Economics 210c/236a
Fall 2011

Christina Romer
David Romer

LECTURE 3

The Effects of Monetary Changes: Vector Autoregressions

September 14, 2011

I. VARs in General

A Two-Variable VAR

Suppose the true model is:

$$x_{1t} = \theta x_{2t} + b_{11} x_{1,t-1} + b_{12} x_{2,t-1} + \varepsilon_{1t},$$

$$x_{2t} = \gamma x_{1t} + b_{21} x_{1,t-1} + b_{22} x_{2,t-1} + \varepsilon_{2t},$$

where ε_{1t} and ε_{2t} are uncorrelated with one another, with the contemporaneous and lagged values of the right-hand side variables, and over time.

Rewrite this as:

$$\begin{bmatrix} 1 & -\theta \\ -\gamma & 1 \end{bmatrix} \begin{matrix} x_{1t} \\ x_{2t} \end{matrix} = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{matrix} x_{1t} \\ x_{2t} \end{matrix} + \begin{matrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{matrix},$$

or

$$CX_t = BX_{t-1} + E_t,$$

where

$$C \equiv \begin{bmatrix} 1 & -\theta \\ -\gamma & 1 \end{bmatrix}, \quad X_t \equiv \begin{matrix} x_{1t} \\ x_{2t} \end{matrix}, \quad B \equiv \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}, \quad E_t \equiv \begin{matrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{matrix}.$$

This implies

$$X_t \;=\; C^{-1}(BX_{t-1} \;+\; E_t)$$

$$=\; \Pi X_{t-1} + \; U_t,$$

where $\Pi \equiv C^{-1}B,\ U_t \equiv C^{-1}E_t.$

Extending to K Variables and N Lags

The "true model" takes the form:

$$CX_t = \sum_{n=1}^{N} B^n X_{t-n} + E_t,$$

where C is K x K, X is K x 1, B is K x K, and E is K x 1.

This leads to:

$$X_t = \sum_{n=1}^{N} \Pi^n X_{t-n} + U_t,$$

where

$$\Pi^n \equiv C^{-1}B^n,\ U_t \equiv C^{-1}E_t.$$

II. Christiano, Eichenbaum, and Evans, "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds"

Simplified Version of Christiano, Eichenbaum, and Evans

Two variables, one lag:

$$y_t = \qquad b_{11}y_{t-1} + b_{12}r_{t-1} + \varepsilon_{yt},$$

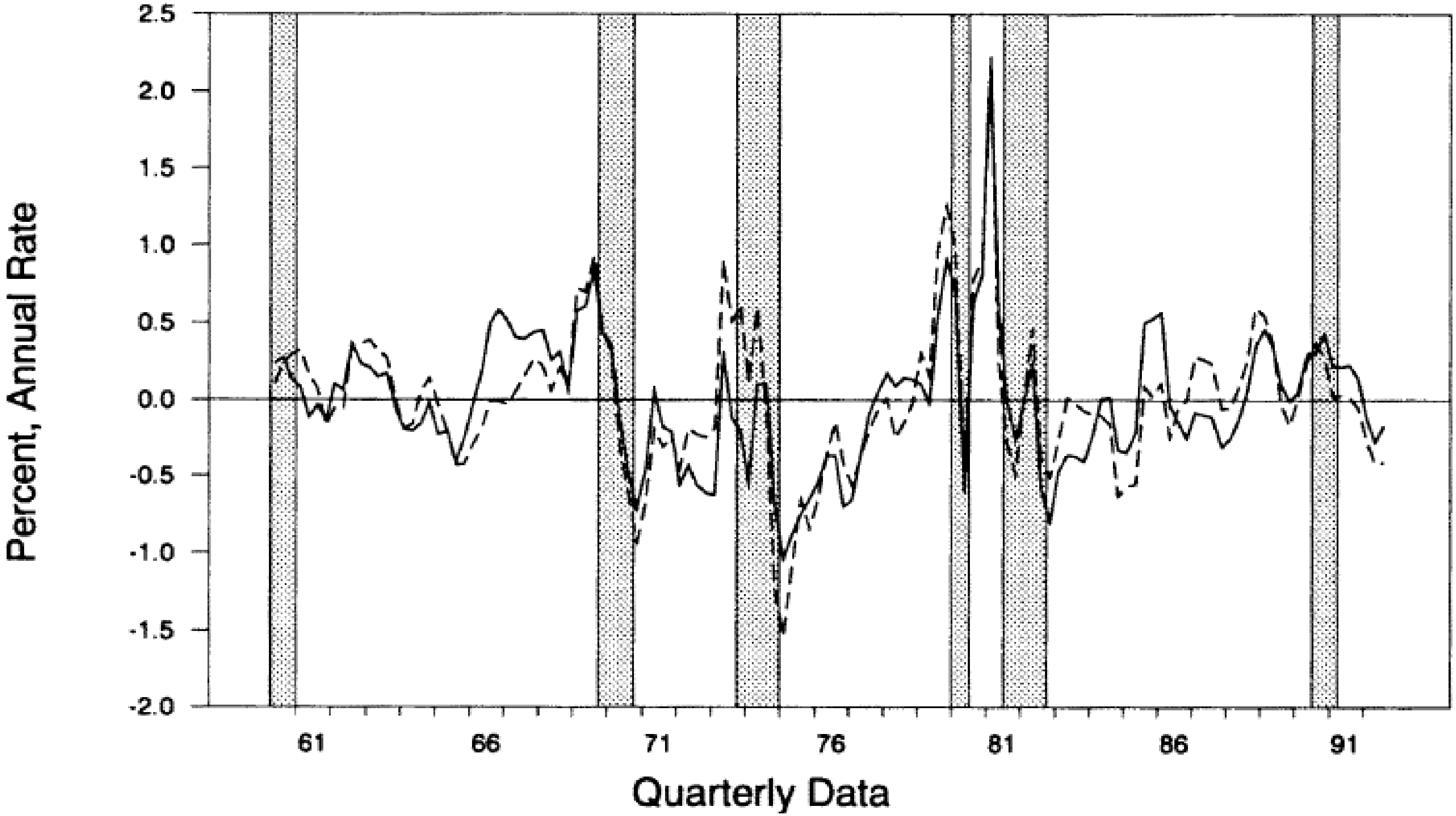
$$r_t = \gamma y_t + b_{21}y_{t-1} + b_{22}r_{t-1} + \varepsilon_{rt}.$$

The reduced form is:

