Lecture V

Harvard Econ 2416
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Outline

1. Bayesian identification (Baumeister and Hamilton, AER 2019)
2. Narrative monetary (Romer and Romer, NBERMA 1989)
3. Monetary Policy Wrap-up
4. Narrative tax (Romer and Romer, AER 2010)
5. Narrative VAR identification (Antolín-Díaz and Rubio-Ramírez, AER 2018)

Outline

Overview

- Traditional approaches to identification can be viewed as dogmatic priors on some parameters and complete agnosticism on others.
  - Cholesky: some elements of contemporaneous response zero, others unrestricted.
  - Sign restrictions: some responses inadmissable, others unrestricted.
- Generalizes naturally to any prior beliefs.

Mechanics (my notation)

- VAR: $B(L)Y_t = e_t, e_t = Rv_t, Var(v_t) = \Sigma, R = A_0^{-1}$.
- Separate parameters into three blocks: $R, \Sigma, B(L)$.
- Specify prior over parameters $p(R, \Sigma, B(L))$.
- Computationally convenient to use distributions which conjugate together nicely – see paper for details.
- Compute posterior $p(R, \Sigma, B(L)|Y_1, \ldots, Y_T)$.
- Setup accommodates priors over A_0, structural IRFs, etc.

Example: oil markets

- Trivariate monthly VAR in growth rate of world crude oil production q_t, real economic activity y_t, and real oil price p_t.
- Structural model:

$$\begin{aligned}
\text{Oil supply curve:} \quad & q_t = \alpha_{qy} y_t + \alpha_{qp} p_t + b_1{}' x_{t-1} + v_{1,t}, \\
\text{Total economic activity:} \quad & y_t = \alpha_{yq} q_t + \alpha_{yp} p_t + b_2{}' x_{t-1} + v_{2,t}, \\
\text{Oil demand curve:} \quad & p_t = \alpha_{pq} q_t + \alpha_{py} y_t + b_3{}' x_{t-1} + v_{3,t}, \\
& x_{t-1} = \left(q_{t-1}, y_{t-1}, p_{t-1}, \ldots, q_{t-p}, y_{t-p}, p_{t-p}\right)'
\end{aligned}$$

- In VAR notation:

$$\underbrace{\begin{pmatrix} 1 & -\alpha_{qy} & -\alpha_{qp} \\ -\alpha_{yq} & 1 & -\alpha_{yp} \\ -\alpha_{pq} & -\alpha_{py} & 1 \end{pmatrix}}_{A_0} \underbrace{\begin{pmatrix} q_t \\ y_t \\ p_t \end{pmatrix}}_{Y_t} = \underbrace{\begin{pmatrix} b_1' \\ b_2' \\ b_3' \end{pmatrix}}_{b} x_{t-1} + \underbrace{\begin{pmatrix} v_{1,t} \\ v_{2,t} \\ v_{3,t} \end{pmatrix}}_{v_t}.$$

- Could rewrite as $B(L)Y_t = e_t = Rv_t$.

Example: Cholesky (Kilian AER 2009)

- Ordering $(q_t, y_t, p_t) \Rightarrow \alpha_{qy} = \alpha_{qp} = \alpha_{yp} = 0$.
- Implement with flat prior over unrestricted elements of A_0 and all elements of Σ and $B(L)$.

Example: Cholesky (Kilian AER 2009)

- Ordering $(q_t, y_t, p_t) \Rightarrow \alpha_{qy} = \alpha_{qp} = \alpha_{yp} = 0$.
- Implement with flat prior over unrestricted elements of A_0 and all elements of Σ and $B(L)$.
- Result 1: Bayesian approach numerically equivalent to Cholesky.
- Result 2: Demand elasticity α_{pq}^{-1} either extremely flat or upward sloping. BH: "The key feature in the data that forces us to impute such unlikely values for the demand elasticity is the very low correlation between the reduced-form residuals for q_t and p_t. If we assume that innovations in q_t represent pure supply shifts, the lack of response of price would force us to conclude that the demand curve is extremely flat."

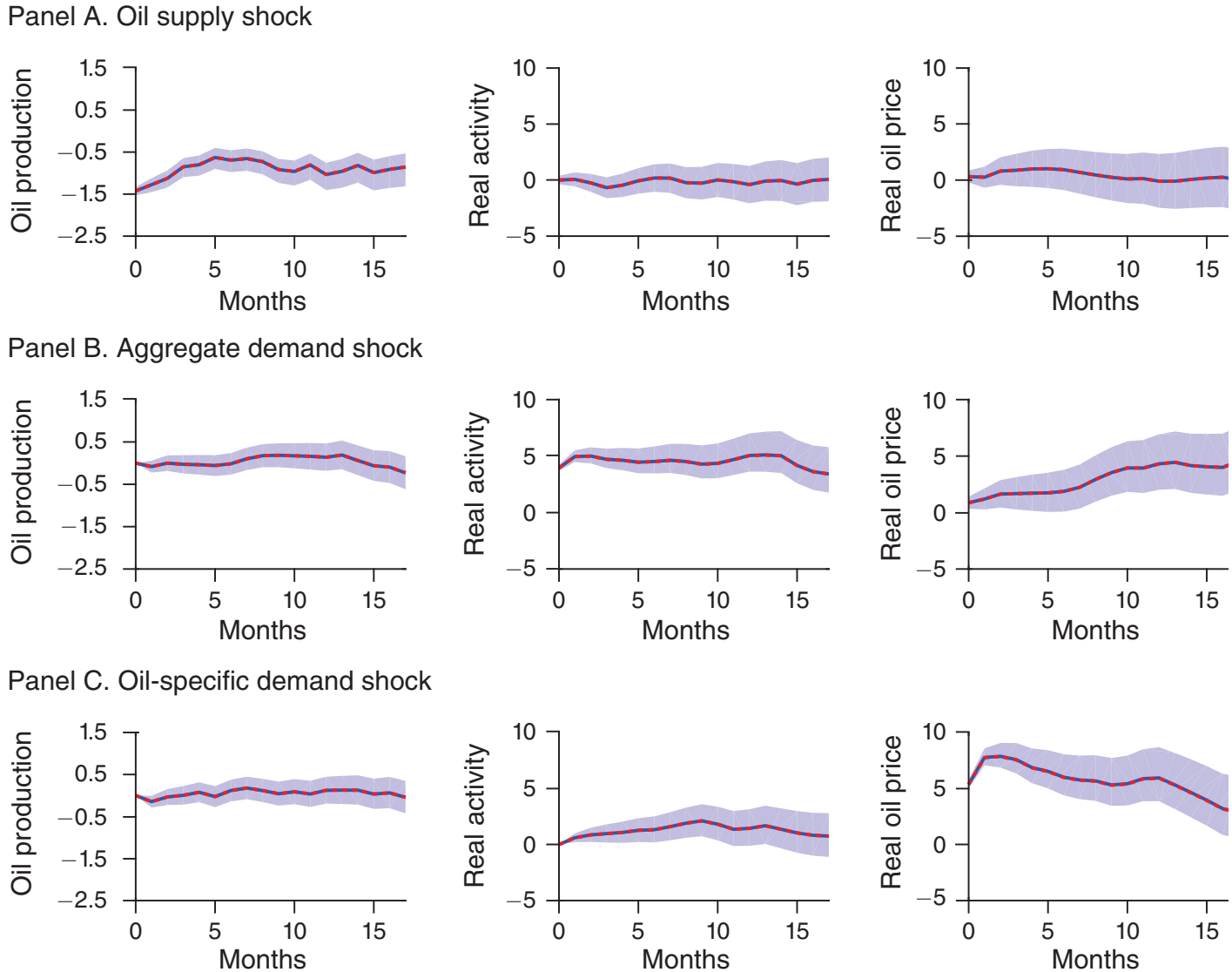
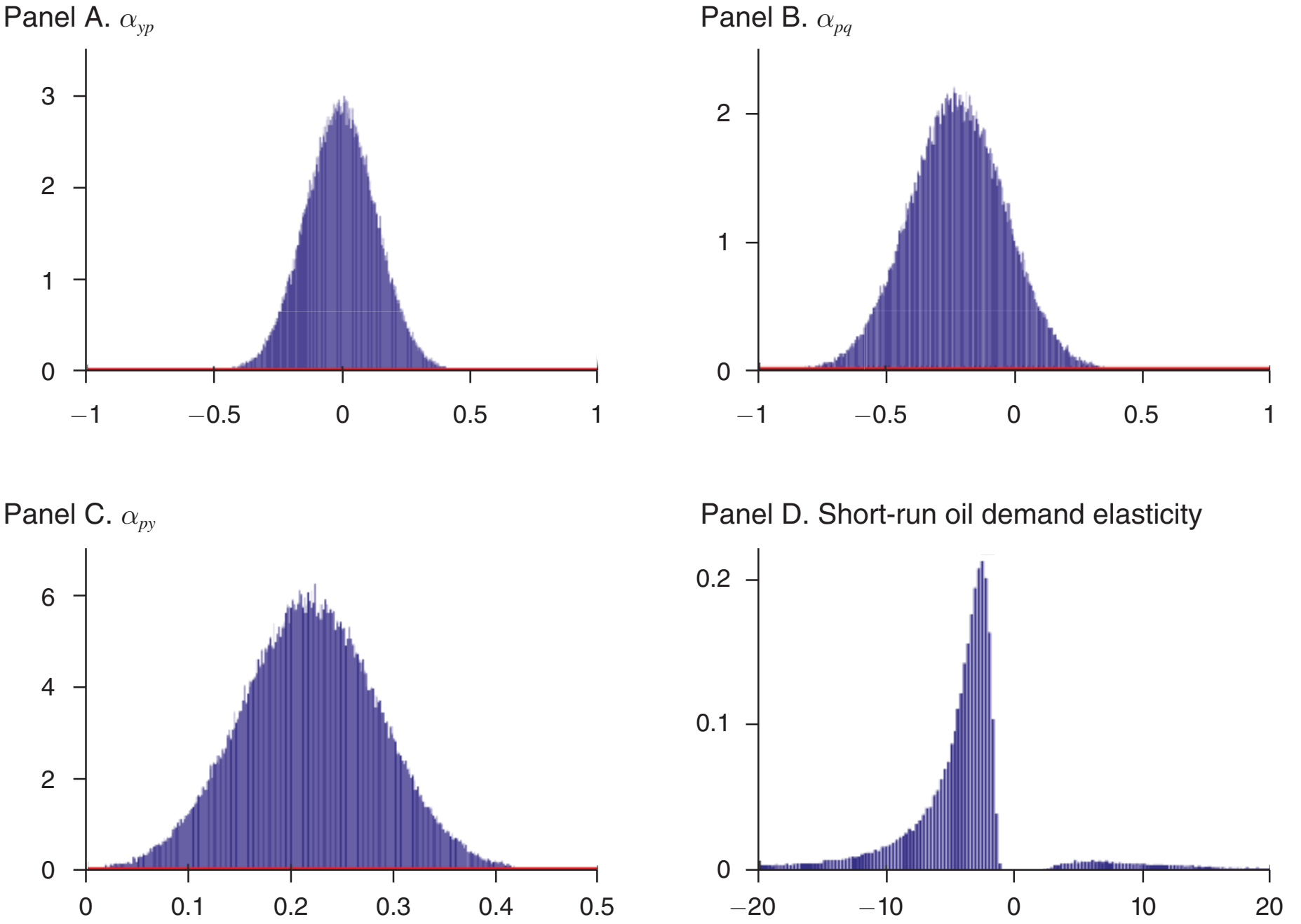


FIGURE 1. IMPULSE-RESPONSE FUNCTIONS FOR THREE-VARIABLE MODEL UNDER TRADITIONAL CHOLESKY IDENTIFICATION

Note: Red dotted lines: point estimates arrived at using Kilian's (2009) original methodology; blue solid lines median of Bayesian posterior distribution; shaded regions: 95 percent posterior credible set.


Panel A. α_{yp}
3
2
1
0
−1
−0.5
0
0.5
1
Panel B. α_{pq}
2
1
0
−1
−0.5
0
0.5
1
Panel C. α_{py}
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5
Panel D. Short-run oil demand elasticity
0.2
0.1
0
−20
−10
0
10
20

BH implementation

- External information on short-run supply and demand elasticities discipline priors.
  - Like external instruments, incorporate auxiliary information for identification.
- Oil price changes and production largely unforecastable $\Rightarrow$ small coefficients in lag matrices.
- Down-weight earlier observations.
- General principle to use all information to construct priors.
  - Contrast with minimal assumptions in standard setup.

Outline

Overview

- What is a shock?
- Narrative approach.
- Results.

Friedman and Schwartz shocks

The varied character of U.S. monetary history renders this century of experience particularly valuable to the student of economic change. He cannot control the experiment, but he can observe monetary experience under sufficiently disparate conditions to sort out what is common from what is adventitious...
Three counterparts of such crucial experiments stand out in the monetary record since the establishment of the Federal Reserve System. ***On three occasions the System deliberately took policy steps of major magnitude which cannot be regarded as necessary or inevitable economic consequences of contemporaneous changes in money income and prices.*** *Like the crucial experiements of the physical scientist, the results are so consistent and sharp as to leave little doubt about their interpretation.*

–Chapter 13: pp. 676, 688.

Friedman and Schwartz narrative approach

The close relation between changes in the stock of money and changes in other economic variables, alone, tells nothing about the origin of either or the direction of influence. The monetary changes might be dancing to the tune called by independently originating changes in the other economic variables; the changes in income and prices might be dancing to the tune called by independently originating monetary changes; the two might be mutually interacting, each having some element of independence; or both might be dancing to the common tune of still a third set of influences. ***A great merit of the examination of a wide range of qualitative evidence, so essential in a monetary history, is that it provides a basis for discriminating between these possible explanations of the observed statistical covariation. We can go beyond the numbers alone and, at least on some occasions, discern the antecedent circumstances whence arose the particular movements that become so anonymous when we feed the statistics into the computer.***

–Chapter 13: p. 686.

Friedman and Schwartz episodes

- January-June 1920: discount rate rises from 4.75% to 7%.
  - Economy entered recession in January 1920. IP declines 30%.
- October 1931: discount rate rises from 1.5% to 3.5% in response to Britain leaving the gold standard.
  - IP declines 24%.
- June 1936-January 1937: doubling of reserve requirements coincident with gold sterilization.
  - Recession starting in May 1937 is sharpest since the Great Depression.
- 1929-1931: "sin of omission" in letting money supply fall.

Romer and Romer critique

- Definition of shock is imprecise.
- 1933 banking holiday, 1941 reserve requirement increase look similar to included episodes but not followed by contractions.
- 1920: contractionary government spending, international contraction, recession started already in January.
- October 1931: contractionary fiscal policy and trade war.
- 1936-37: contractionary fiscal policy, Wagner act, timing not aligned, cross-sectional evidence on auto production (Hausman JEH 2016) and member and non-member banks (Park and Van Horn 2014).
- 1929-31: ...

