\ \varepsilon_t^{FF} \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ \phi^d & \phi^b & 1 \end{bmatrix}}_{A^p} \begin{bmatrix} v_t^d \\ v_t^b \\ v_t^s \end{bmatrix}$$

Measuring Monetary Policy

We can thus solve for v_t^s as

$$v_t^s = -(\phi^d + \phi^b)\varepsilon_t^{TR} + (1 + \phi^b)\varepsilon_t^{NBR} - (\alpha\phi^d - \beta\phi^b)\varepsilon_t^{FF}.$$

Measuring Monetary Policy

1. FFR Model: $\phi^d = 1$, $\phi^b = -1$,

$$v_t^s = -(\alpha + \beta)\varepsilon_t^{FF}.$$

2. NBR Model: $\phi^d = 0$, $\phi^b = 0$,

$$v_t^s = \varepsilon_t^{NBR}.$$

3. NBR/TR Model: $\alpha = 0$, $\phi^b = 0$,

$$v_t^s = -\phi^d \varepsilon_t^{TR} + \varepsilon_t^{NBR}.$$

4. BR Model: $\phi^d = 1$, $\phi^b = \alpha/\beta$,

$$v_t^s = -\left(1 + \frac{\alpha}{\beta}\right)(\varepsilon_t^{TR} - \varepsilon_t^{NBR}).$$

5. JI Model: $\alpha = 0$,

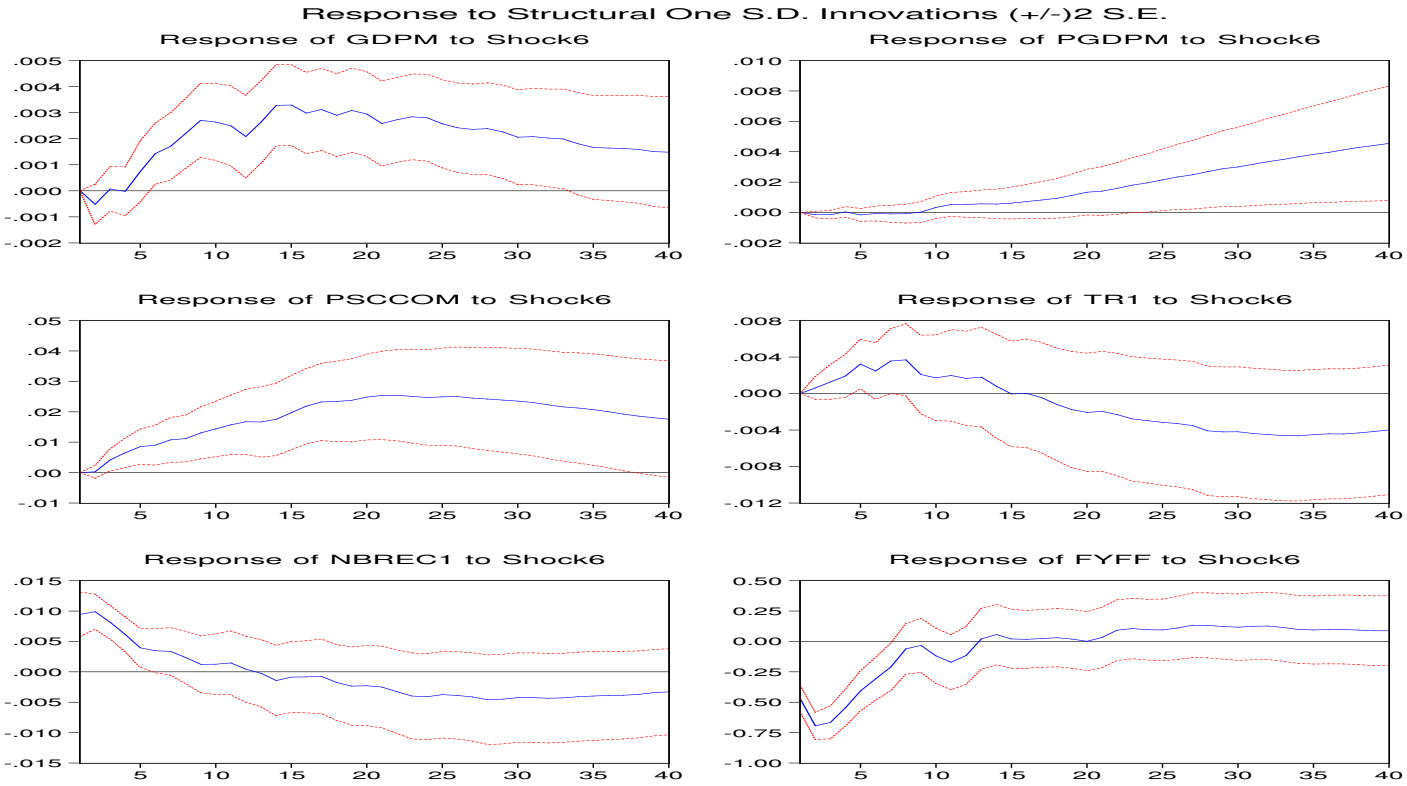
$$v_t^s = -(\phi^d + \phi^b)\varepsilon_t^{TR} + (1 + \phi^b)\varepsilon_t^{NBR} + \beta\phi^b\varepsilon_t^{FF}.$$