$$y_t = b_{11}y_{t-1} + b_{12}r_{t-1} + \varepsilon_{yt},$$

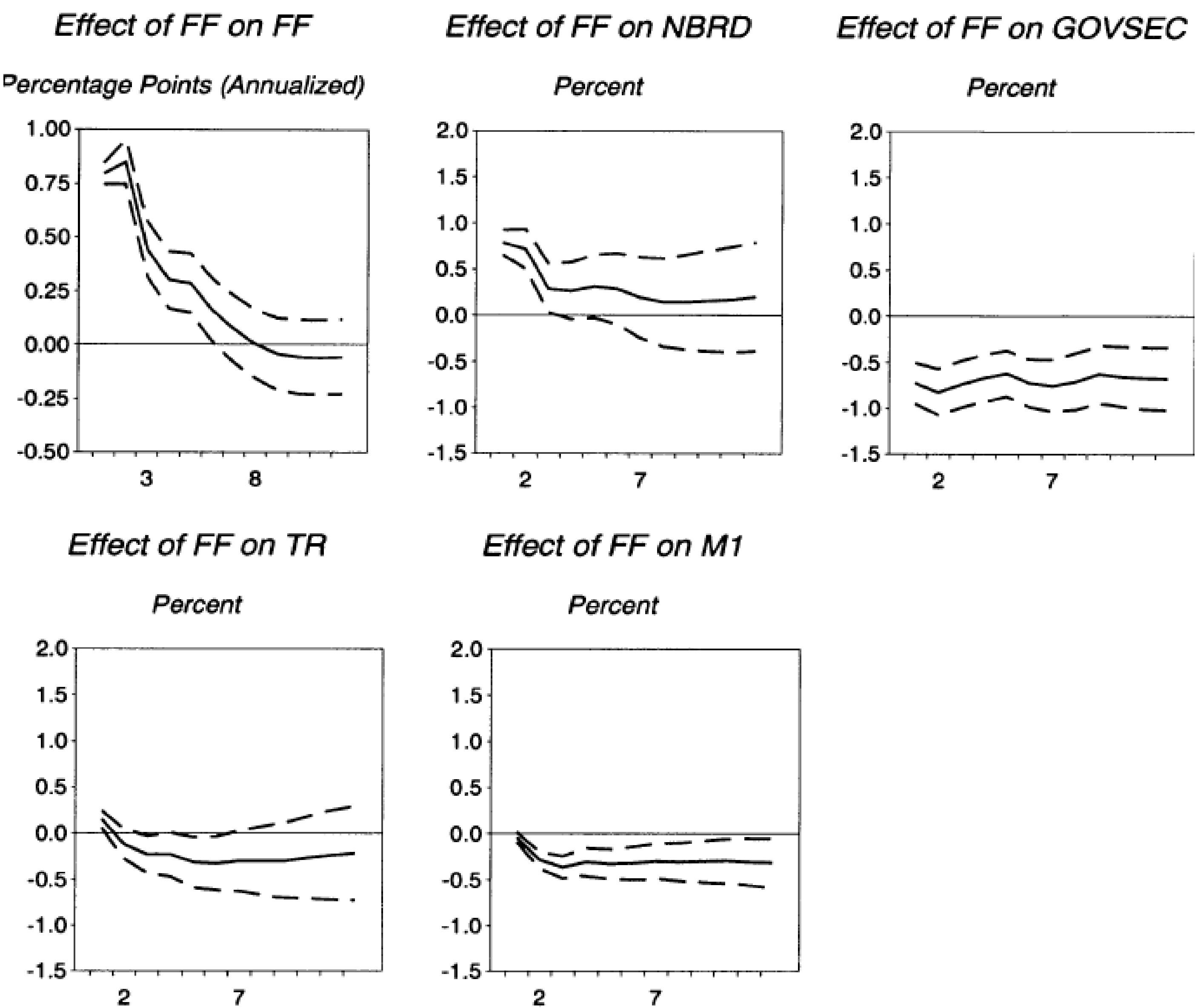
$$r_t = (b_{21} + \gamma b_{11})y_{t-1} + (b_{22} + \gamma b_{12})r_{t-1} + \left(\gamma\varepsilon_{yt} + \varepsilon_{rt}\right).$$

FIGURE 1. — THREE QUARTER, CENTERED AVERAGE OF FF POLICY SHOCKS WITH AND WITHOUT COMMODITY PRICES



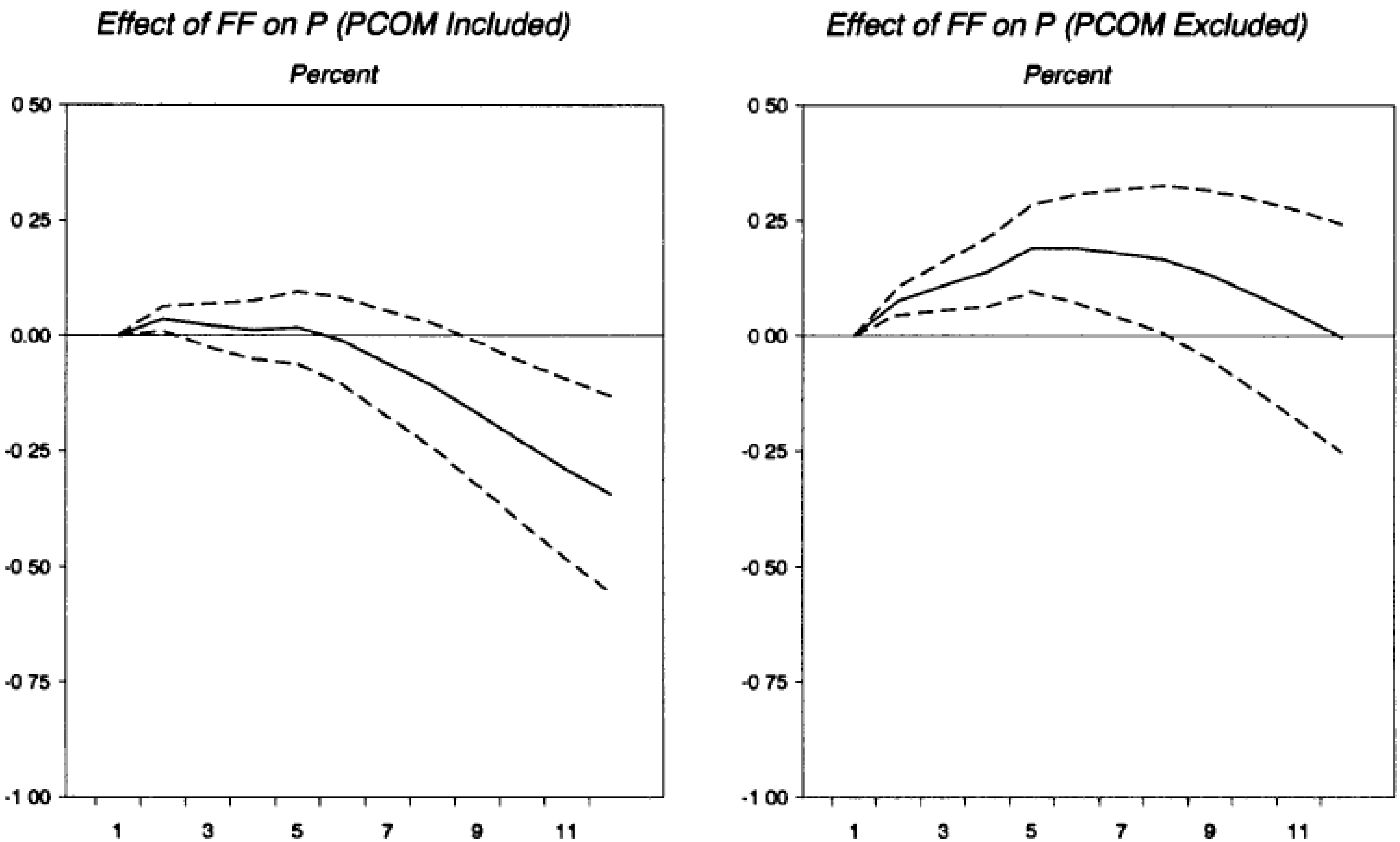
From: Christiano, Eichenbaum, and Evans, "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds"