Romer and Romer shocks

... we count as a shock only episodes in which the Federal Reserve attempted to exert a contractionary influence on the economy in order to reduce inflation. That is, ***we focus on times when the Federal Reserve attempted not to offset perceived or prospective increases in aggregate demand but to actively shift the aggregate demand curve back in response to what it perceived to be "excessive" inflation...*** *we believe that policy decisions to attempt to cure inflation come as close as practically possible to being independent of factors that affect real output... This belief rests partly on an assumption that trend inflation by itself does not affect the dynamics of real output.*

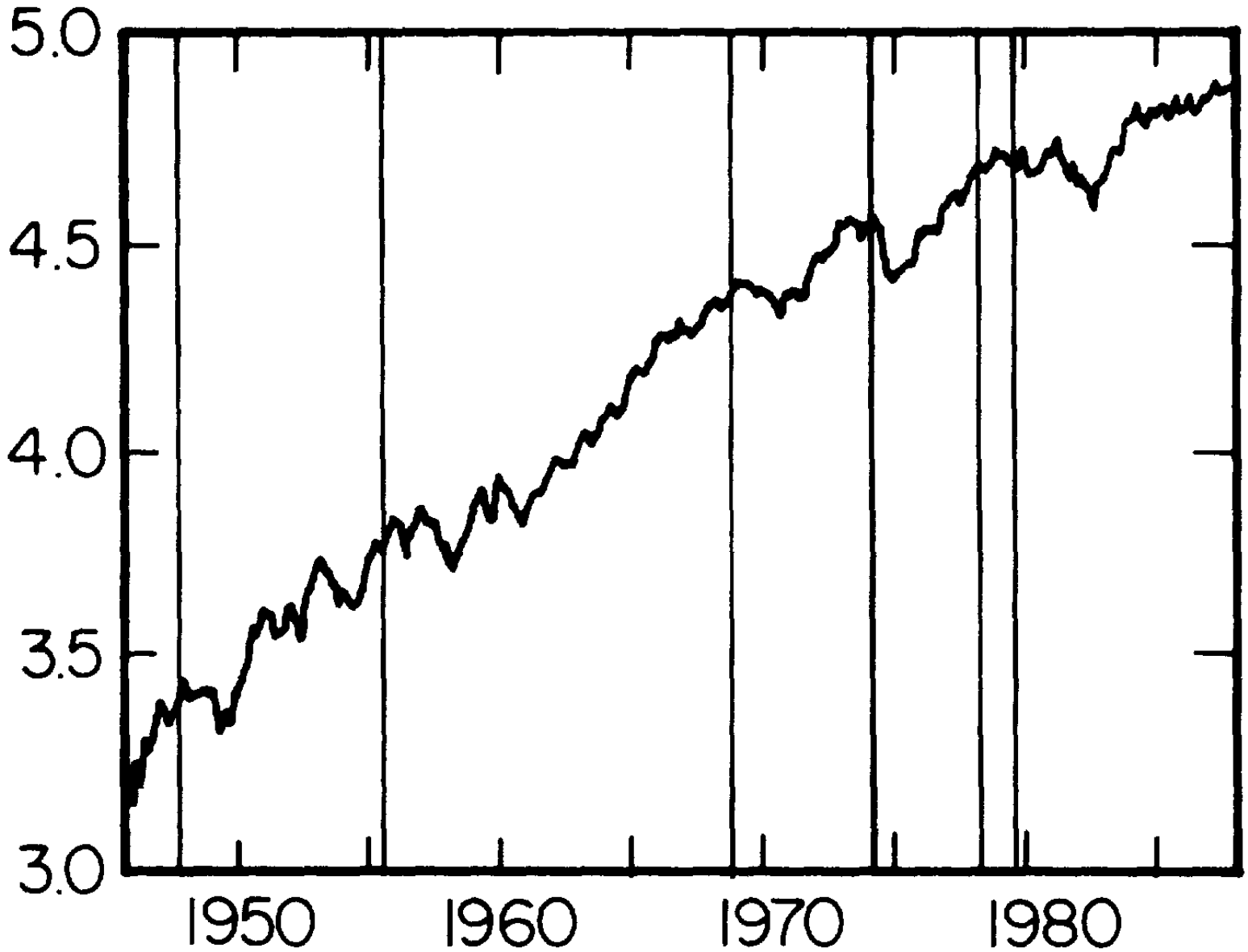
Romer and Romer narrative approach

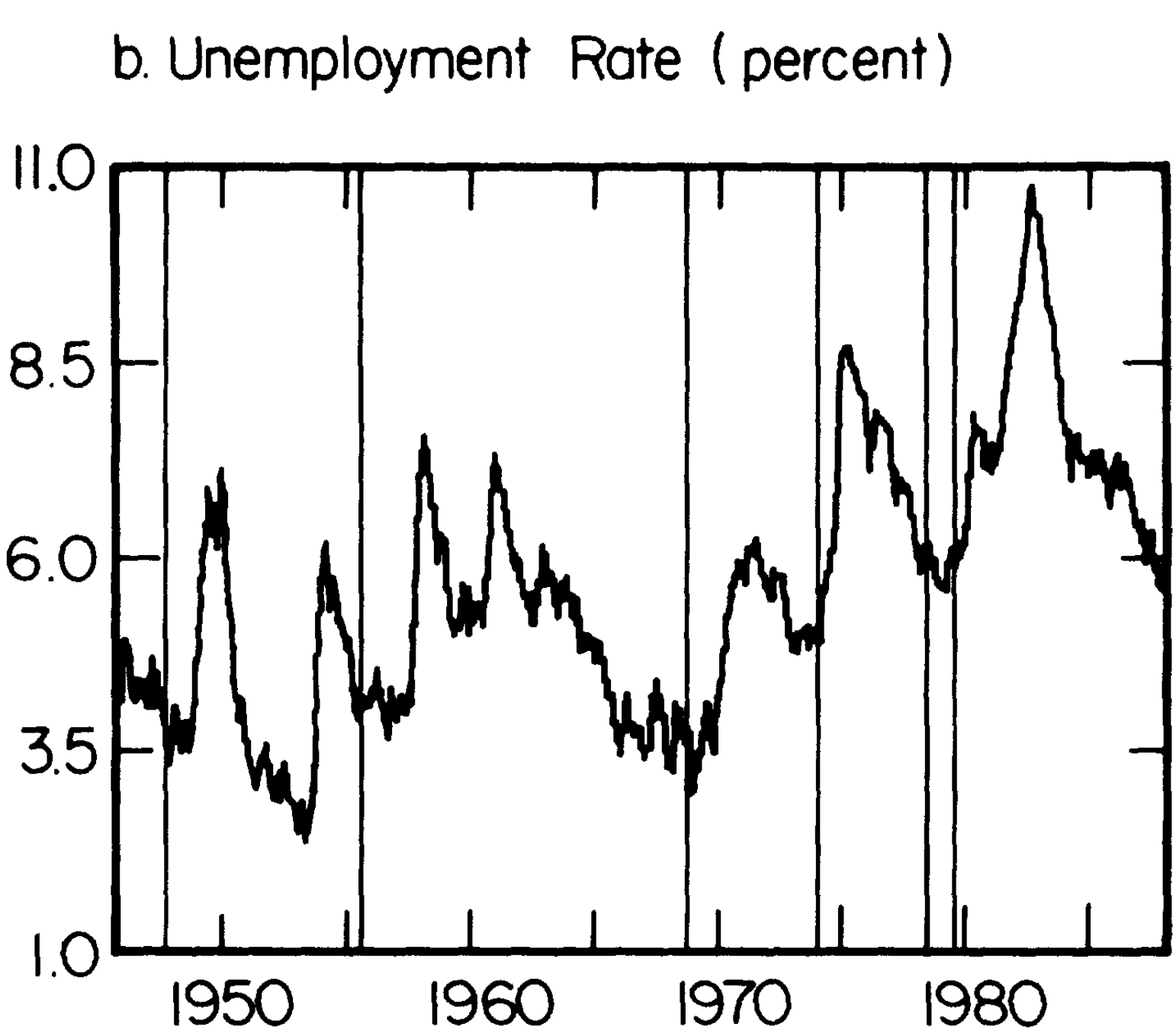
To actually discern the intentions of the Federal Reserve, we rely entirely on contemporary Federal Reserve records – the "Record of Policy Actions" of the Board of Governors and the Federal Open Market Committee (FOMC) and, until their discontinuance in 1976, the minutes of FOMC meetings. ***To identify a shock from these sources we look both for a clear statement of a belief that the current level of inflation needed to be lowered and some indication that output consequences would be sought, or at least tolerated, to bring the reduction about.*** *In this process we only consider contemporaneous (or nearly contemporaneous) statements of the Federal Reserve's intent. We do not consider retrospective discussions of intent because such descriptions could be biased by a knowledge of the subsequent behavior of real activity.*

Romer and Romer dates

- October 1947, September 1955, December 1968, April 1974, August 1978, October 1979.
- Example (December 1968): *Concern about inflation caused the Federal Reserve to attempt to maintain tight monetary policy despite evidence of considerably weaker real growth. In March 1969, for example, despite reductions in present and projected growth, "the Committee agreed that, in light of the persistence of inflationary pressures and expectations, the existing degree of monetary restraint should be continued at present". In May, "The Committee took note of the signs of some slowing in the economic expansion and of the indications of stringency in financial markets. In view of the persistence of strong inflationary pressures and expectations, however, the members agreed that a relaxation of the existing degree of monetary restraint would not be appropriate at this time". In October, faced with projections of essentially no real growth over the coming three quarters, "the Committee decided that a relaxation of monetary restraint would not be appropriate at this time in light of the persistence of inflationary pressures and expectations".*

a. Index of Industrial Production (in logarithms)



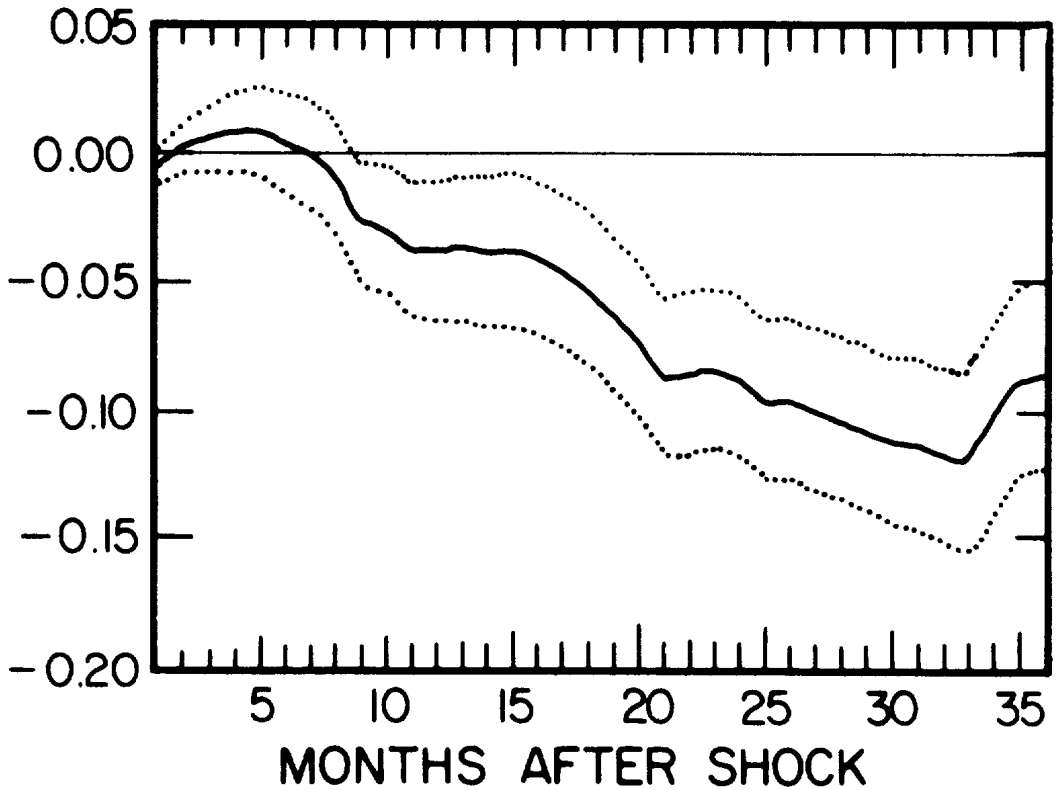

b. Unemployment Rate (percent)
11.0
8.5
6.0
3.5
1.0
1950
1960
1970
1980

Econometric specification

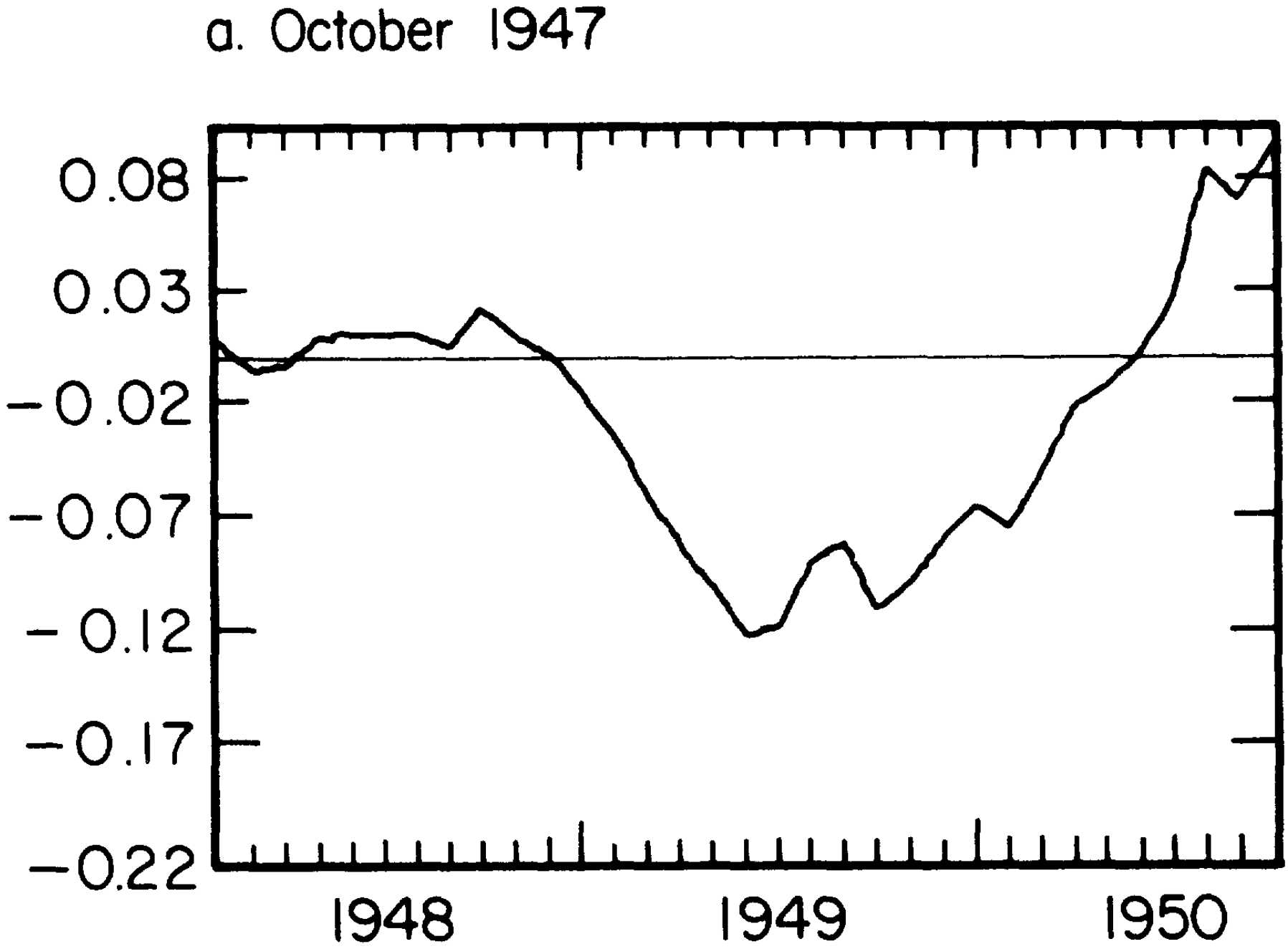
$$y_t = \sum_{i=1}^{12} a_i M_{it} + \sum_{j=1}^{24} b_j y_{t-j} + \sum_{k=0}^{36} c_k D_{t-k}.$$