Identification: An Alternative Representation

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ d_{21} & 1 & 0 & 0 & 0 & 0 \\ d_{31} & d_{32} & 1 & 0 & 0 & 0 \\ d_{41} & d_{42} & d_{43} & 1 & 0 & \alpha \\ d_{51} & d_{52} & d_{53} & 1 & -1 & -\beta \\ d_{61} & d_{62} & d_{63} & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{GDP} \\ \varepsilon_t^{P} \\ \varepsilon_t^{Pcm} \\ \tilde{\varepsilon}_t^{TR} \\ \tilde{\varepsilon}_t^{NBR} \\ \tilde{\varepsilon}_t^{FF} \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & \phi^d & \phi^b & 1 \end{bmatrix} \begin{bmatrix} v_{1t}^{NP} \\ v_{2t}^{NP} \\ v_{3t}^{NP} \\ v_t^{d} \\ v_t^{b} \\ v_t^{s} \end{bmatrix}$$

Impulse Responses: Expansive Monetary Shock



- Hump-shaped and Significant Response of Real Output
- Liquidity Effect
- No Price Puzzle

Summary: VAR Models as Measures of Monetary Policy

- Incorporate the effects of possible changes in reserve-market structure and in the Fed's operating procedures.
- Can be generalized to other countries or periods.
- For instance,
  公開市場操作為中央銀行經由金融市場, 買賣票債券的方式增減銀行體系的準備金, 以調控準備貨幣與拆款市場利率的操作機制, 為中央銀行最重要的貨幣政策工具。(中華民國中央銀行之制度與功能, 2003)

Recent Developments

- Alternative Identification Schemes:
  - Sign Restrictions: Uhlig (2005, JME)
  - Identification through Heteroskedasticity: Rigobon (2003, REStat), Rigobon and Sack (2003, QJE) and Rigobon and Sack (2004, JME), Lanne and Lutkepohl (2008, JMCB)
- Factor-augmented VAR
  - Bernanke et al. (2005, QJE)

Sign Restrictions

- Uhlig (2005, JME)
- Method: impose all the other sign restrictions, but not the restriction on output and total reserves.

Series	Response restricted?
Real output	no
GDP deflator	Negative or zero
Commodity price index	Negative or zero
Total Reserves	no
Nonborrowed Reserves	Negative or zero
Federal Funds Rate	Positive or zero

The restrictions are for horizons k, $k = 0, ..., K$.

Identification through Heteroskedasticity

- Rigobon (2003, REStat), Rigobon and Sack (2003, QJE) and Rigobon and Sack (2004, JME)
- Example:

$$p_t = \beta q_t + \varepsilon_t$$
$$q_t = \alpha p_t + \eta_t$$

where $\sigma_{\varepsilon,\eta} = 0$ (structural shocks are orthogonal)

- 4 unknown: α, β, σ_ε^2, and σ_η^2 (not identified)

$$\begin{bmatrix} Var(p_t) & Cov(p_t, q_t) \\ Cov(q_t, p_t) & Var(q_t) \end{bmatrix} = \frac{1}{(1-\alpha\beta)^2} \begin{bmatrix} \beta^2\sigma_\eta^2 + \sigma_\varepsilon^2 & \beta\sigma_\eta^2 + \alpha\sigma_\varepsilon^2 \\ \cdot & \sigma_\eta^2 + \alpha^2\sigma_\varepsilon^2 \end{bmatrix}$$

Identification through Heteroskedasticity

- Assume there are two regimes in the variances of the structural shocks: high and low ($s \in \{1, 2\}$).

$$\hat{\Omega}_s = \frac{1}{(1-\alpha\beta)^2} \begin{bmatrix} \beta^2\sigma^2_{\eta,s} + \sigma^2_{\varepsilon,s} & \beta\sigma^2_{\eta,s} + \alpha\sigma^2_{\varepsilon,s} \\ \cdot & \sigma^2_{\eta,s} + \alpha^2\sigma^2_{\varepsilon,s} \end{bmatrix}$$

- 6 unknown: α, β, $\sigma^2_{\varepsilon,1}$, $\sigma^2_{\varepsilon,2}$, $\sigma^2_{\eta,1}$, and $\sigma^2_{\eta,2}$

Factor Augmented VAR

- Bernanke et al. (2005, QJE)
- The joint dynamics of unobserved factors F_t and observable economic variables Y_t are

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + v_t.$$

- Observation equation:

$$X_t = \Lambda_f F_t + \Lambda_y Y_t + u_t,$$

where X_t are a number of informational time series.

Monetary Policy and Exchange Rate Dynamics

Early Work: Recursive VAR

- Eichenbaum and Evans (1995, QJE).
  - Identification (Wold ordering):

$$[Y_t \quad P_t \quad NBRX_t \quad (R_t^{For} - R_t^{US}) \quad S_t^{For}]'$$

  - Findings:
    (a) Delayed overshooting
    (b) U.S. contractionary monetary shocks lead to U.S. dollar appreciation
    (c) Significant and persistent deviations from UIP (forward discount puzzle)
  - Further readings: Faust and Rogers (2003, JME), Faust et al. (2003, JEEA).

Monetary Policy and Exchange Rate Dynamics

Further Investigatons

- Structural VAR: Kim and Roubini (2000, JME)
- Sign Restrictions: Scholl and Uhlig (2008, JIE)
- Long-run Restriction: Bjornland (2009, JIE)
- Heteroskedasticity: Caporale et al. (2005, JIMF)
- FVAR: Mumtaz and Surico (2009, JMCB).

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