FIGURE 2. — EFFECT OF POLICY SHOCKS ON MONETARY VARIABLES



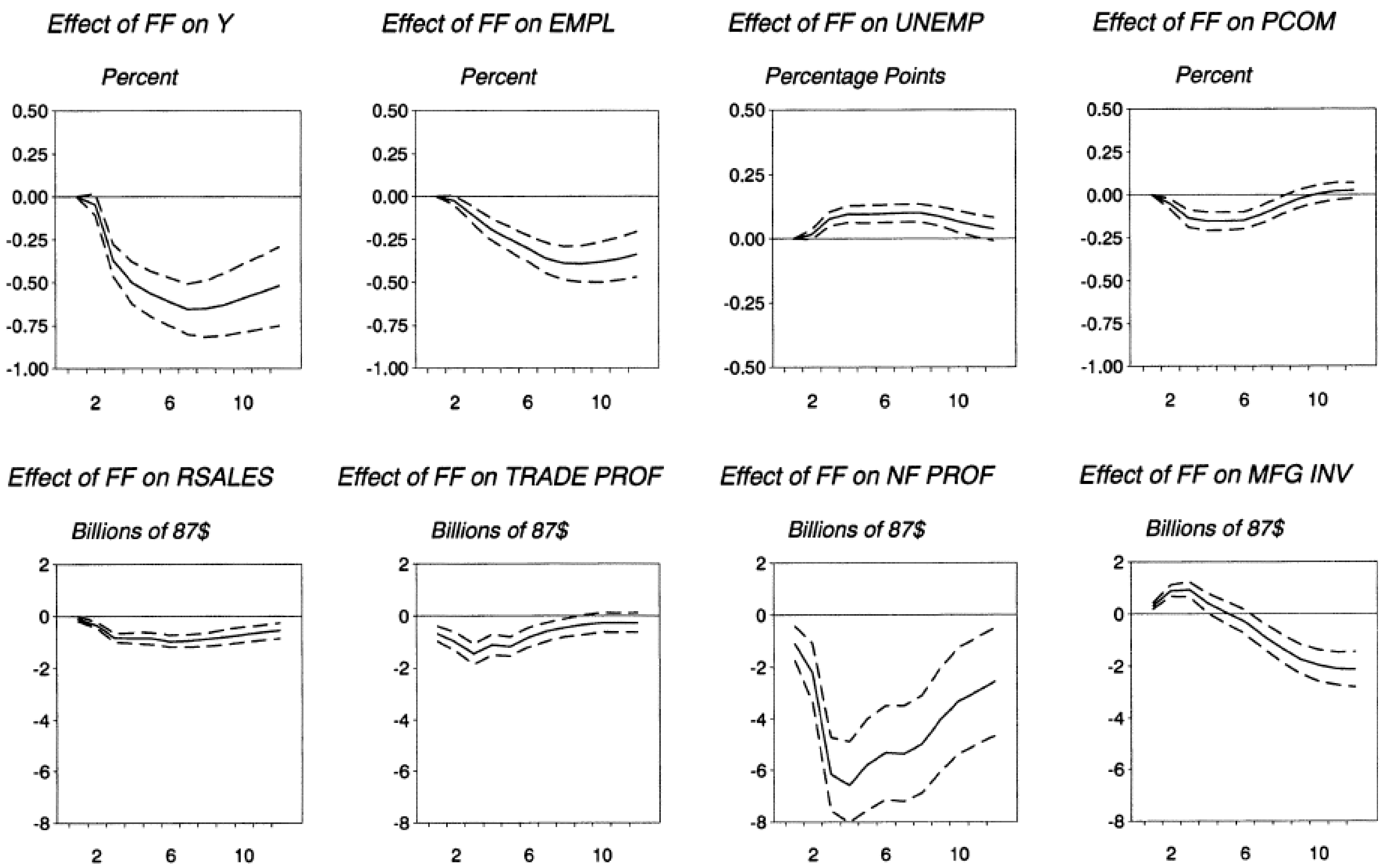
From: Christiano, Eichenbaum, and Evans

FIGURE 4. — EFFECT OF POLICY SHOCKS ON PRICE LEVEL



From: Christiano, Eichenbaum, and Evans

FIGURE 3. — EFFECT OF POLICY SHOCKS ON MACROECONOMIC VARIABLES



From: Christiano, Eichenbaum, and Evans

III. Galí, "How Well Does the IS-LM Model Fit Postwar U.S. Data?"

Simplified Version of Galí

True model:

$$y_t = \theta m_t + b_{11} y_{t-1} + b_{12} m_{t-1} + \varepsilon_{yt},$$
$$m_t = \gamma y_t + b_{21} y_{t-1} + b_{22} m_{t-1} + \varepsilon_{mt}.$$

Long-run impact of a realization of ε_{mt} of +1 on y:

Assume system is such that the impact on *m* eventually settles down at some level; call this level m_{LR}. Then:

$$y_{LR} = \theta m_{LR} + b_{11} y_{LR} + b_{12} m_{LR}.$$

So: $y_{LR} = 0$ requires $\Theta + b_{12} = 0$.

TABLE I
IDENTIFYING RESTRICTIONS

Long-run restrictions

R1: no long-run effects of money supply shocks on GNP
R2: no long-run effects of money demand shocks on GNP
R3: no long-run effects of IS shocks on GNP

Short-run restrictions

R4: no contemporaneous effect of money supply shocks on output
R5: no contemporaneous effect of money demand shocks on output
R6: contemporaneous prices do not enter the money supply rule
R7: contemporaneous GNP does not enter the money supply rule
R8: (contemporaneous) homogeneity in money demand

From: Galí, "How Well Does the IS-LM Model Fit Postwar U.S. Data?"

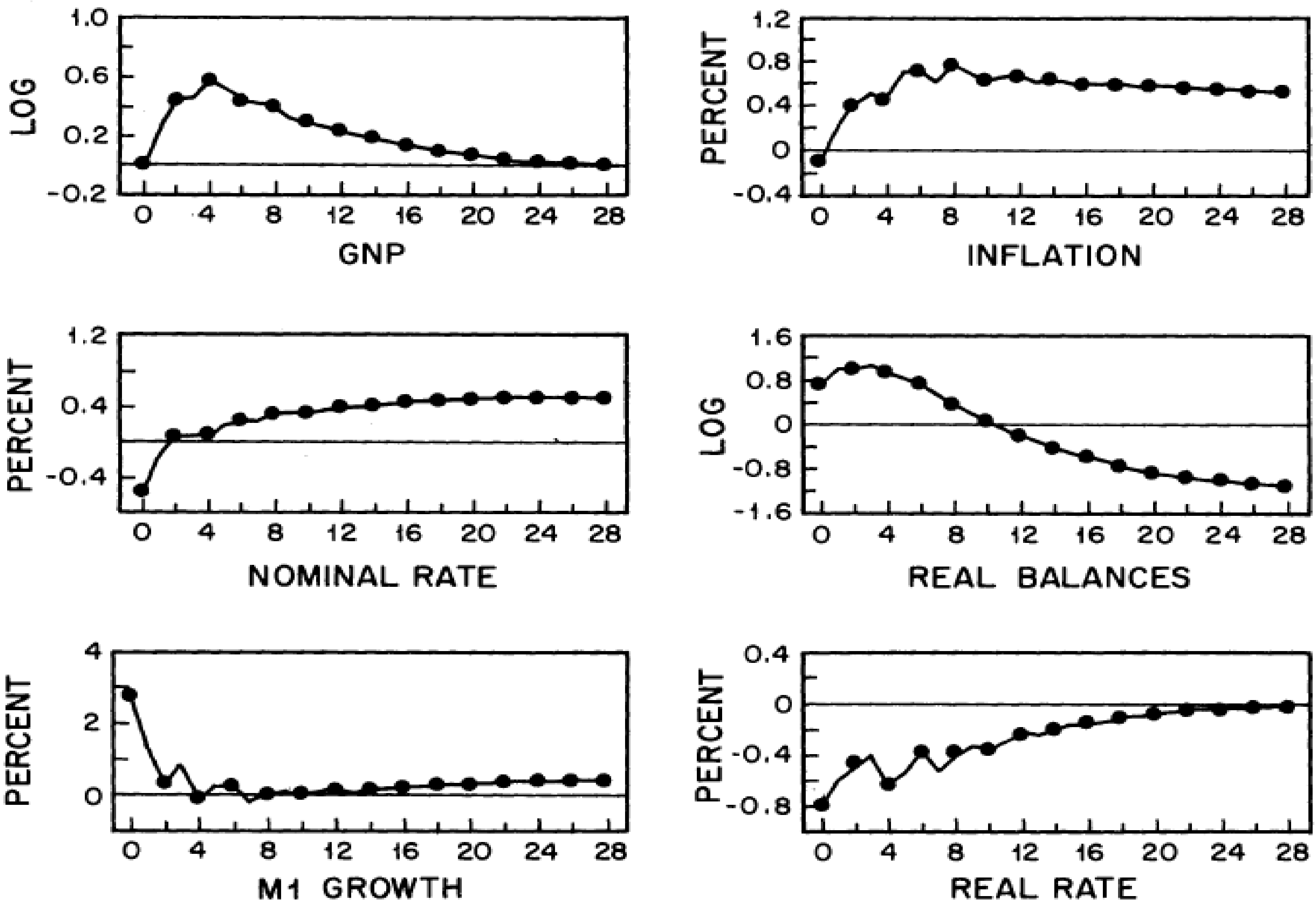


FIGURE II
Dynamic Response to a Money Supply Shock

From: Galí, "How Well Does the IS-LM Model Fit Postwar U.S. Data?"

IV. Bernanke and Mihov, "Measuring Monetary Policy"

Simplified Version of Bernanke and Mihov

$$Y_t = B_0 Y_t + \sum_{n=1}^{N} B_n Y_{t-n} + \sum_{n=1}^{N} C_n P_{t-n} + A^y v_t^y,$$

$$P_t = G_0 P_t + \sum_{n=0}^{N} D_n Y_{t-n} + \sum_{n=1}^{N} G_n P_{t-n} + A^p v_t^p.$$

This implies:

$$P_t = \sum_{n=1}^{N} (I - G_0)^{-1} D_n Y_{t-n} + \sum_{n=1}^{N} (I - G_0)^{-1} G_n P_{t-n} + u_t^p,$$

where $u_t^p \equiv (I - G_0)^{-1} A^p v_t^p$.

Bernanke and Mihov's Policy Block

$$TR = \cdots - \alpha FF + v^D,$$

$$(TR - NBR) = \cdots + \beta FF + v^B,$$

$$NBR = \cdots + \phi^D v^D + \phi^B v^B + v^S.$$

Example 1: $\phi^D = \phi^B = 0$. Then NBR = ... + v^S, so NBR can be used to measure policy shocks.