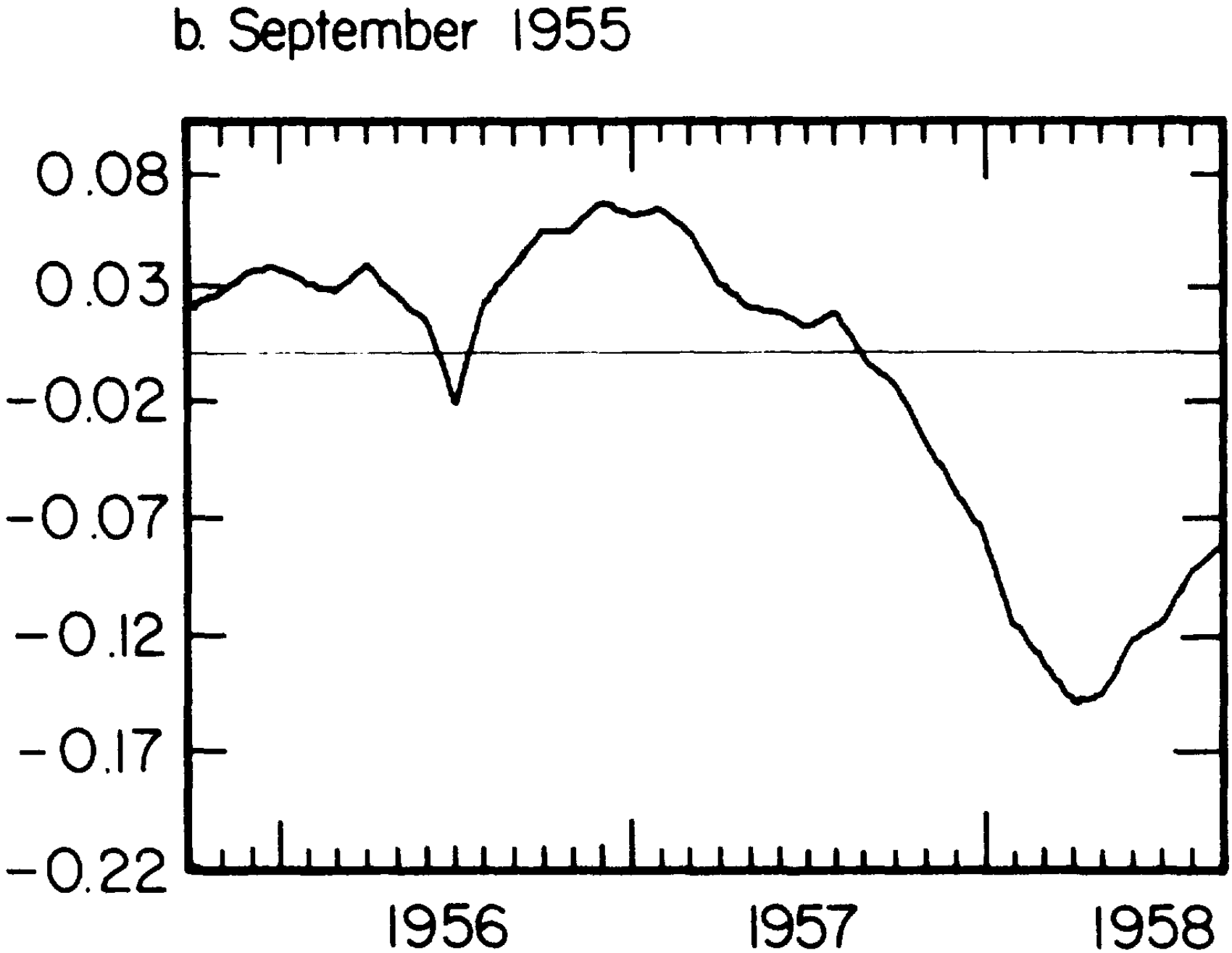
- $y_t \in \{\Delta \log(IP_t), u_t\}$.
- Baseline from univariate forecasting model with 24 lags and 12 monthly seasonal variables.
- $D_t = 0$ in the six months beginning with the Romer and Romer date.
- No adjustment made for duration or intensity of monetary policy deviation.

Figure 4 IMPULSE RESPONSE FUNCTION FOR BASIC INDUSTRIAL PRODUCTION REGRESSION

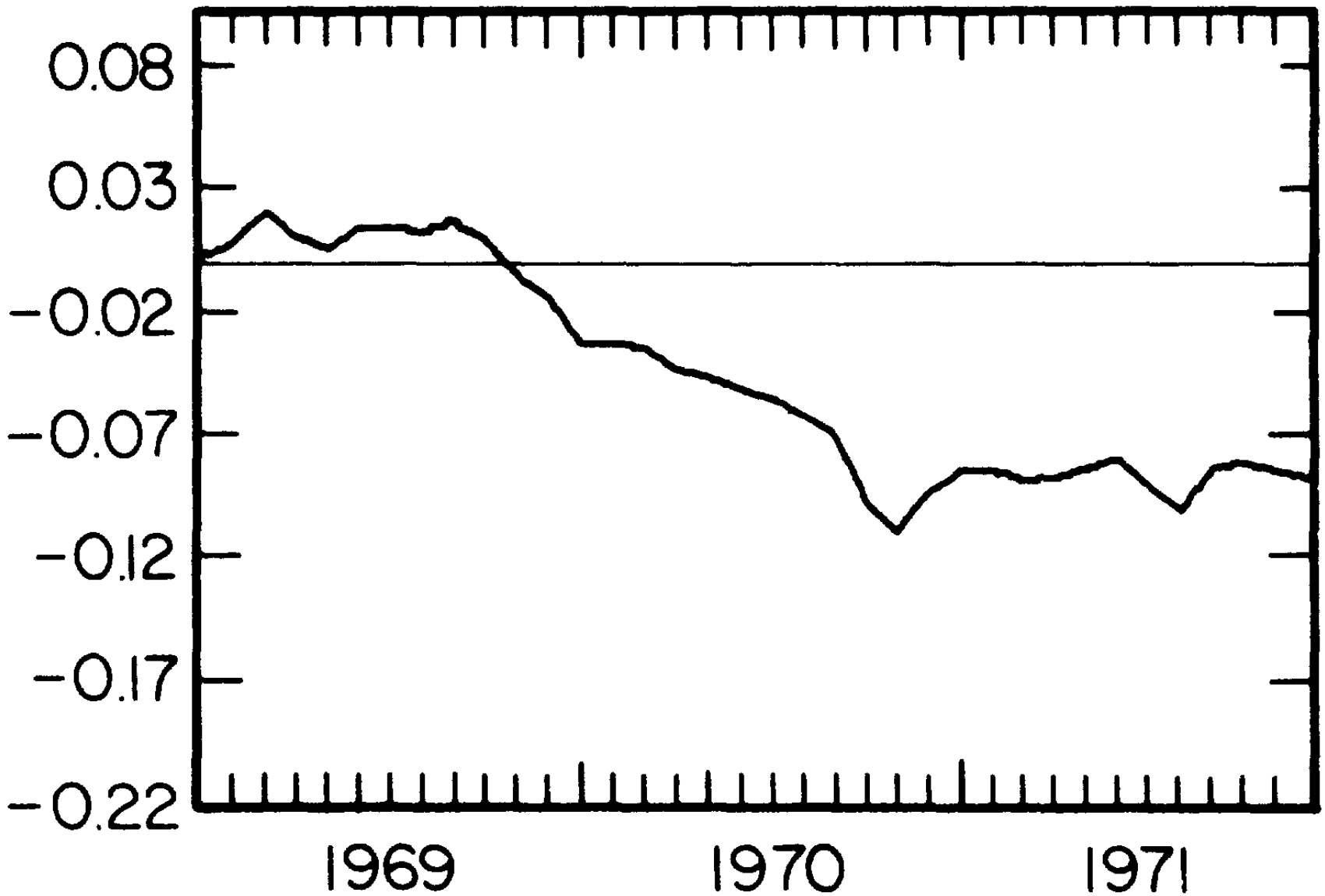


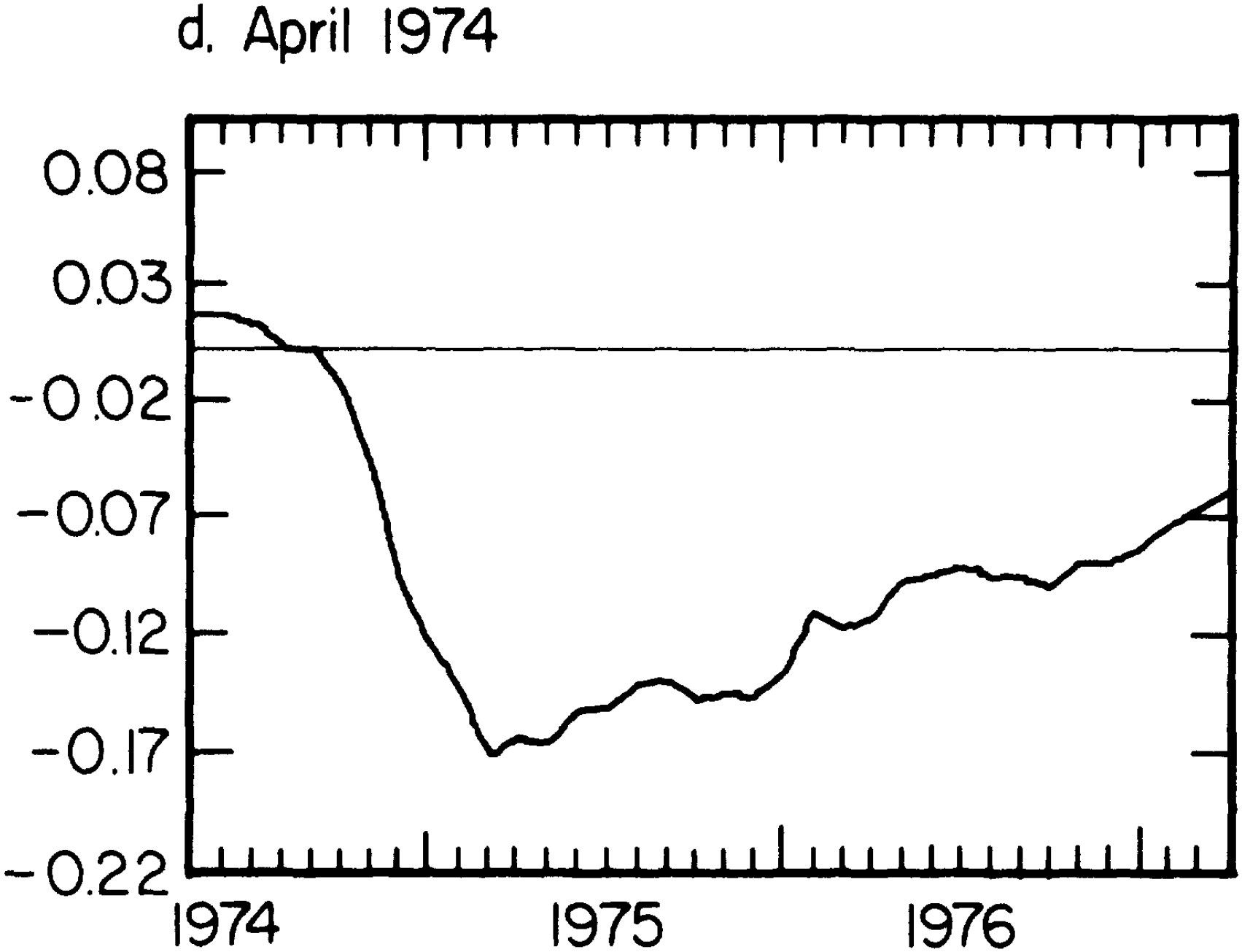
Notes: The impulse response function shows the impact of a unit shock to the monetary dummy variable. The impulse responses for the change in industrial production have been cumulated to reflect the effect on the log level. The coefficient estimates used to generate the impulse response function are given in Table 1. The dashed lines show the one standard error bands.

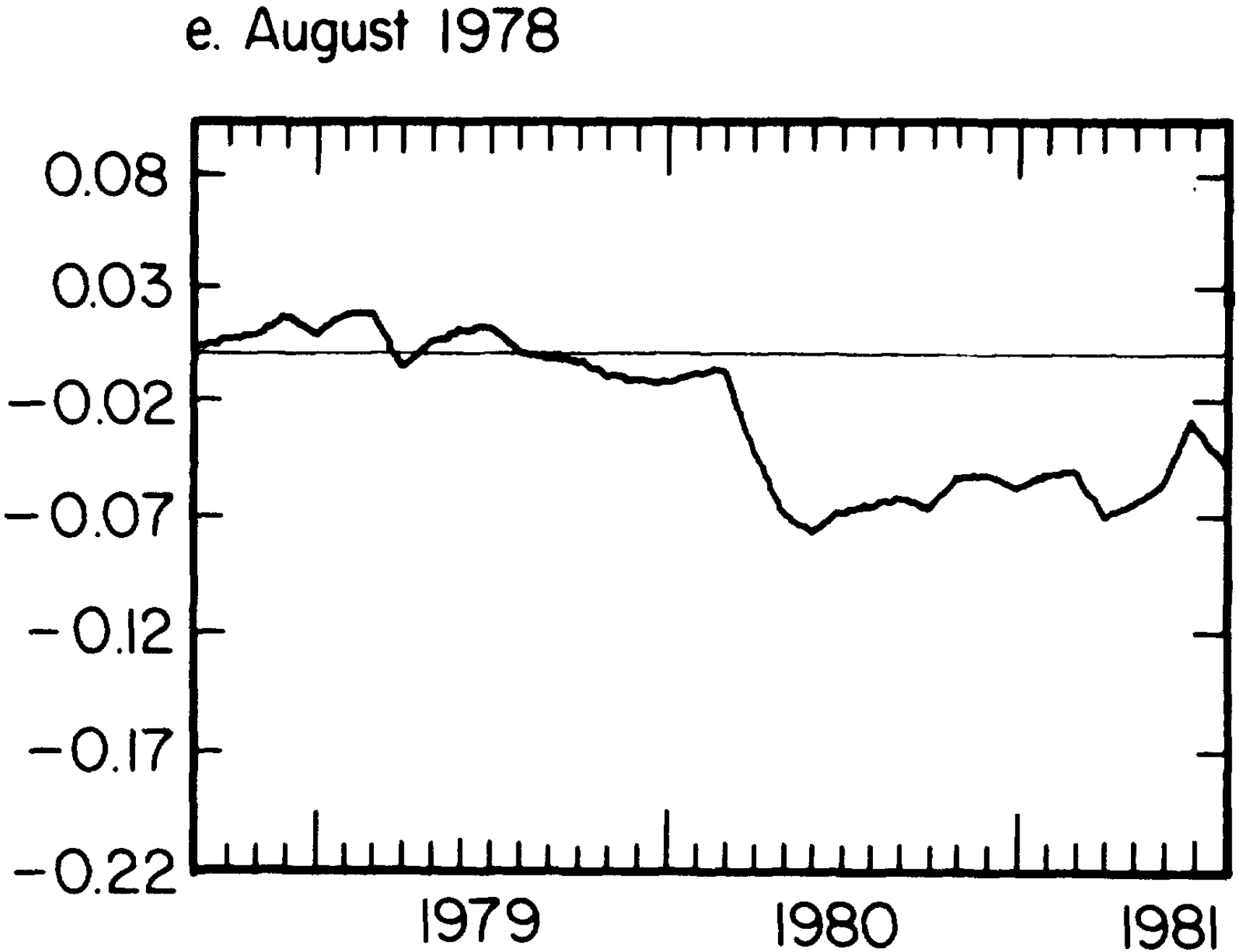

a. October 1947
0.08
0.03
−0.02
−0.07
−0.12
−0.17
−0.22
1948
1949
1950


b. September 1955
0.08
0.03
-0.02
-0.07
-0.12
-0.17
-0.22
1956
1957
1958

c. December 1968




d. April 1974
0.08
0.03
-0.02
-0.07
-0.12
-0.17
-0.22
1974
1975
1976


e. August 1978
0.08
0.03
−0.02
−0.07
−0.12
−0.17
−0.22
1979
1980
1981

f. October 1979

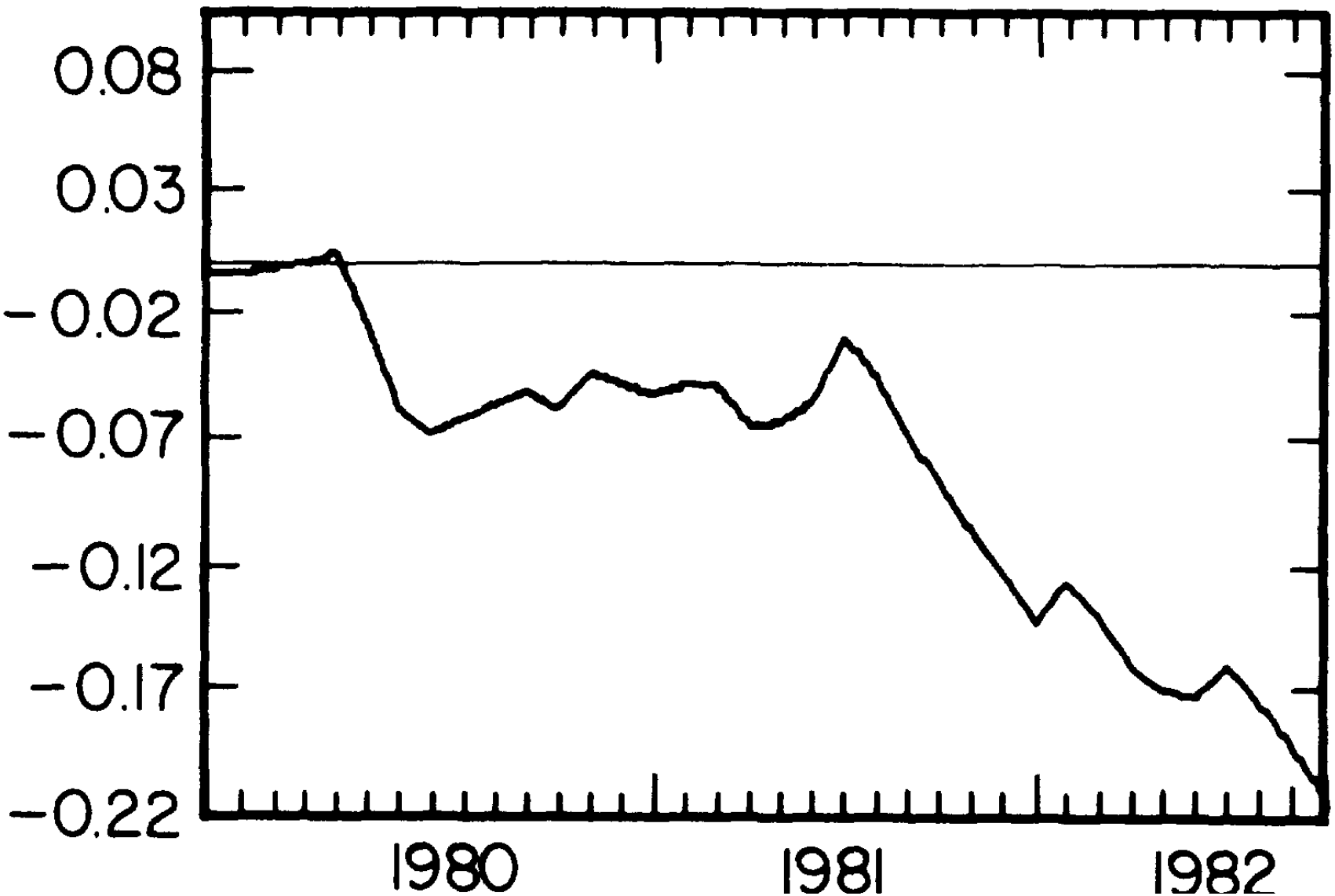
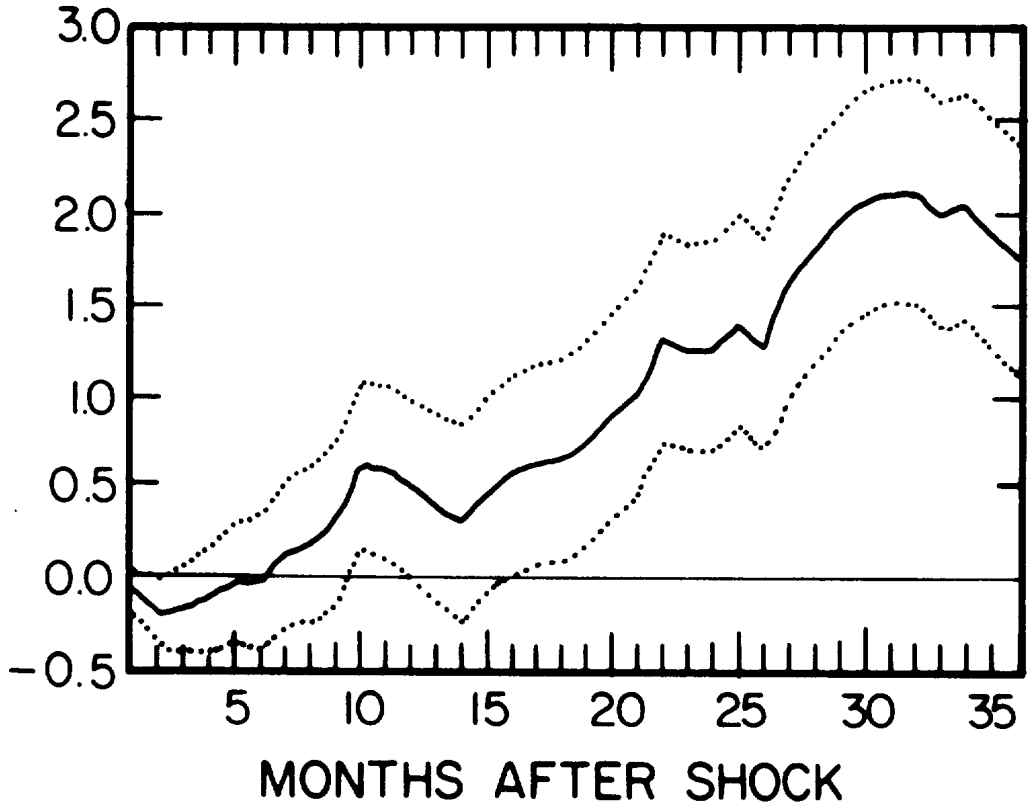


Figure 5 IMPULSE RESPONSE FUNCTION FOR BASIC UNEMPLOYMENT REGRESSION.



Notes: The impulse response function shows the impact of a unit shock to the monetary dummy variable on the level of the unemployment rate (expressed in percentage points). The coefficient estimates used to generate the impulse response function are given in Table 2. The dashed lines show the one standard error bands.

Discussion

- Narrative approach: actions or beliefs?
- Timing: Fed may have been concerned about inflation in August 1978, but not acted sufficiently strongly (Volcker appointed in August 1979).
- Check Granger causality. Does it matter?
- Absence of measure of intensity makes quantitative interpretation difficult.
- Asymmetric: only studies contractionary shocks.
- Are these shocks or external instruments?

Romer and Romer (AER 2004)

- Problem set asked you to compare the Cholesky shocks to a series from Romer and Romer (2004).
- Paper constructs measure of intended federal funds rate purged of endogenous interest rate changes.
- Purged how? "Greenbook" internal forecasts to control for policy makers' expectations of GDP growth, the GDP deflator, and the unemployment rate:

$$\Delta ff_{m,t} = \alpha + \beta ff_{m-1} + \sum_{i=-1}^{2} \gamma_i E_m \Delta y_{t+i} + \sum_{i=-1}^{2} \lambda_i [E_m \Delta y_{t+i} - E_{m-1} \Delta y_{t+i}]$$
$$+ \sum_{i=-1}^{2} \phi_i E_m \pi_{t+i} + \sum_{i=-1}^{2} \theta_i [E_m \pi_{t+i} - E_{m-1} \pi_{t+i}] + \rho E_m [u_t] + \epsilon_{m,t}.$$

- Intensity measure overcomes some of the interpretation issues in the Macroannual paper.

What is a Romer and Romer (AER 2004) shock?

- Romer and Romer (2004):
  It is important to note that the goal of this regression is not to estimate the Federal Reserve's reaction function as well as possible. What we are trying to do is to purge the intended funds rate series of movements taken in response to useful information about future economic developments. Once we have accomplished this, it is desirable to leave in as much of the remaining variation as possible.

- Cochrane (2004) Proposition 1:
  To measure the effects of monetary policy on output it is enough that the shock is orthogonal to output forecasts. The shock does not have to be orthogonal to price, exchange rate, or other forecasts. It may be predictable from time t information; it does not have to be a shock to agent's or the Fed's entire information set.

What is a Romer and Romer (AER 2004) shock?

- Change in operating procedure: target interest rate or money supply.
- Federal Reserve beliefs: how Fed reacts depends on whether it thinks monetary policy is effective.
- Tastes and goals: Fed gets "fed up" with inflation.
- Politics: Fed chair wants to please president to get reappointed.

Are these shocks?

- Simplest case: Taylor rule coefficients change.
- This clearly is useful for understanding effects of monetary policy.
- But how?

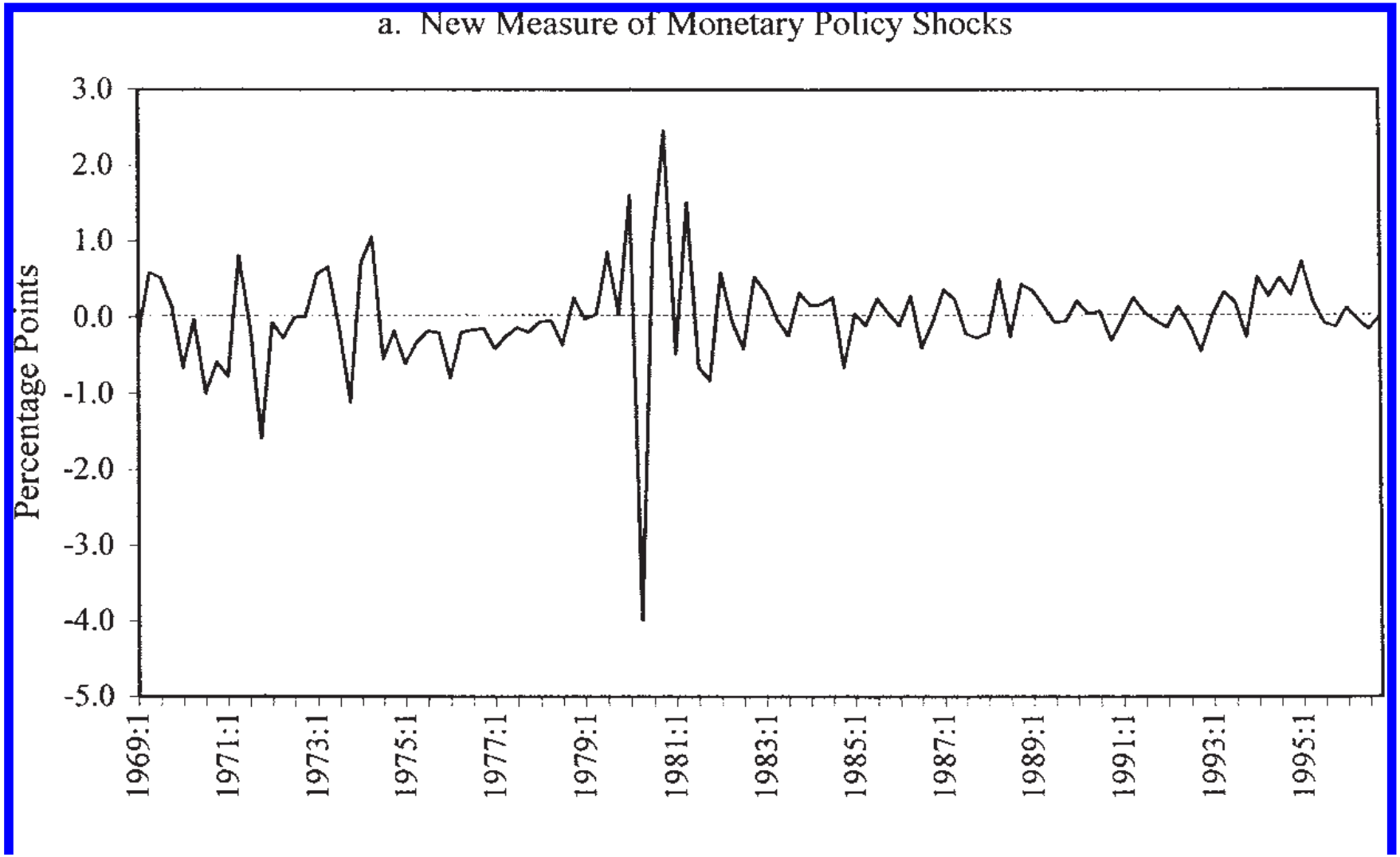
Example: Richard Nixon and Arthur Burns

- In run-up to 1972 reelection campaign (of Watergate fame), President Nixon pressured Federal Reserve Chairman Arthur Burns to ease monetary policy to ensure a booming economy. Because of the Nixon tapes, we have recorded evidence.
- December 10, 1971. Burns: "I want more aggressive steps taken by that committee on next Tuesday." Nixon: "Great. Great. You can lead 'em. Just kick 'em in the rump a little." Burns: "Time is getting short. We want to get this economy going."
- December 24, 1971. Nixon to George Shultz: "Do you feel, as far as Arthur [Burns] and the money supply, we got that about as far as we can turn it right now, have we? I mean as far as my influence on him, that's what I'm really asking." Shultz: "Yeah. Well, you know he said that he, that they voted to increase it [the money supply]." Nixon: "I know. What was his view, his words?" Shultz: "'And I'm on the line on that."' Nixon: "Well, you watch it and remind me. If I have to talk to him again, I'll do it. Next time I'll just bring him in."
- Etc.

Example: Trump

This paper presents market-based evidence that President Trump influences expectations about monetary policy. We use tick-by-tick fed funds futures data and a collection of Trump tweets criticizing the conduct of monetary policy and consistently advocating that the Fed lower interest rates. Identification exploits a short time window around the precise timestamp for each tweet. The average effect on the expected fed funds rate is negative and statistically significant, with an average cumulative effect of around -10 bps and a peak of -18.5 bps at the longest horizon. We conclude that market participants do not perceive the Fed as fully independent.