Example 2: $\phi^D = 1$, $\phi^B = -1$. Then one can show FF = ... - $v^S/(\alpha + \beta)$, so FF can be used to measure policy shocks.

TABLE I

PARAMETER ESTIMATES FOR ALL MODELS (MONTHLY)

Sample	Model	α	β	ϕ^d	ϕ^b	Tests: For OIR	Tests: Restrictions under JI model
1965:1–1996:12	FFR	−0.004 (0.001)	0.012 (0.001)	1	−1	**0.119**	0.004
	NBR	0.031 (0.010)	0.014 (0.001)	0	0	0.000	0.000
	NBR/TR	0	0.049 (0.012)	0.828 (0.061)	0	0.033	0.020
	BR	−0.004 (0.001)	0.041 (0.008)	1	α/β	**0.119**	0.000
	JI	0	0.020 (0.006)	0.809 (0.058)	−0.636 (0.274)	—	—
1965:1–1979:9	FFR	−0.005 (0.002)	0.015 (0.003)	1	−1	**0.148**	0.048
	NBR	0.014 (0.004)	0.056 (0.005)	0	0	0.000	0.000
	NBR/TR	0	0.077 (0.012)	0.776 (0.106)	0	**0.078**	0.049
	BR	−0.005 (0.002)	0.067 (0.010)	1	α/β	**0.148**	0.000
	JI	0	0.028 (0.011)	0.749 (0.102)	−0.620 (0.315)	—	—
1979:10–1996:12	FFR	−0.002 (0.001)	0.013 (0.001)	1	−1	0.013	0.000
	NBR	0.029 (0.008)	0.014 (0.001)	0	0	0.001	0.000
	NBR/TR	0	0.036 (0.009)	0.725 (0.076)	0	**0.778**	**0.753**
	BR	−0.002 (0.001)	0.024 (0.004)	1	α/β	0.013	0.001
	JI	0	0.041 (0.021)	0.730 (0.079)	0.040 (0.128)	—	—
1984:2–1996:12	FFR	−0.007 (0.005)	0.005 (0.002)	1	−1	0.041	0.031
	NBR	−0.498 (0.593)	0.005 (0.002)	0	0	0.007	0.000
	NBR/TR	0	0.254 (0.126)	0.812 (0.090)	0	**0.161**	**0.202**
	BR	−0.007 (0.005)	0.117 (0.073)	1	α/β	0.041	0.002
	JI	0	0.043 (0.027)	0.810 (0.078)	−0.402 (0.315)	—	—
1988:9–1996:12	FFR	−0.021 (0.005)	−0.001 (0.002)	1	−1	**0.466**	**0.636**
	NBR	−0.131 (0.029)	−0.005 (0.002)	0	0	0.048	0.000
	NBR/TR	0	0.141 (0.117)	0.904 (0.035)	0	0.001	0.000
	BR	−0.021 (0.005)	−0.462 (1.374)	1	α/β	**0.466**	0.000
	JI	0	0.002 (0.005)	0.984 (0.033)	−0.980 (0.071)	—	—

The estimates come from a six-variable monthly VAR (see text for explanations). The next-to-the-last column presents *p*-values from tests of overidentifying restrictions based on the minimized value of the criterion function. The last column gives *p*-values from tests of the implied restrictions under the just-identified model ($\alpha = 0$). In the last two columns the values in boldface indicate that the restrictions implied by the particular model cannot be rejected at the 5 percent level of significance. The figures in parentheses are standard errors.

From: Bernanke and Mihov, “Measuring Monetary Policy”