–Francesco Bianchi, Thilo Kind, Howard Kung, "Threats to Central Bank Independence: High-Frequency Identification with Twitter"


a. New Measure of Monetary Policy Shocks
Percentage Points
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
1969:1
1971:1
1973:1
1975:1
1977:1
1979:1
1981:1
1983:1
1985:1
1987:1
1989:1
1991:1
1993:1
1995:1

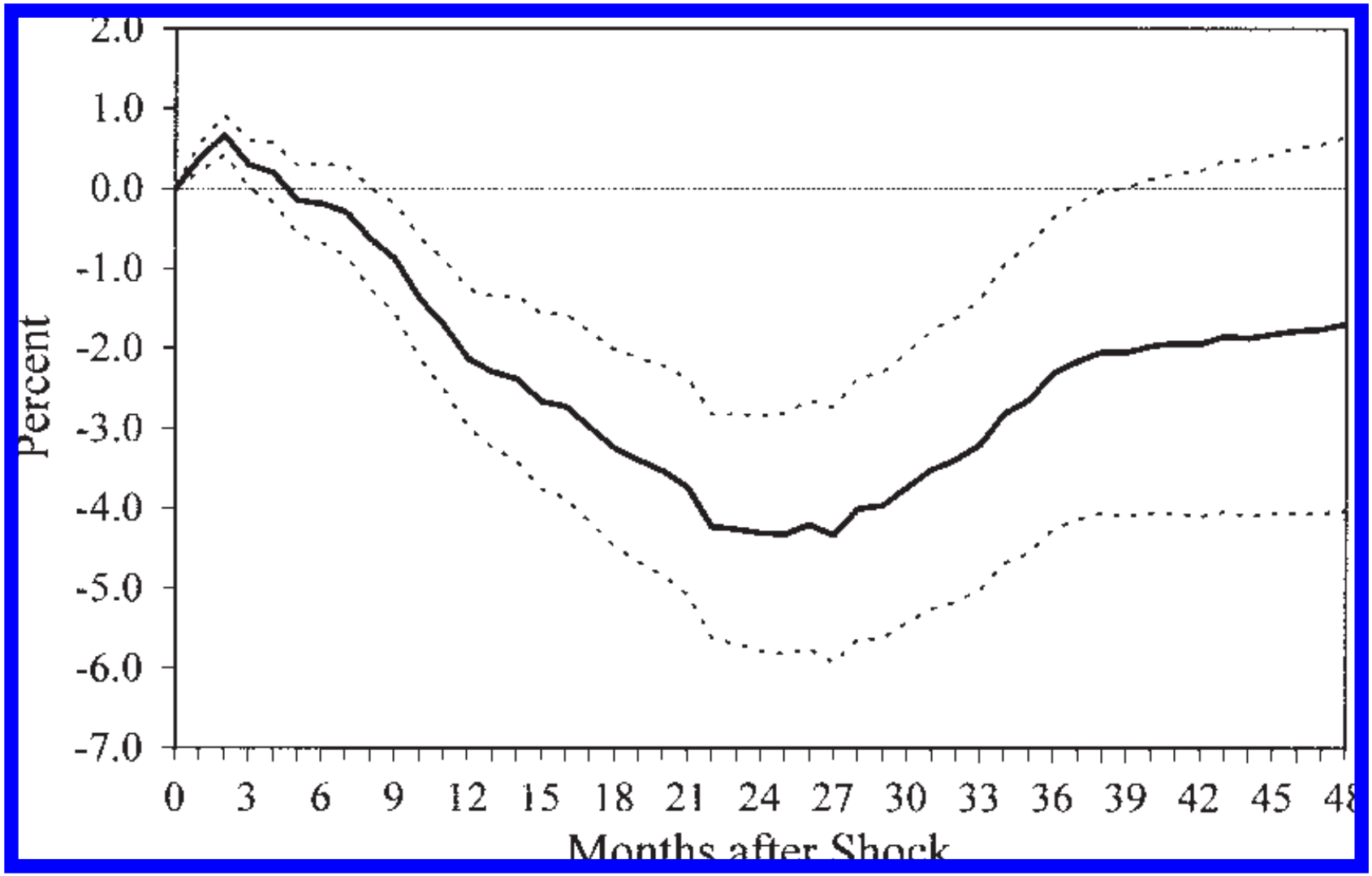


FIGURE 2. THE EFFECT OF MONETARY POLICY ON OUTPUT

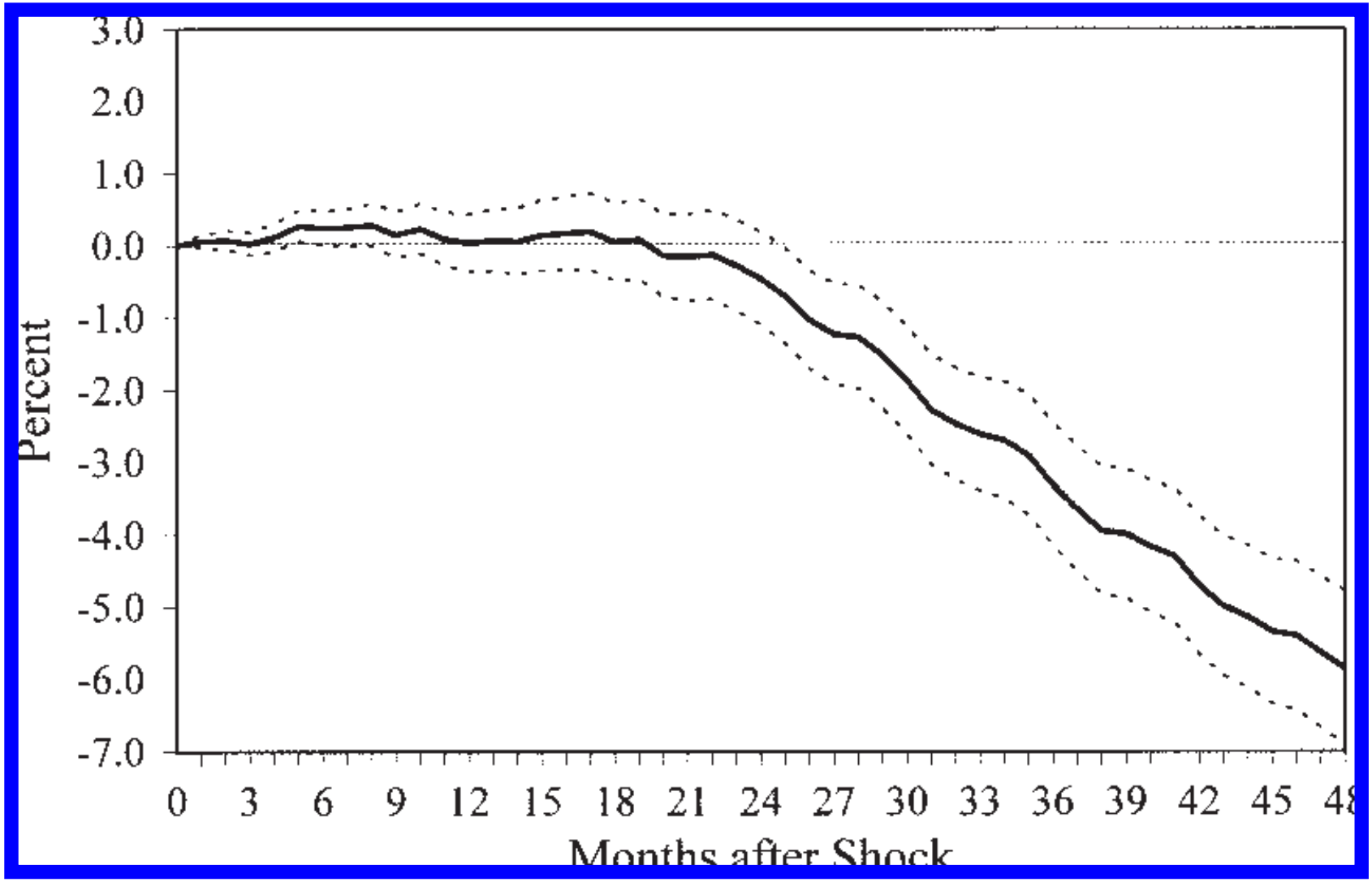


FIGURE 4. THE EFFECT OF MONETARY POLICY ON THE PRICE LEVEL

Outline

Post Romer and Romer evidence

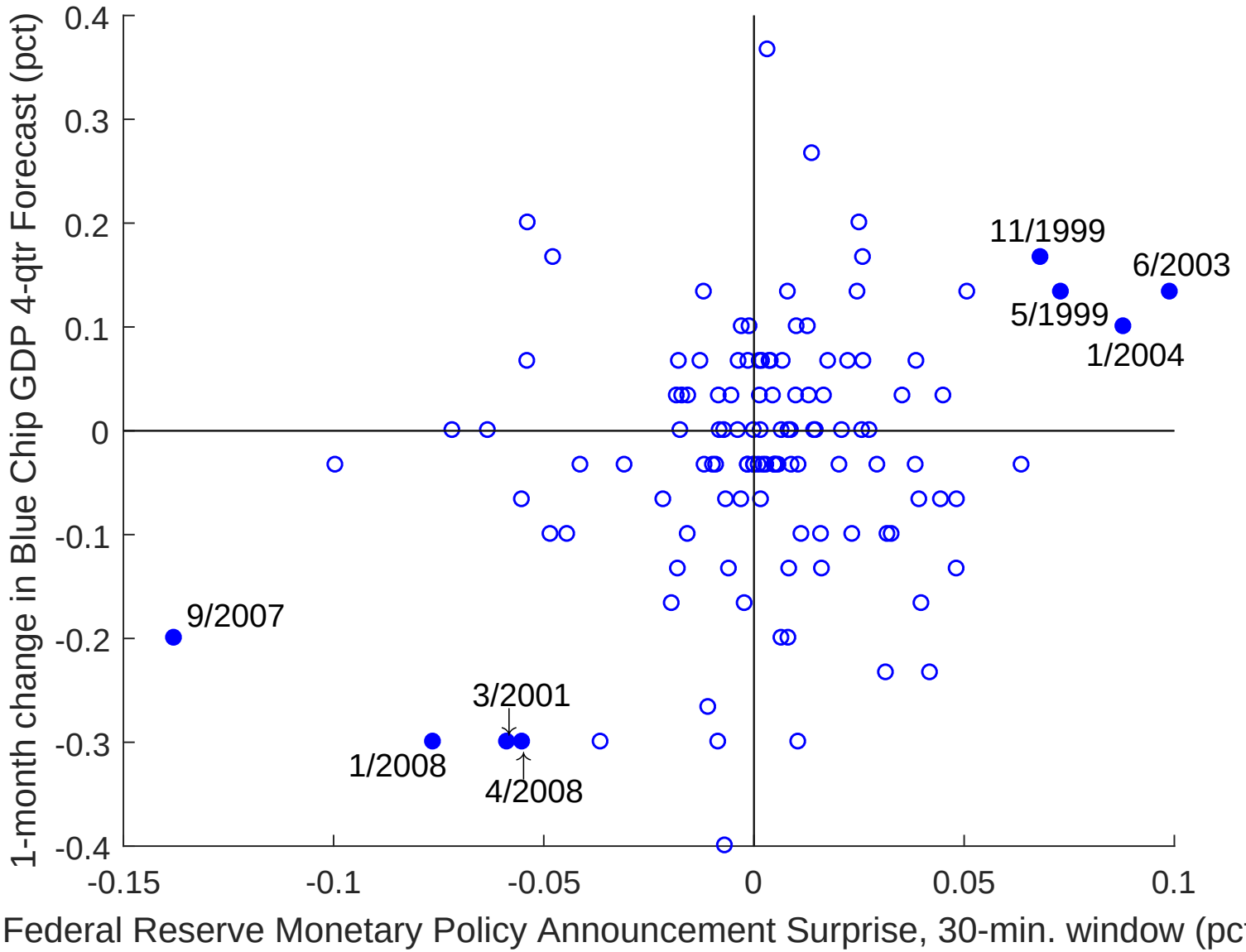
- Coibon (AEJ: Macro 2012) on Romer and Romer (2004):
  - Large output effects sensitive to number of lags in specification.
  - Large output effects sensitive to including 1979-82 period of nonborrowed reserves targeting.
  - Using Romer and Romer variable in VAR results in "medium effects."
- Barakchian and Crowe (JME 2013): impulse response of output to monetary shock weaker or wrong sign for post 1983 sample across many identification schemes.

High-frequency identification, redux

- What about federal funds surprises as in Gertler and Karadi?
- Criticized by Romer and Romer (2000), Nakamura and Steinsson (2018) as contaminated by information effect.
- Suppose Fed has superior forecast. A surprise loosening conveys economy in worse shape than previously thought by private agents.
- Response to surprise combines impact of interest rate cut and revision to private sector forecasts.

Bauer,Swanson (WP)

Figure 1: Blue Chip GDP Forecast Revisions and FOMC Monetary Policy Surprises



Back to Gertler and Karadi

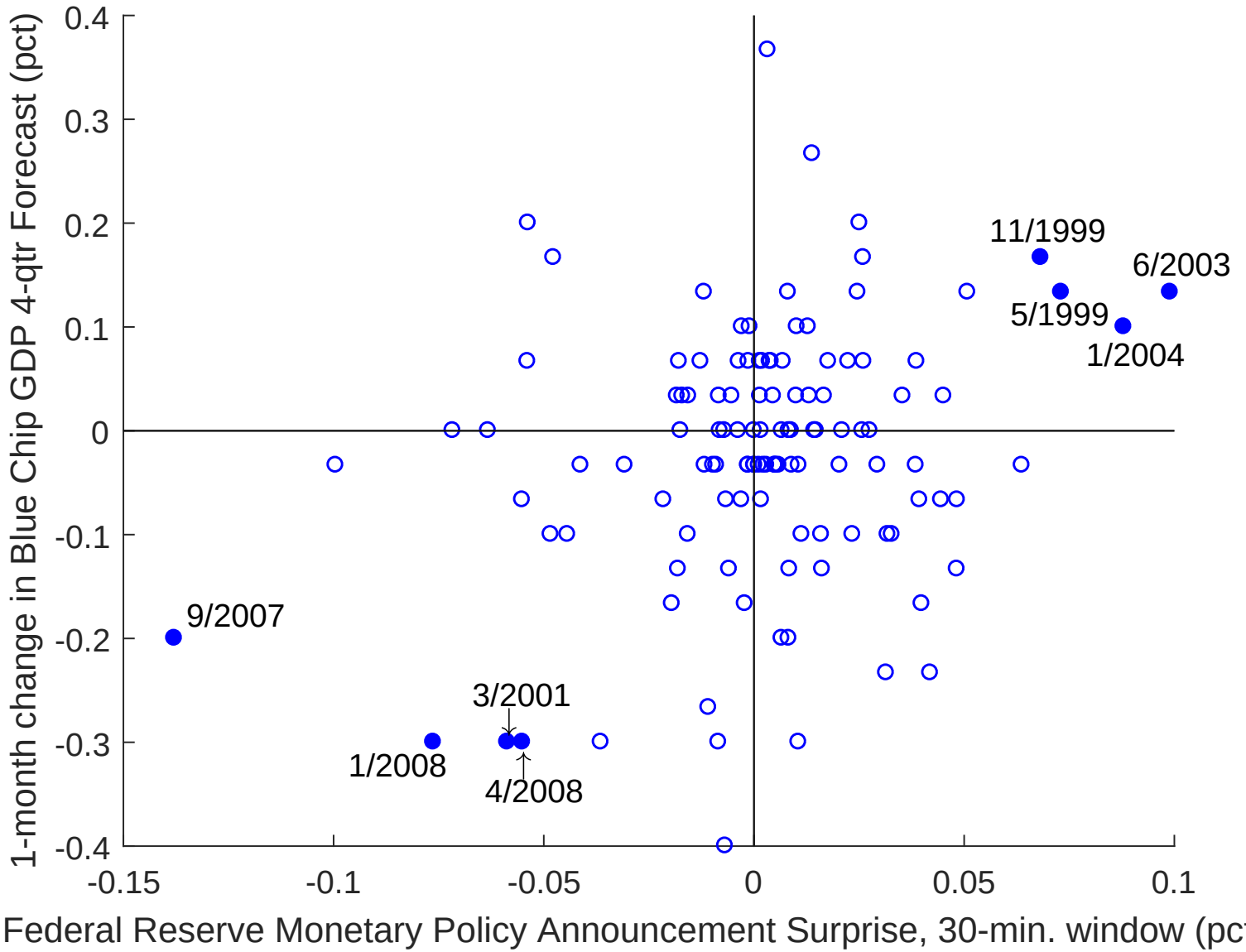
Table 4—Effects of Private Information on Tight Window Monetary Policy Surprise (1991–2007)

Variables	FF1 (1)	FF4 (2)	ED4 (3)
π	0.0227**	0.0145**	0.0152
	(2.161)	(2.109)	(1.611)
dy	0.0166*	0.0209***	0.0256***
	(1.724)	(3.077)	(3.072)
$\Delta\pi$	−0.0289**	−0.0178*	−0.0185
	(−2.387)	(−1.925)	(−1.528)
Δdy	−0.00663	−0.00755*	−0.00627
	(−1.309)	(−1.881)	(−1.033)
Observations	141	141	141
R^2	0.108	0.155	0.135
F-statistic	2.175	3.243	3.368
prob > F	0.0751	0.0141	0.0116

We construct a measure of the Fed's "private information" by taking the difference between the Greenbook forecast and the private sector forecast of the same economic activity variable, where we use the Blue Chip Economic Indicators Survey to measure the latter. Then we regress our measure of monetary policy surprises on this private information measure to determine the variation in the former explained by the latter. We then use the residuals from this regression to construct a new measure of policy surprises that eliminates the component that may be due to private information.

Bauer,Swanson (WP)

Figure 1: Blue Chip GDP Forecast Revisions and FOMC Monetary Policy Surprises



$$mps_t = \alpha + \beta news_t + \epsilon_t$$

Table 7: Economic News Predicts High-Frequency Monetary Policy Surprises

Monetary policy surprise measure	Economic news measure: (1) Nonfarm payrolls	(2) Brave et al. index	(3) Δ logS&P500
(A) Replication sample: 1/1990–6/2007 for Campbell et al., 1/1995–3/2014 for NS ($N = 129, 120$)			
fed funds target factor	.158***	.033***	.179
	(.050)	(.011)	(.128)
fwd guidance path factor	.032	.017**	.235***
	(.038)	(.0085)	(.088)
NS MP surprise	.041*	.013**	.096*
	(.022)	(.0059)	(.051)

$$BCrev_t = \alpha + \beta target_t + \gamma path_t + \theta mps_t + \delta news_t + \epsilon_t$$

Table 8: Economic News Drives Out the "Fed Information Effect"

	(1) Campbell et al.		(2) Nakamura-Steinsson
Blue Chip forecast	fed funds rate target factor	fwd. guidance path factor	first princip. comp. MP surprise
(A) Replication sample: 1/1990–6/2007 for Campbell et al., 1/1995–3/2014 for NS ($N = 129, 120$)			
Unemployment rate	.088	−.036	.191
	(.093)	(.127)	(.266)
Real GDP growth	−.045	−.083	.502
	(.181)	(.267)	(.307)

- So what are monetary policy surprises? How should they be used?

Ramey (HOME 2016) summary

I would argue that the most likely reason for the breakdown of many specifications in the later sample is simply that we can no longer identify monetary policy shocks well. Monetary policy is being conducted more systematically, so true monetary policy shocks are now rare. It is likely that what we now identify as monetary policy shocks are really mostly the effects of superior information on the part of the Fed, foresight by agents, and noise. While this is bad news for econometric identification, it is good news for economic policy.

What, then, are we to conclude about the output effects of monetary shocks? I would argue that the best evidence still remains the historical case studies, such as Friedman and Schwarz, and the times series models estimated on samples that exclude recent decades. Of course, one worries that the structure of the economy may have changed in the last few decades, but we simply do not have enough information to produce estimates with any great certainty. Monetary policy can have big effects, but it is likely that monetary shocks are no longer an important source of macro instability.

Other narrative evidence: Velde (JPE 2009)

- France 1724: three unanticipated proportional reductions in value of currency in circulation by total of 45%.
- Foreign exchange markets react fully and instantaneously.
- Commodity and final goods prices only partially adjust.
- Severe contraction in textile industry.
- Reverse when France raises value of currency in 1726.

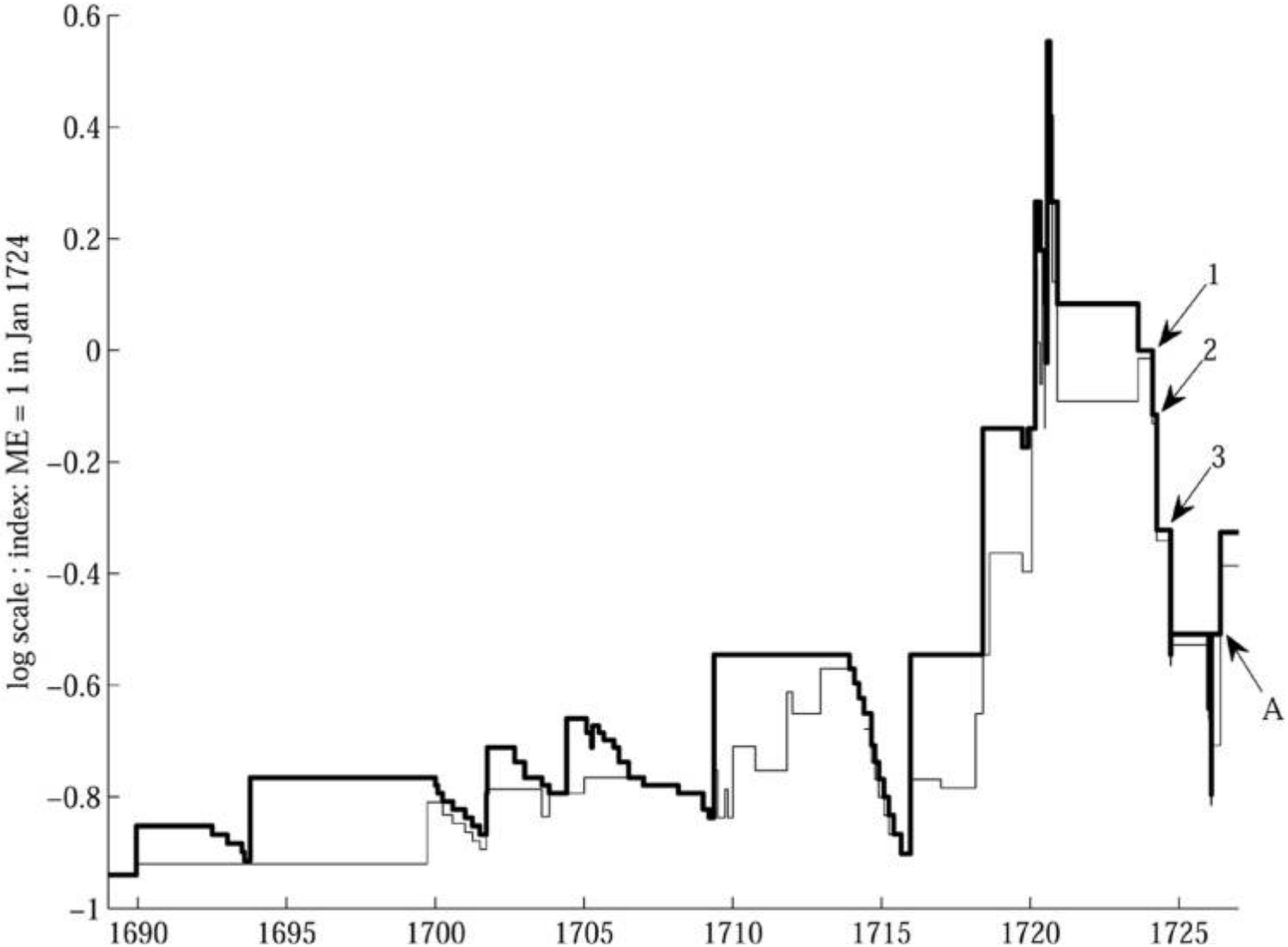


FIG. 1.—ME (upper thick line) and MP (lower thin line), France, 1685–1730 (log scale). Sources: original decrees at http://www.ordonnances.org/.

FIG. 3.—Exchange rates on Paris in London, in French units of account per British unit of account, 1721–29. The line plots an index of the silver parity between the units of account. Source: *Course of the Exchange*.

TABLE 2

PRICES OF VARIOUS COMMODITIES AT THE HALLES MARKET, 1724

	WHEAT			BREAD		EGGS	PORK	CANDLES	BUTTER
	High	Low	Mode	High	Low	(Average)	(Average)	(Average)	(Average)
February 1724:									
1	25.5			3.75		52.5	6.75	14.5	95
5	25.5			3.75		52	7.75	14.5	75
9	25			3.5		57.5	7.75	14.5	80
12*	24.25			3.5		65	7.75	14.5	85
16	24.5			3.5		70	6.75	14.5	85
April 1724:									
1	27.5			3.25				14.5	85
5*	23.5			3.25				14.5	85
8	25			3.25				14.5	92
12	24.5			3.25				14.5	90
September 1724:									
6	25			3		29	6.75	10.5	60
9	25.25			3		29.5	6.75	10.5	63
13	26.5			3.25		30	6.75	10.5	60
16	27.25			3.25		34	6.75	10.5	72
20	26.75			3.25		34	6.75	10.5	66
23*	25			3.25		35	6.75	10.5	65
27	25.75			3.25		32	6.75	10.5	63
30	26			3.25		36.5	6.75	10.5	65
May–June 1726:									
15	24.5	12	20	2.75	2.5	24	5.75	9.75	46
18	24	12.5	18.25	2.75	2.5	23	5.75	9.75	46
22	24	12	19	2.75	2.5	25	5.75	9.75	46
25	23.25	12	18.5	2.75	2.5	23.5	5.75	9.75	46
29*	23.25	12	20.5	2.75	2.5	23.5	5.75	9	43
1	23.25	12.5	19.9	2.75	2.5	23.5	6	9	42
5	23.25	13	21	2.75	2.5	25	6.25	9	
8	23.25	13	22	2.75	2.5	24.5	7.25	9	42
12	23	13	21	2.75	2.5	23.5	6.75	9	40

SOURCES.—Dutot ([1738] 1935, 76), Institut mss. 514.

NOTE.—The units are sous per pound for bread, pork, and candles and livres per bushel (*septier*) of wheat, per hundred pounds of butter, and per thousand eggs.

* The first market date after each diminution.

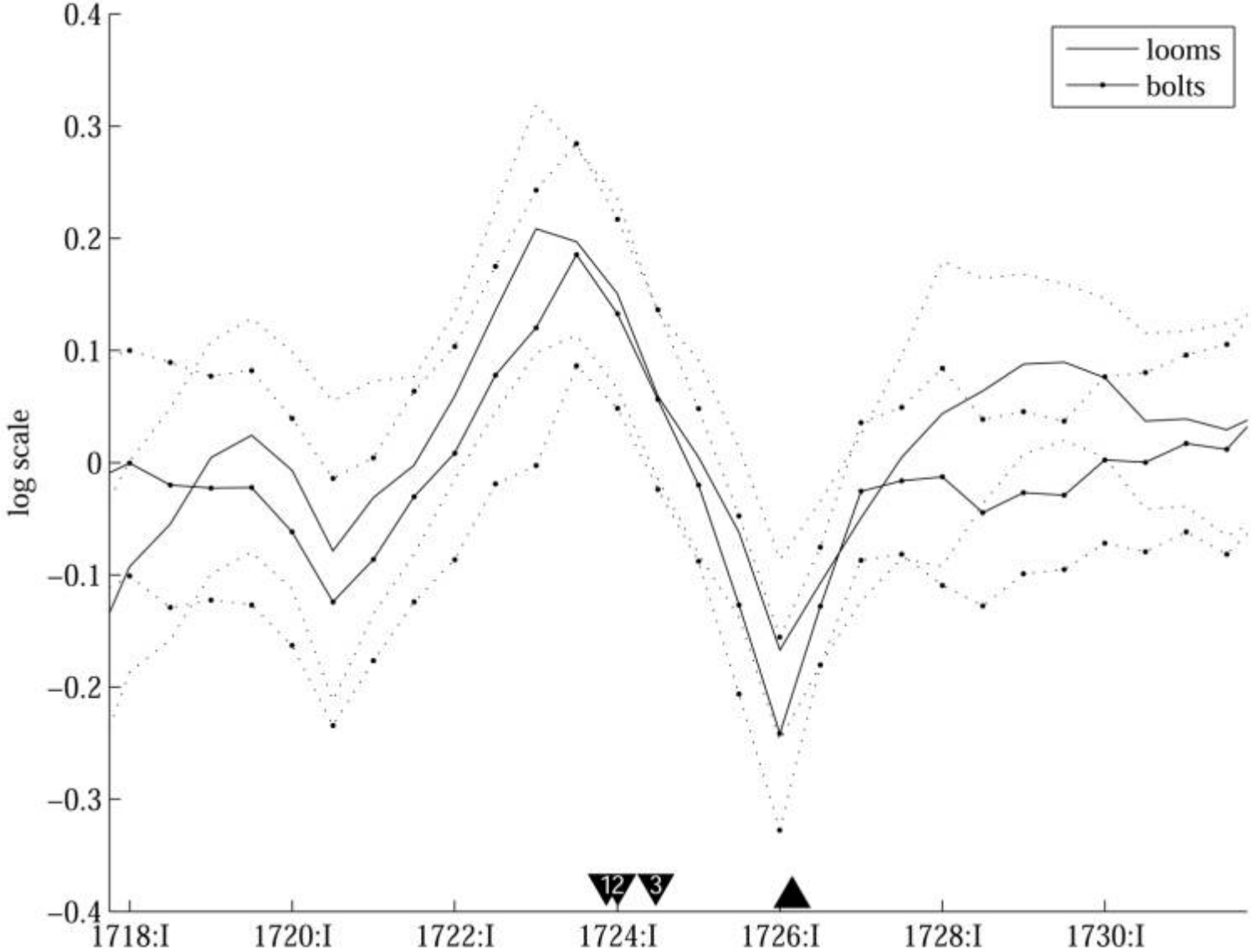
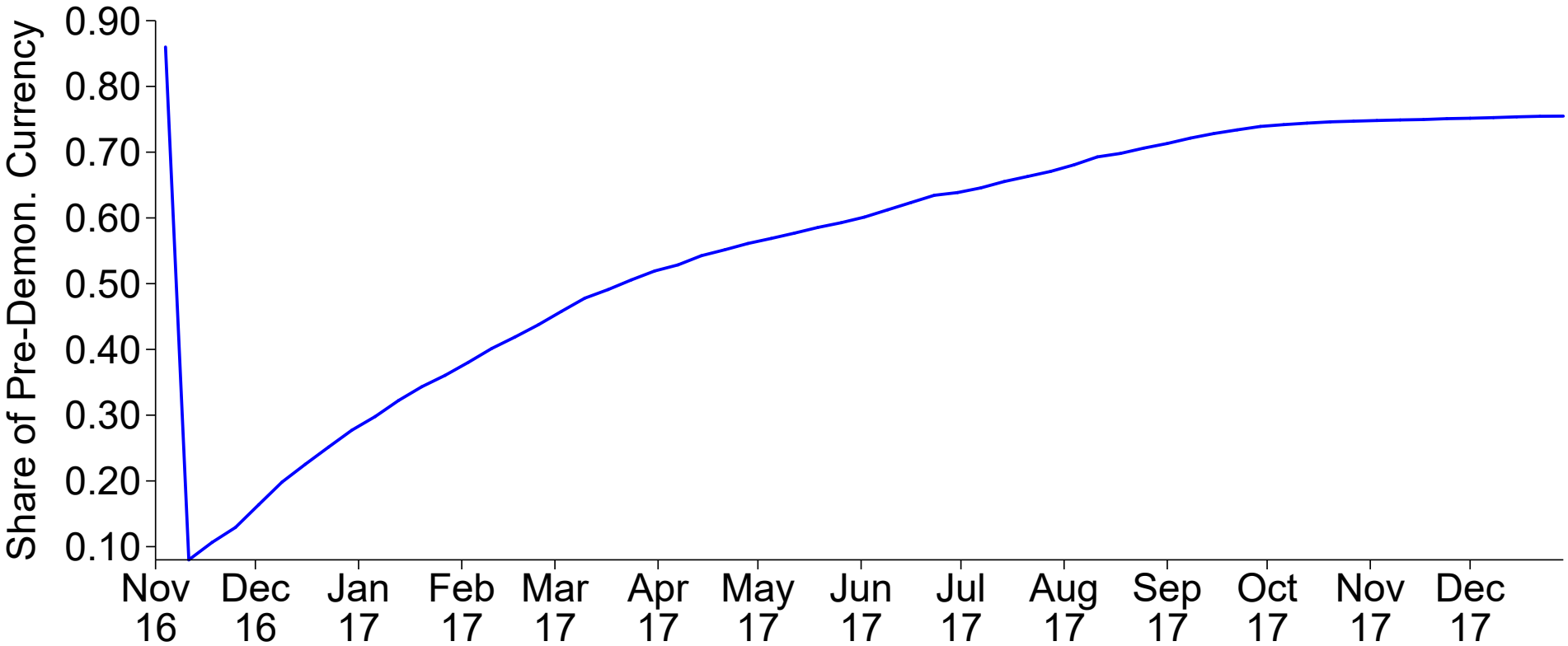