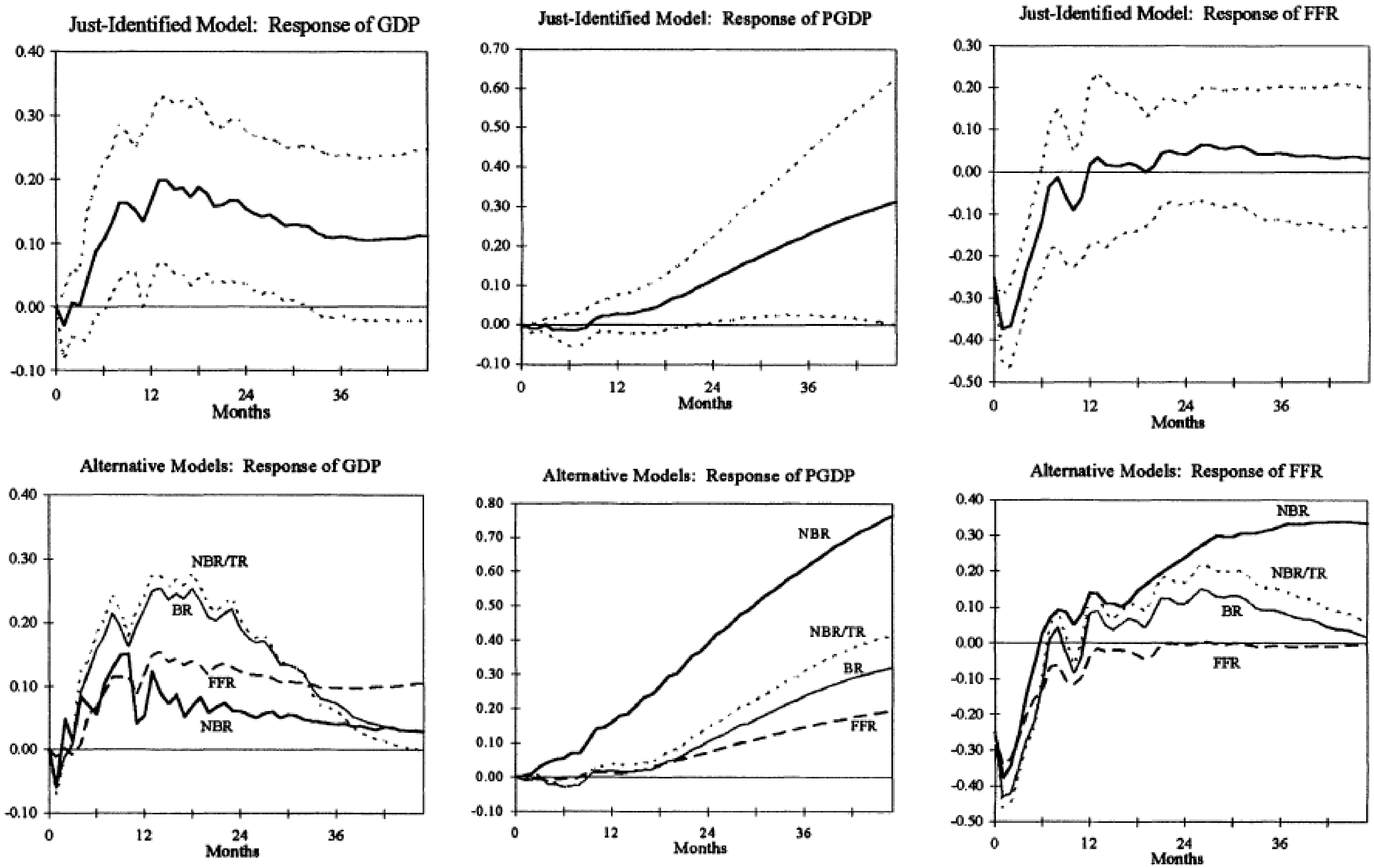


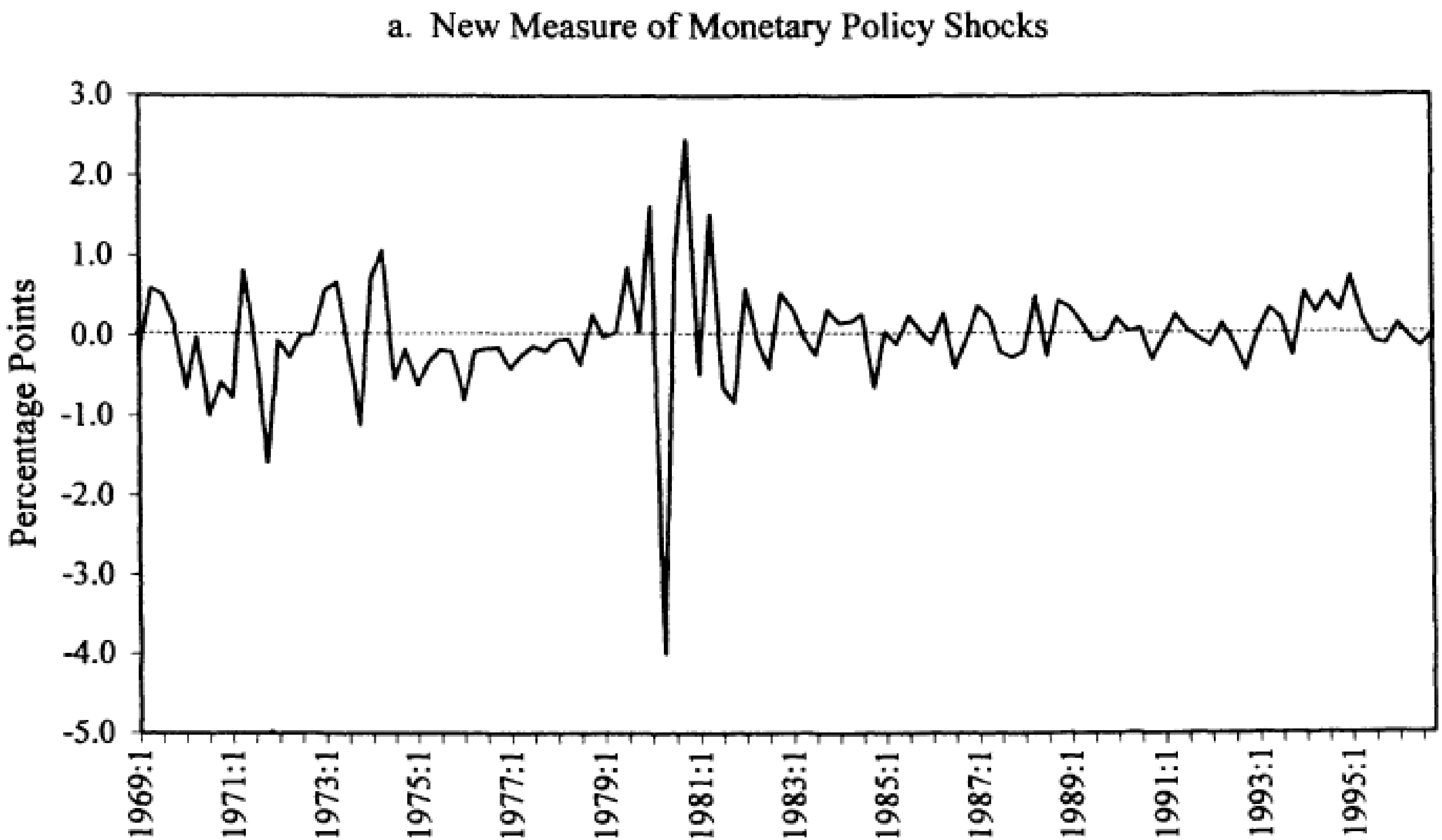
FIGURE II
Responses of Output, Prices, and the Federal Funds Rate to Monetary Policy Shock in Alternative Models (1965:1–1996:12)

From: Bernanke and Mihov, "Measuring Monetary Policy"

V. Romer and Romer: "A New Measure of Monetary Shocks: Derivation and Implications"

Deriving New Measure

- Derive the change in the intended funds rate around FOMC meetings using narrative and other sources.
- Regress on Federal Reserve forecasts of inflation and output growth.
- Take residuals as new measure of monetary policy shocks.



From: Romer and Romer, “A New Measure of Monetary Shocks”

What kinds of thing are in the new shock series?

- Unusual movements in funds rate because the Fed was also targeting other measures.
- Mistakes based on a bad model of economy.
- Change in tastes.
- Political factors.
- Pursuit of other objectives

Single-Equation Regression for Output

$$(2) \quad \Delta y_t = a_0 + \sum_{k=1}^{11} a_k D_{kt} + \sum_{i=1}^{24} b_i \Delta y_{t-i} + \sum_{j=1}^{36} c_j S_{t-j} + e_t,$$

y is the log of industrial production
S is the new measure of monetary policy shocks
D's are monthly dummies

From: Romer and Romer, "A New Measure of Monetary Shocks"

Single-Equation Regression for Output

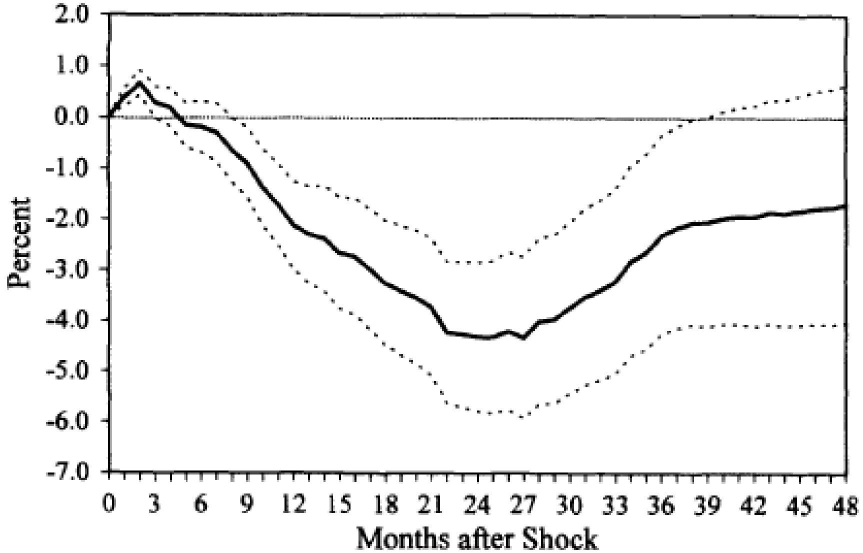


FIGURE 2. THE EFFECT OF MONETARY POLICY ON OUTPUT

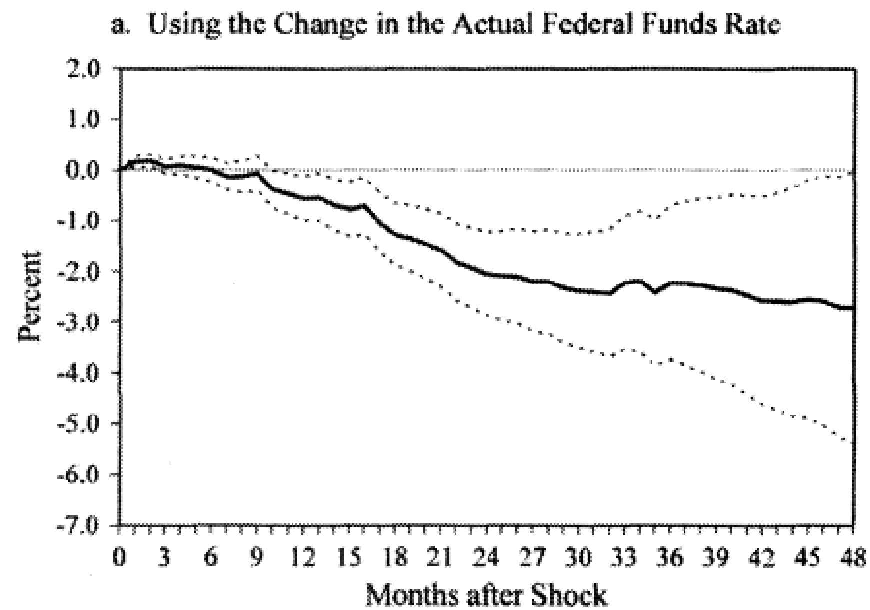


FIGURE 3. THE EFFECT OF BROADER MEASURES OF MONETARY POLICY ON OUTPUT

From: Romer and Romer, “A New Measure of Monetary Shocks”