FIG. 9.—Index of working looms and index of bolts produced, semiannual, 1718–31 (log scale). Dotted lines are 95 percent confidence intervals.

Other extreme evidence: Chodorow-Reich, Gopinath, Mishra, Narayanan, QJE, 2020

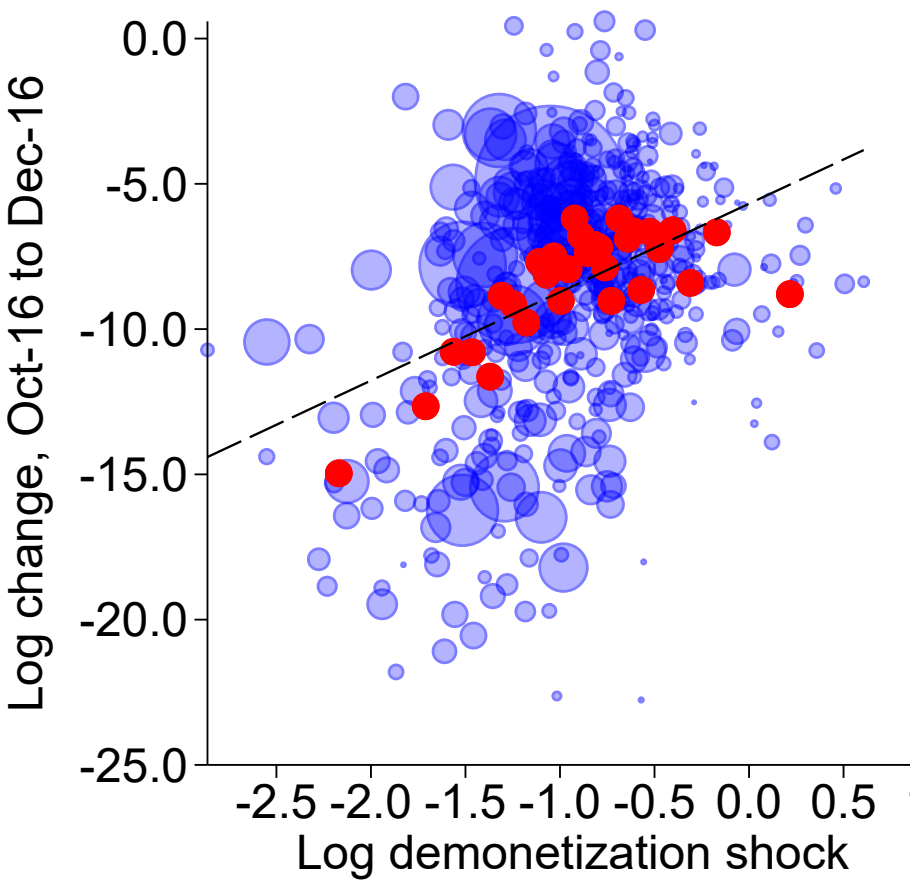
- In November 2016, India suddenly declared 86% of currency non-legal tender.
- Slowly replaced "demonetized" notes with new notes over several months.
- Single episode: use variation across Indian districts in how quickly currency replaced.
- Large cross-district variation: not a small shock.

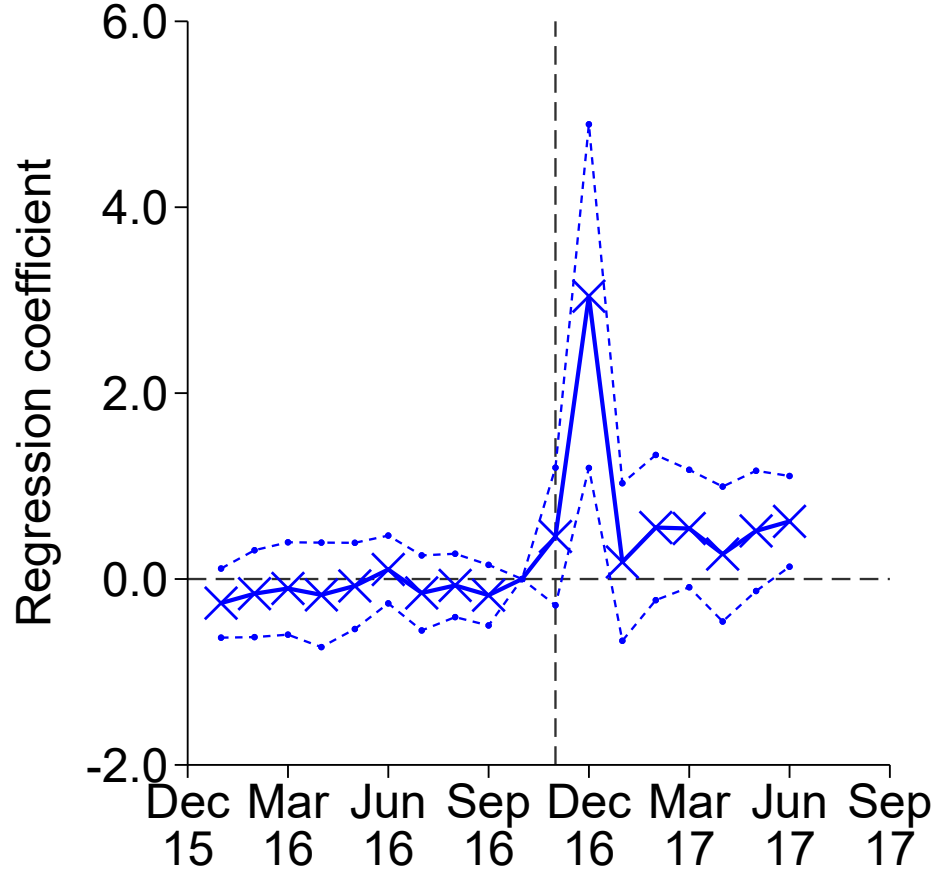
The event: demonetization of large notes



- November 8, 2016: 1000 ($15) and 500 ($7.50) rupee notes declared not legal tender, replaced by 2000 and new 500 note.
- No change in total liabilities of RBI (99% of notes returned).
- No change in interest rates.

CRGMN: ATM WITHDRAWALS

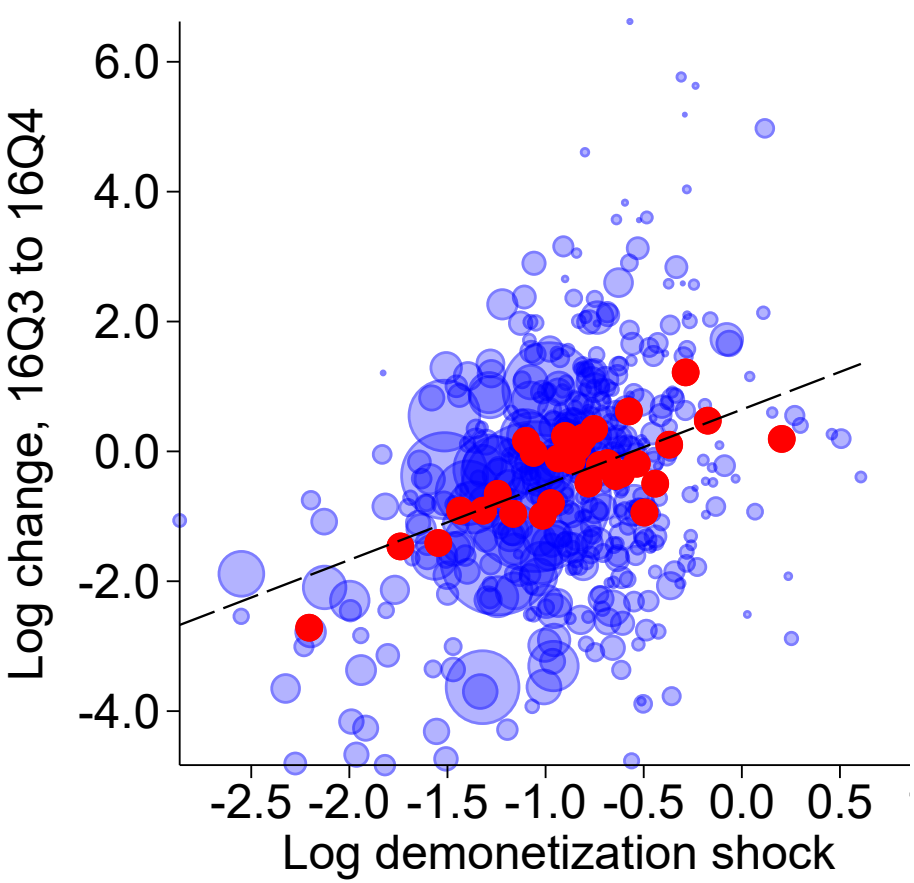


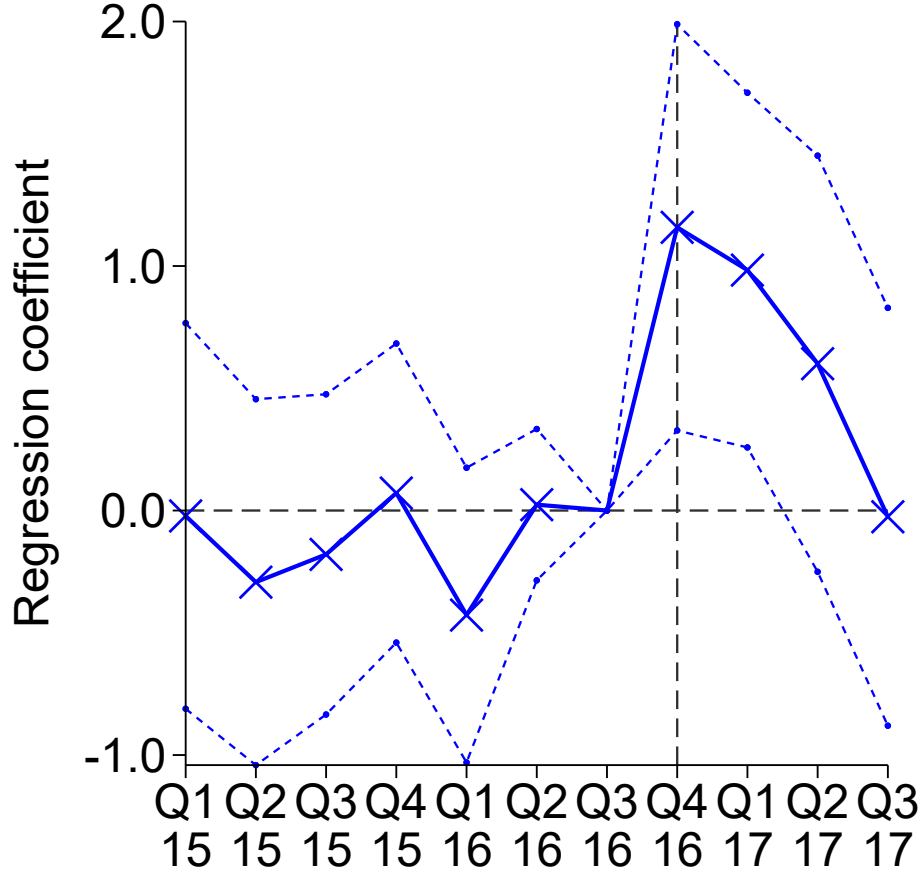


Source for dependent variable: National Payment Corporation of India.

- Areas that received fewer notes had sharper reduction in ATM activity.
- Parallel trend growth of ATM withdrawals before the shock occurred.