Single-Equation Regression for Prices

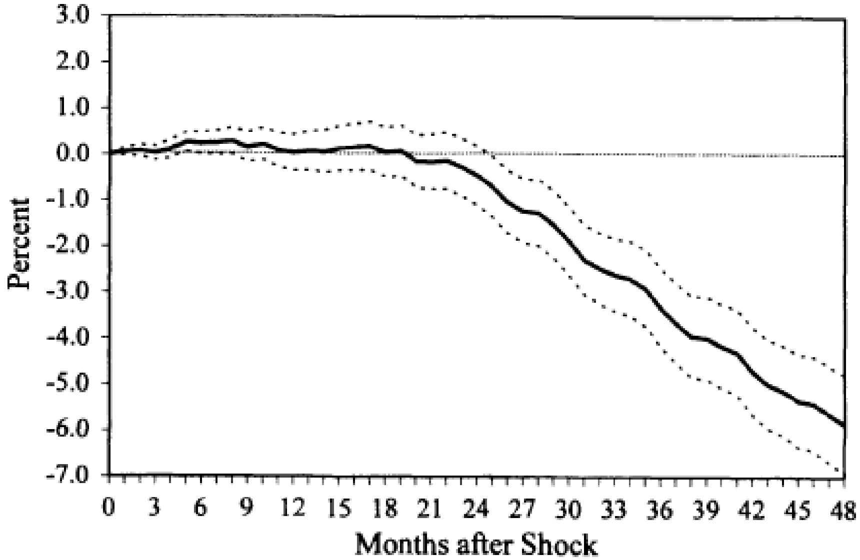


FIGURE 4. THE EFFECT OF MONETARY POLICY ON THE PRICE LEVEL

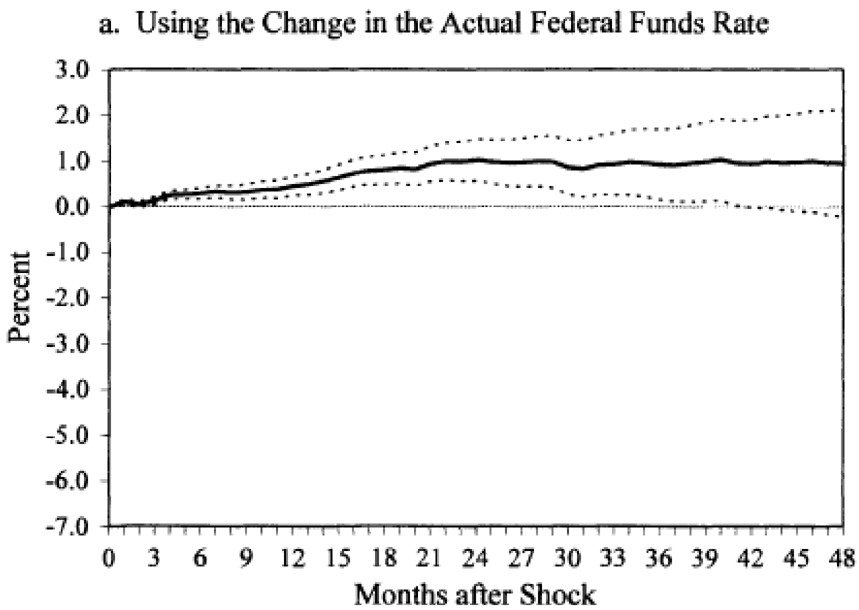


FIGURE 6. THE EFFECT OF BROADER MEASURES OF MONETARY POLICY ON THE PRICE LEVEL

From: Romer and Romer, “A New Measure of Monetary Shocks”

Single-Equation Regression for Prices Controlling for Commodity Prices

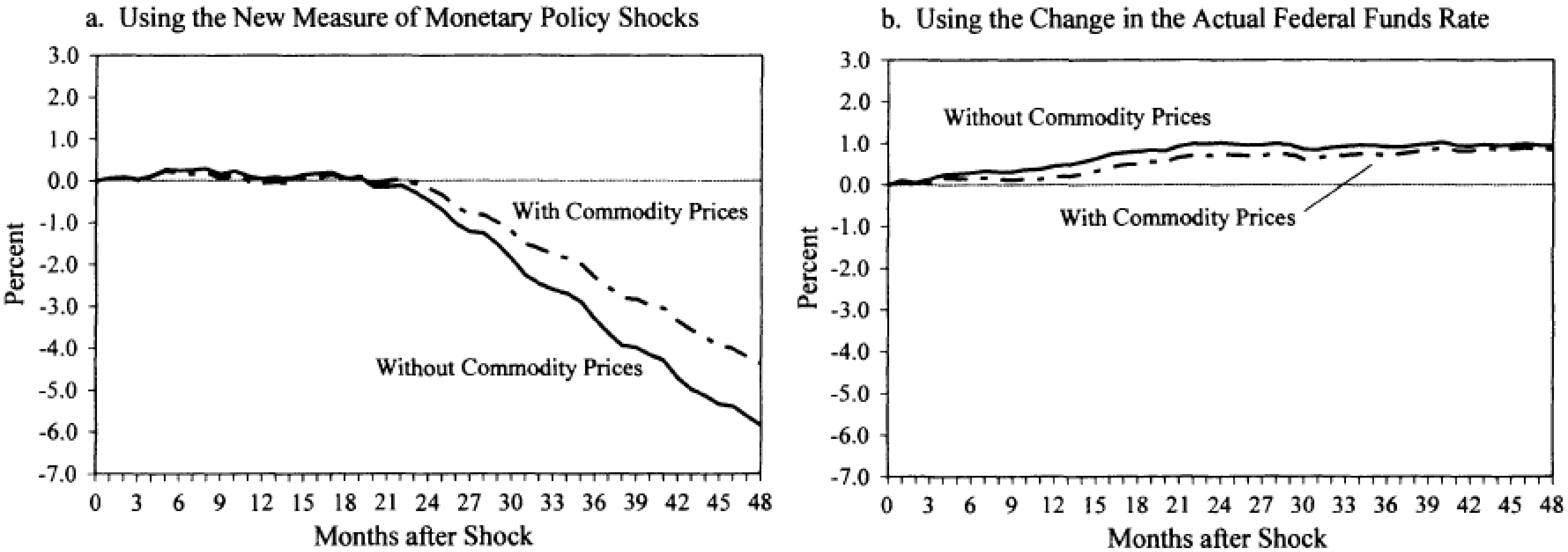


FIGURE 8. THE EFFECT OF MONETARY POLICY ON THE PRICE LEVEL WITH AND WITHOUT COMMODITY PRICES

From: Romer and Romer, “A New Measure of Monetary Shocks”

VAR Specification

- Three variables: log of IP, log of PPI for finished goods, measure of monetary policy (also include commodity prices in one variant).
- Monetary policy is assumed to respond to, but not to affect other variables contemporaneously.
- We include 3 years of lags, rather than 1 as Christiano, Eichenbaum, and Evans do.
- Cumulate shock to be like the level of the funds rate.

VAR Results

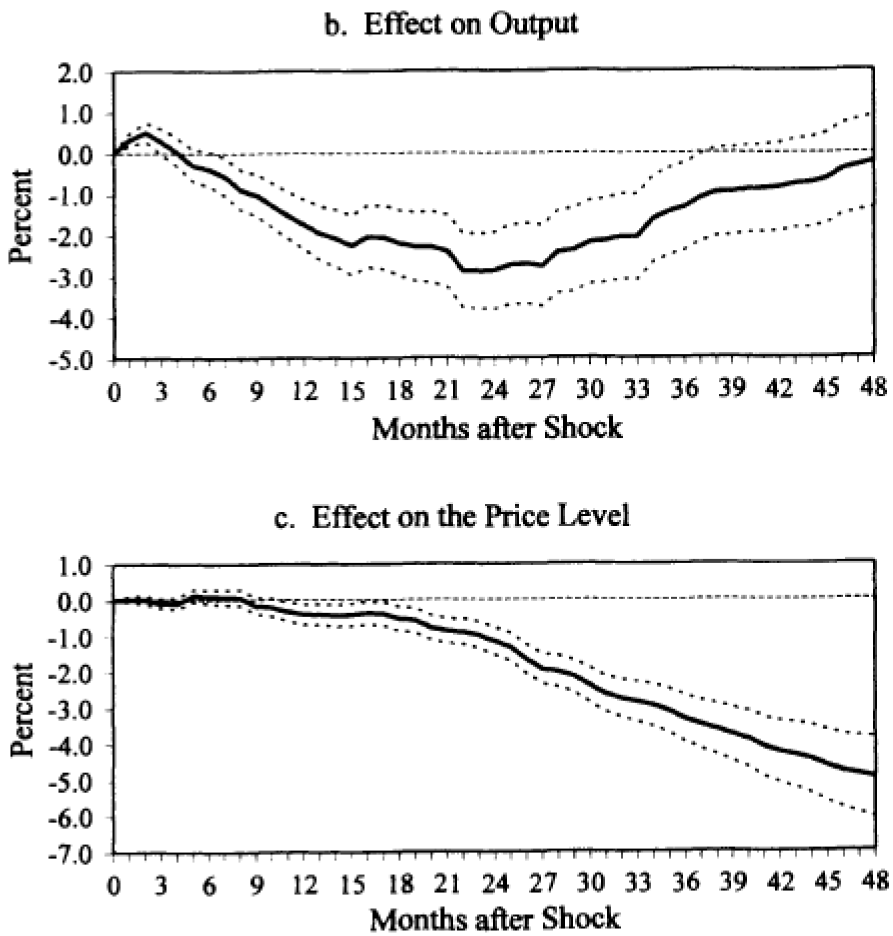
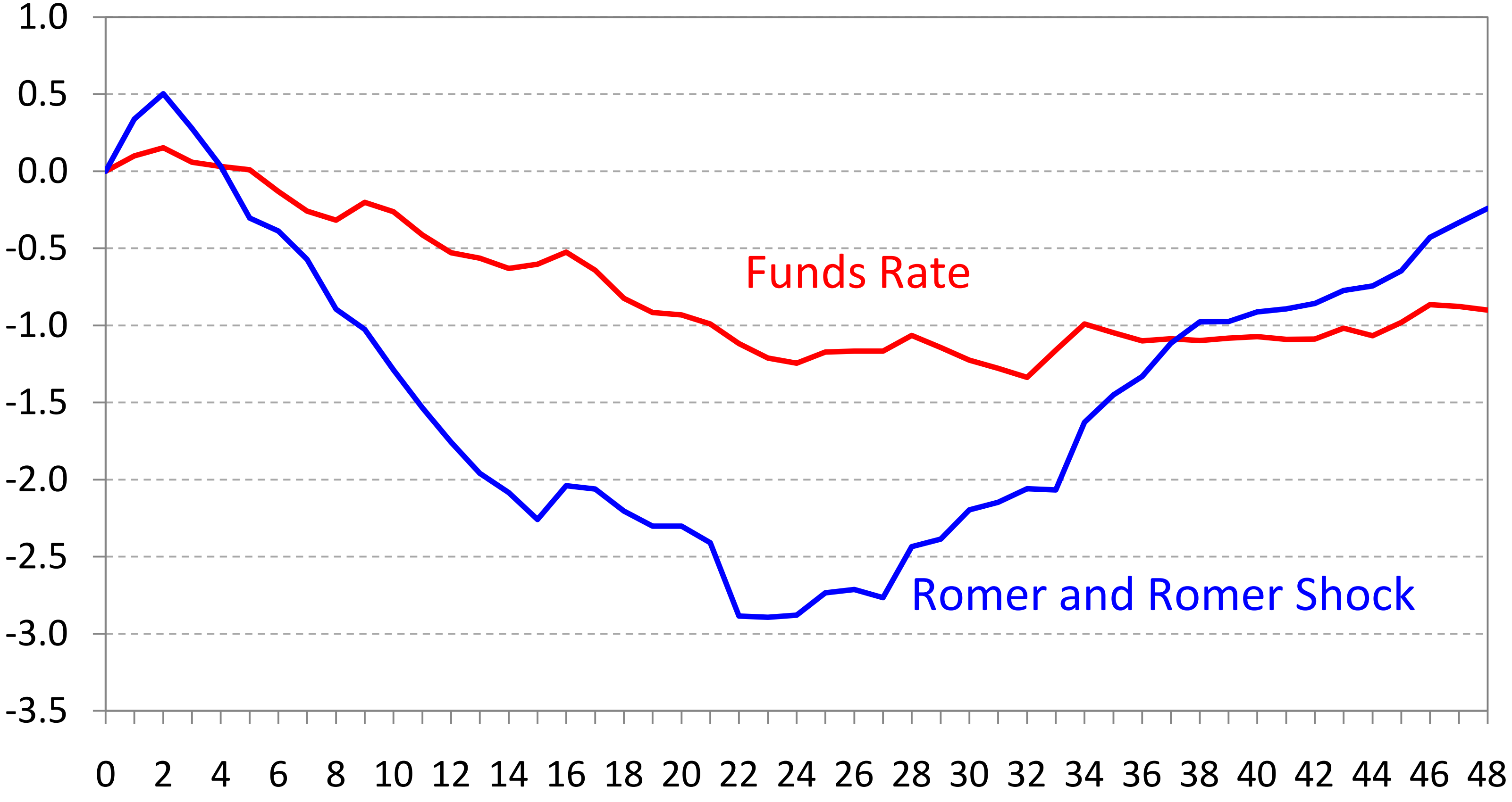


FIGURE 9. THE EFFECT OF MONETARY POLICY IN A VAR USING THE NEW MEASURE OF MONETARY POLICY SHOCKS

Comparison of VAR Results: Impulse Response Function for Output



Comparison of VAR Results: Impulse Response Function for Prices

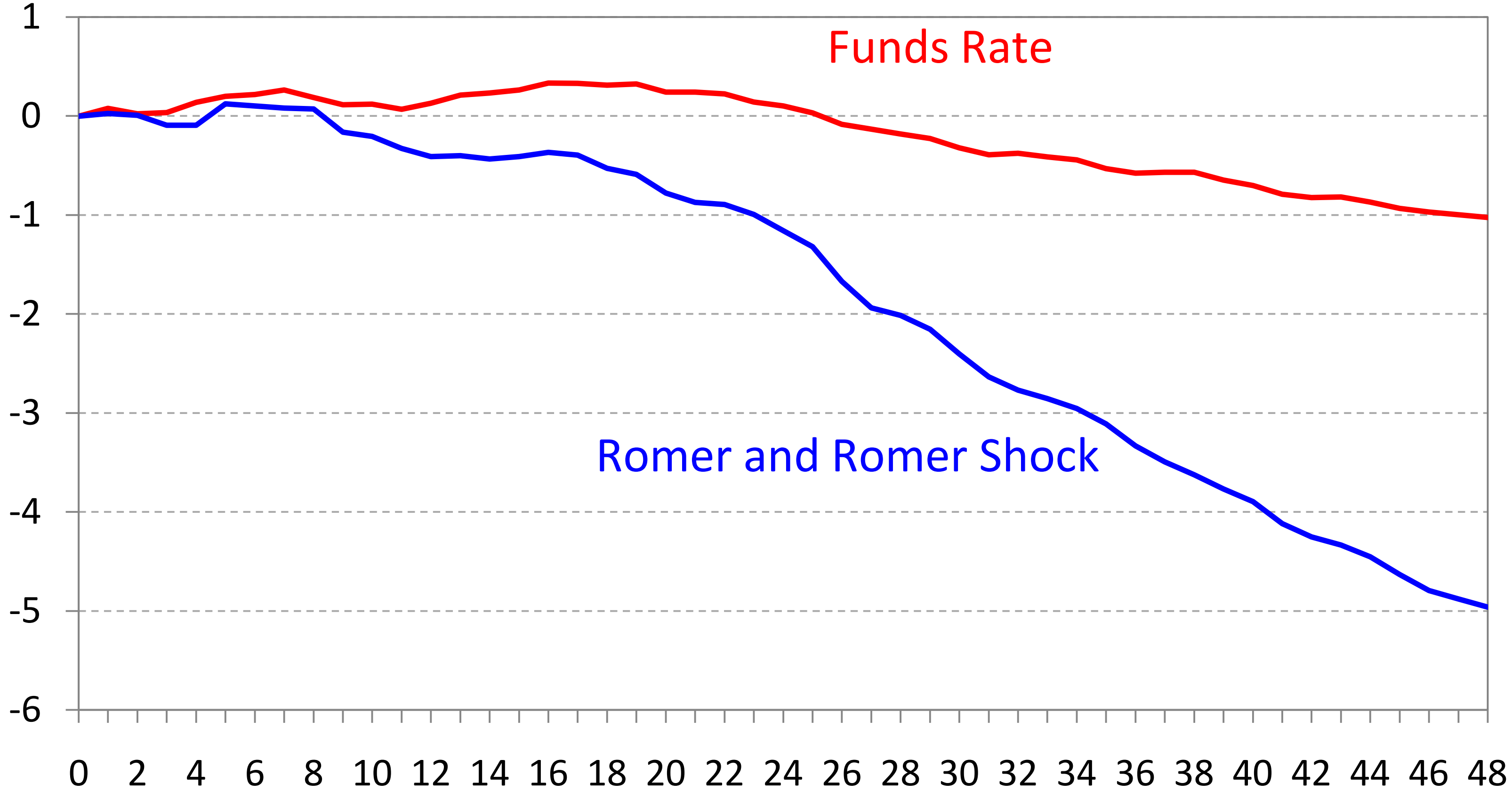
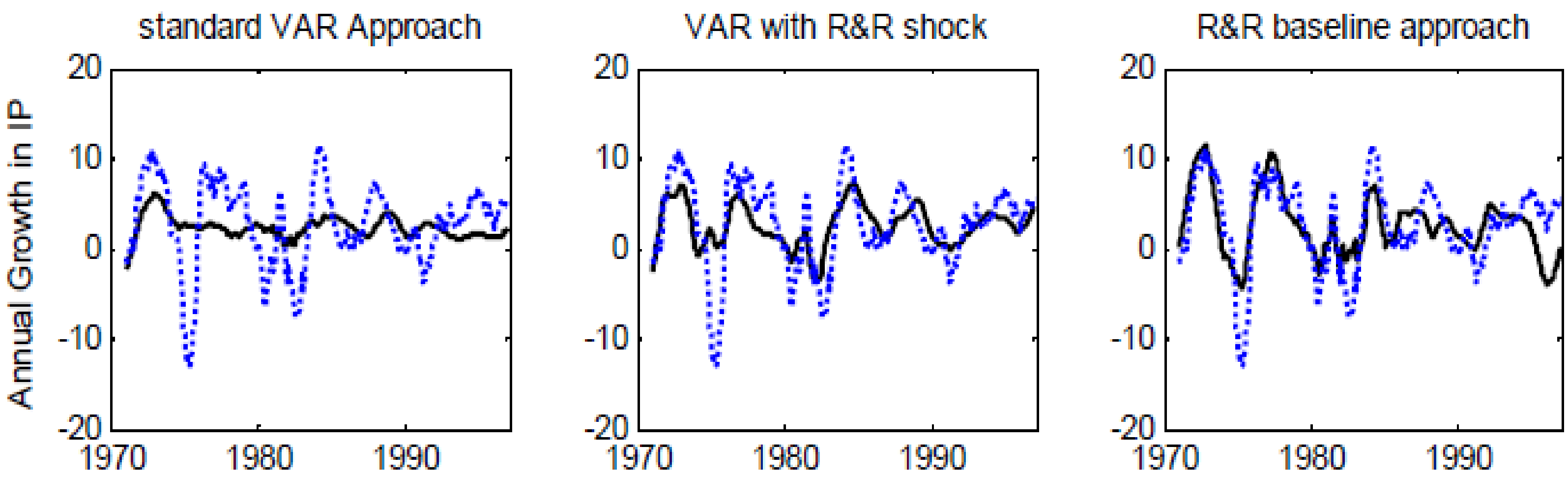


Figure 1: The Contribution of Monetary Policy Shocks to Business Cycle Fluctuations



From: Coibion, "Are the Effects of Monetary Policy Shocks Big or Small?"

Comparison of Funds Rate and Shock: Impulse Response Function of DFF to Shock

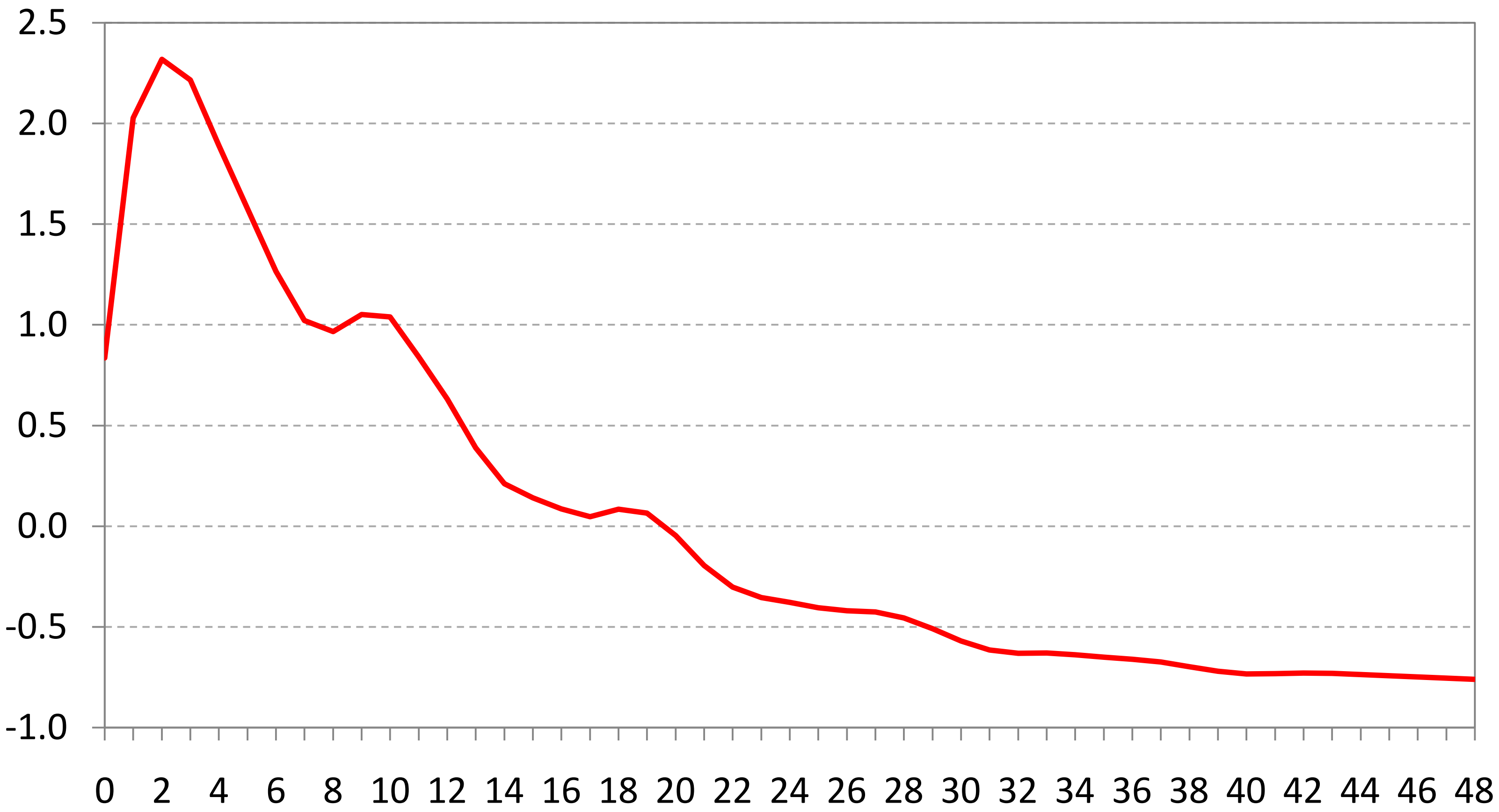
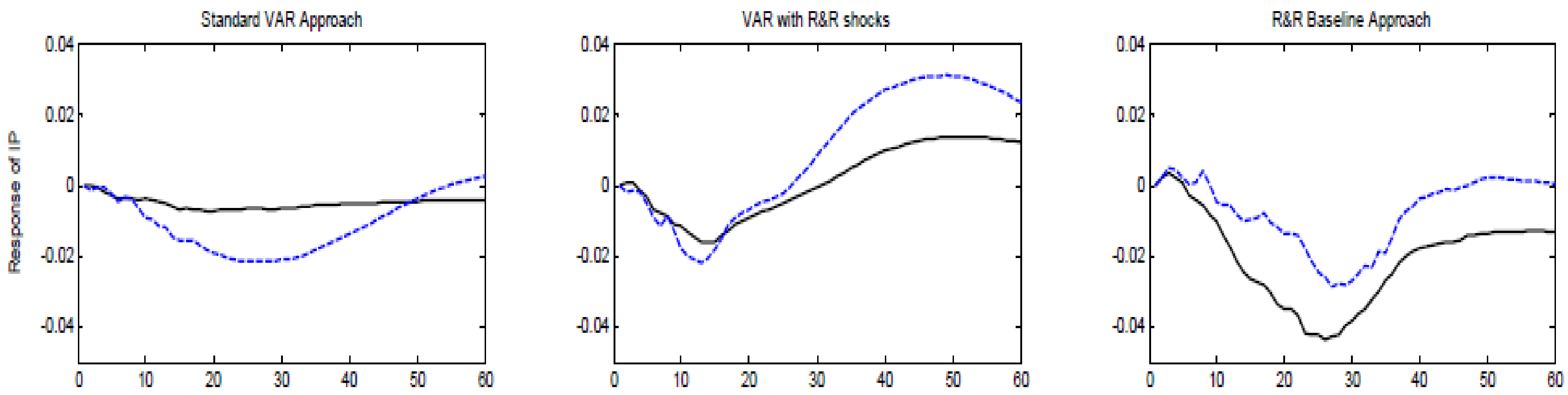


Figure 7: Impulse Responses to Monetary Policy Shocks Omitting the Early Volcker Period



From: Coibion, "Are the Effects of Monetary Policy Shocks Big or Small?"