CRGMN: Night lights

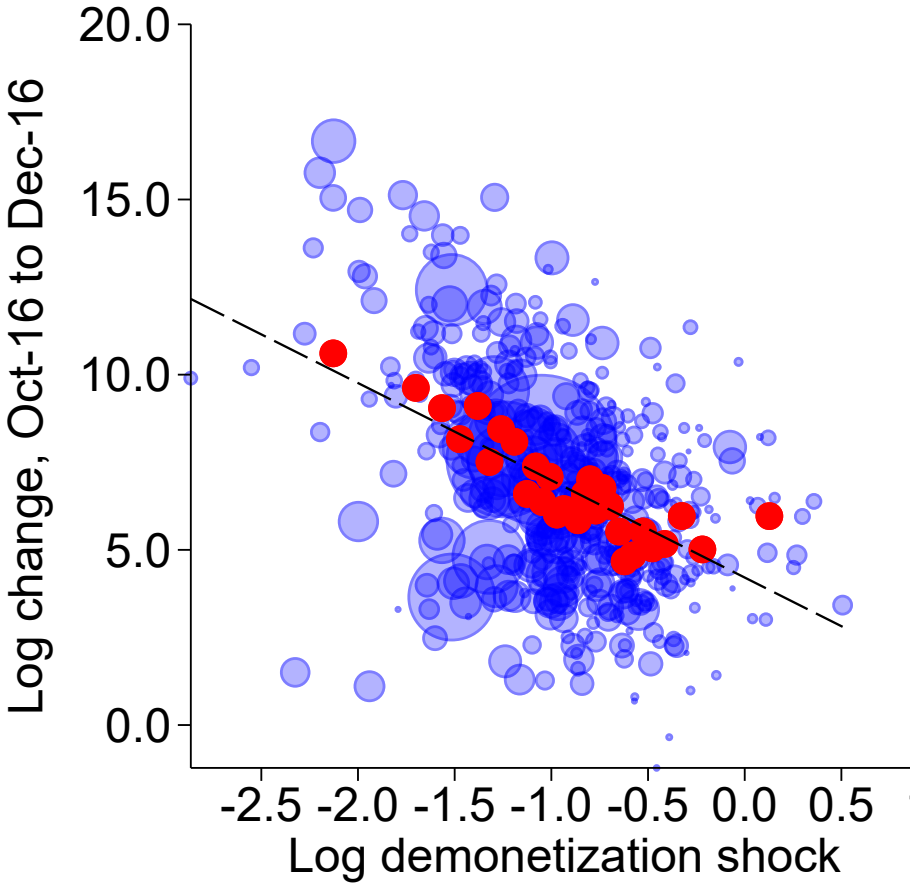


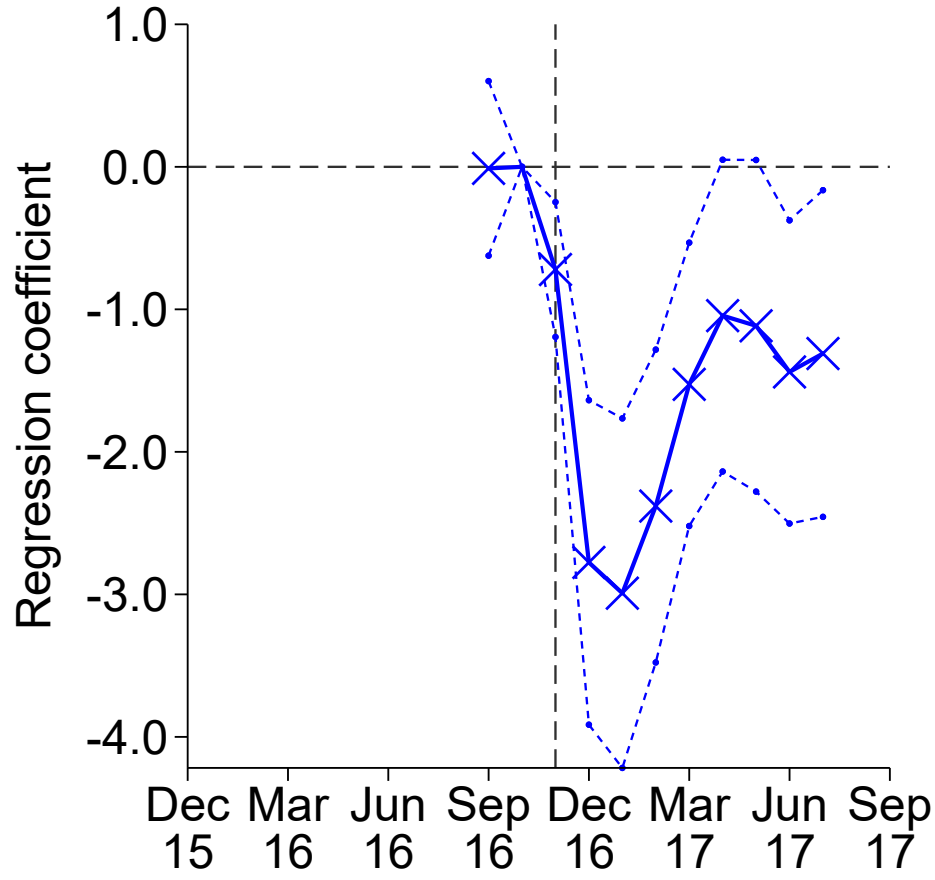


Source for dependent variable: VIIRS DNB.

- Henderson, Storeygard, Weil (AER 2012): Elasticity of GDP growth to nightlight growth$\approx 0.3 \Rightarrow$ Fitted 90-10 differential $= 4.5$ p.p.

CRGMN: E-wallet transactions





Source for dependent variable: E-wallet company.

- Measurable shift to non-cash payment mechanism.
- Validation: output effects due to cash shortage and not demand shock.

Outline

Overview

- Identify *legislated* tax changes.
- Classify tax changes into four categories:
  1. Offsetting a change in government spending.
  2. Offsetting some factor other than spending likely to affect output in the near future.
  3. Dealing with an inherited budget deficit.
  4. Achieving some long-run goal, such as higher normal growth, increased fairness, or a smaller role for government.
- (1) and (2) endogenous variation.
- (3) and (4) valid variation.

Econometric framework

$$\Delta Y_t = \alpha + \beta \Delta T_t + \sum_{i=1}^{K} \epsilon_t^i,$$

$$\Delta T_t = \sum_{i=1}^{K} b_t^i \epsilon_t^i + \sum_{j=1}^{L} \omega_t^j.$$

- Y_t: log output.
- T_t: legislated tax changes.
- $\epsilon_t = \sum_{i=1}^{K} \epsilon_t^i$: business cycle influences on output and tax policy.
- ω_t^j: non business cycle influences.
- Combine:

$$\begin{aligned}\Delta Y_t &= \alpha + \beta \left[\sum_{i=1}^{K} b_t^i \epsilon_t^i + \sum_{j=1}^{L} \omega_t^j \right] + \epsilon_t \\ &= \alpha + \beta \sum_{j=1}^{L} \omega_t^j + \sum_{i=1}^{K} \left(1 + \beta b_t^i\right) \epsilon_t^i.\end{aligned}$$

... CONTINUED

$$\Delta Y_t = \alpha + \beta \left[\sum_{i=1}^{K} b_t^i \epsilon_t^i + \sum_{j=1}^{L} \omega_t^j \right] + \epsilon_t \tag{1}$$

$$= \alpha + \beta \sum_{j=1}^{L} \omega_t^j + \sum_{i=1}^{K} \left(1 + \beta b_t^i\right) \epsilon_t^i. \tag{2}$$

- (1) has omitted variable bias.
- Treating last term in (2) as a composite error term, (2) is a valid regression if can isolate ω_t^j.
- Because some ϵ_t^i are observable, can validate specification by demonstrating observed ϵ_t^j uncorrelated with ω_t^j.

Sources

- Economic Report of the President (ERP).
- Presidential speeches.
- Congressional commitee reports.
- `https://eml.berkeley.edu//~dromer/papers/nadraft609.pdf`: 91 page web index detailing each tax change and the motivation for its classification.

Example: 1975:Q2 tax cut

- Romer and Romer (2010): *Policymakers were explicit that they were cutting taxes because the economy was predicted to fall further, and they were attempting to mitigate the decline.*
  - ERP: *"The tax cut will not prevent a decline in real output from 1974 to 1975 but it will reduce the extent of the year-over-year decline."*
  - Ford SOTU: *"Cutting taxes now is essential if we are to turn the economy around. A tax cut offers the best hope of creating more jobs."*
  - House report: *"The overall tax cut provided by your committee's bill is larger than the $16 billion tax cut recommended by the administration. However, your committee believes that the larger tax cut is more appropriate in the present situation, because the economic situation has deteriorated and forecasts of future economic activity in absence of remedial action are more pessimistic than at the time the administration presented its recommendations."*

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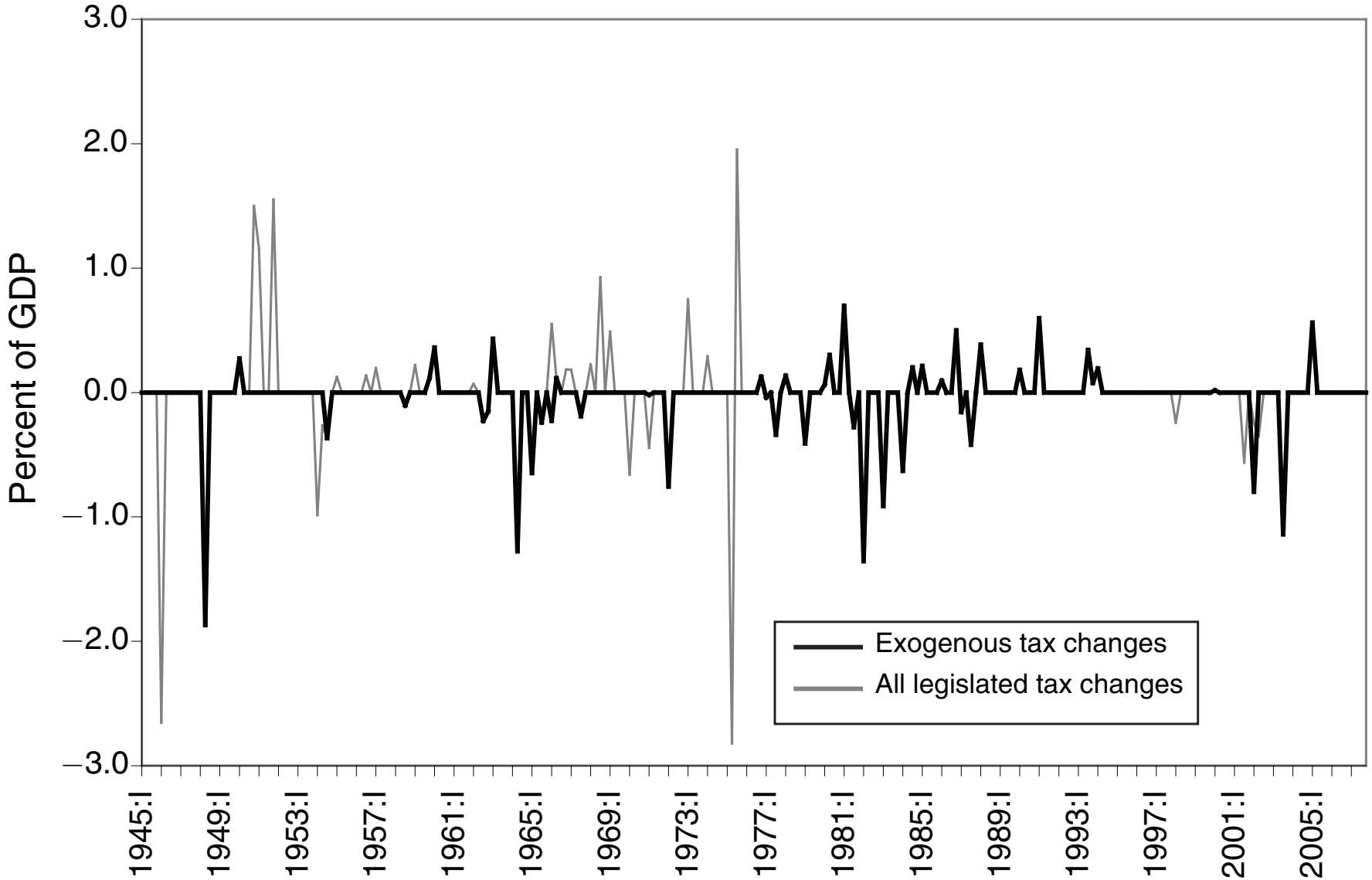
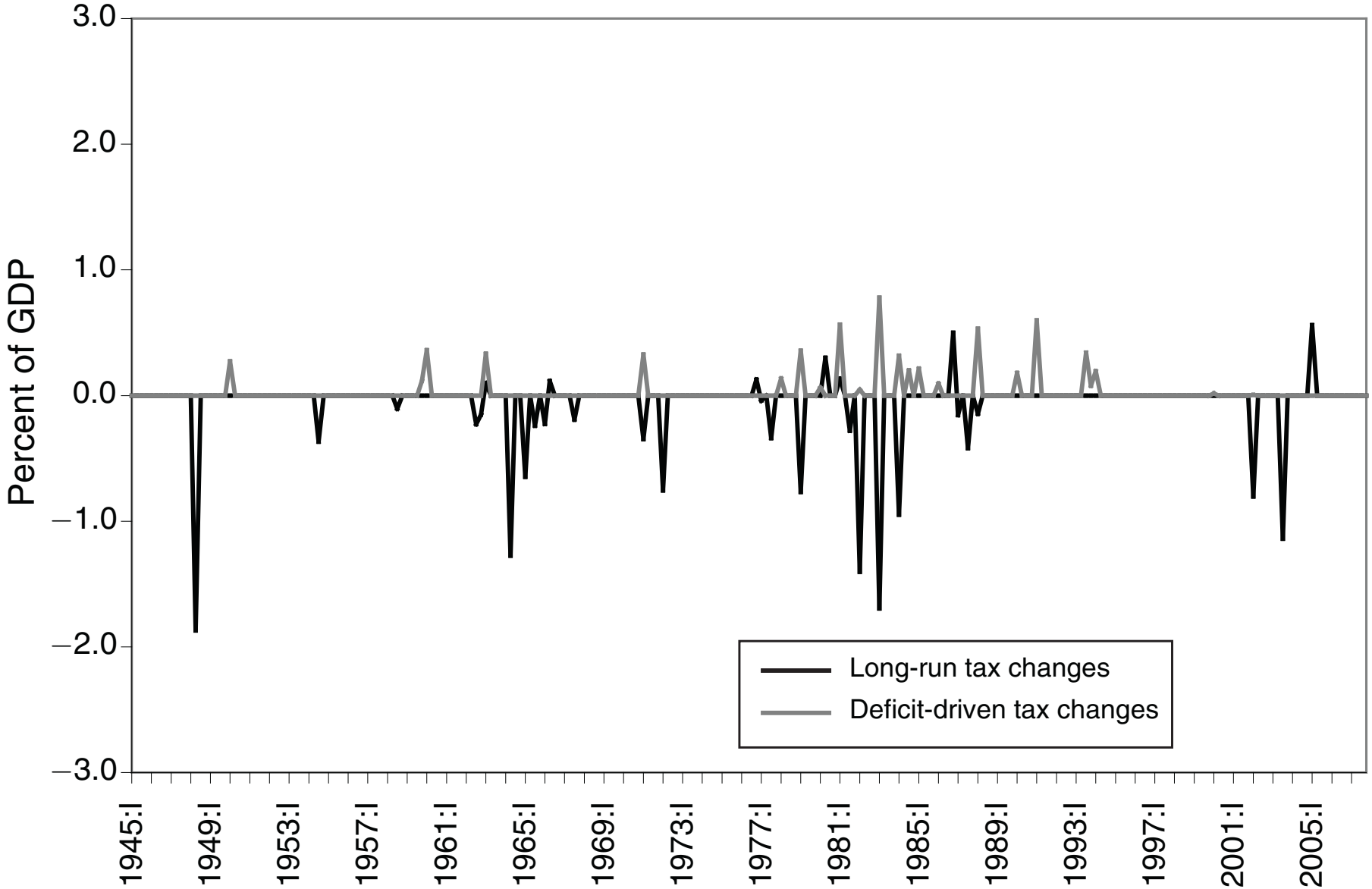
- Blanchard and Perotti (2002):
  - Tax cut so large they fit it with a dummy variable.
  - Section V.B: dynamic effects similar to other IRFs.
  - Footnote 17 caveats interpretation.
  - Truly a problem for Blanchard and Perotti?

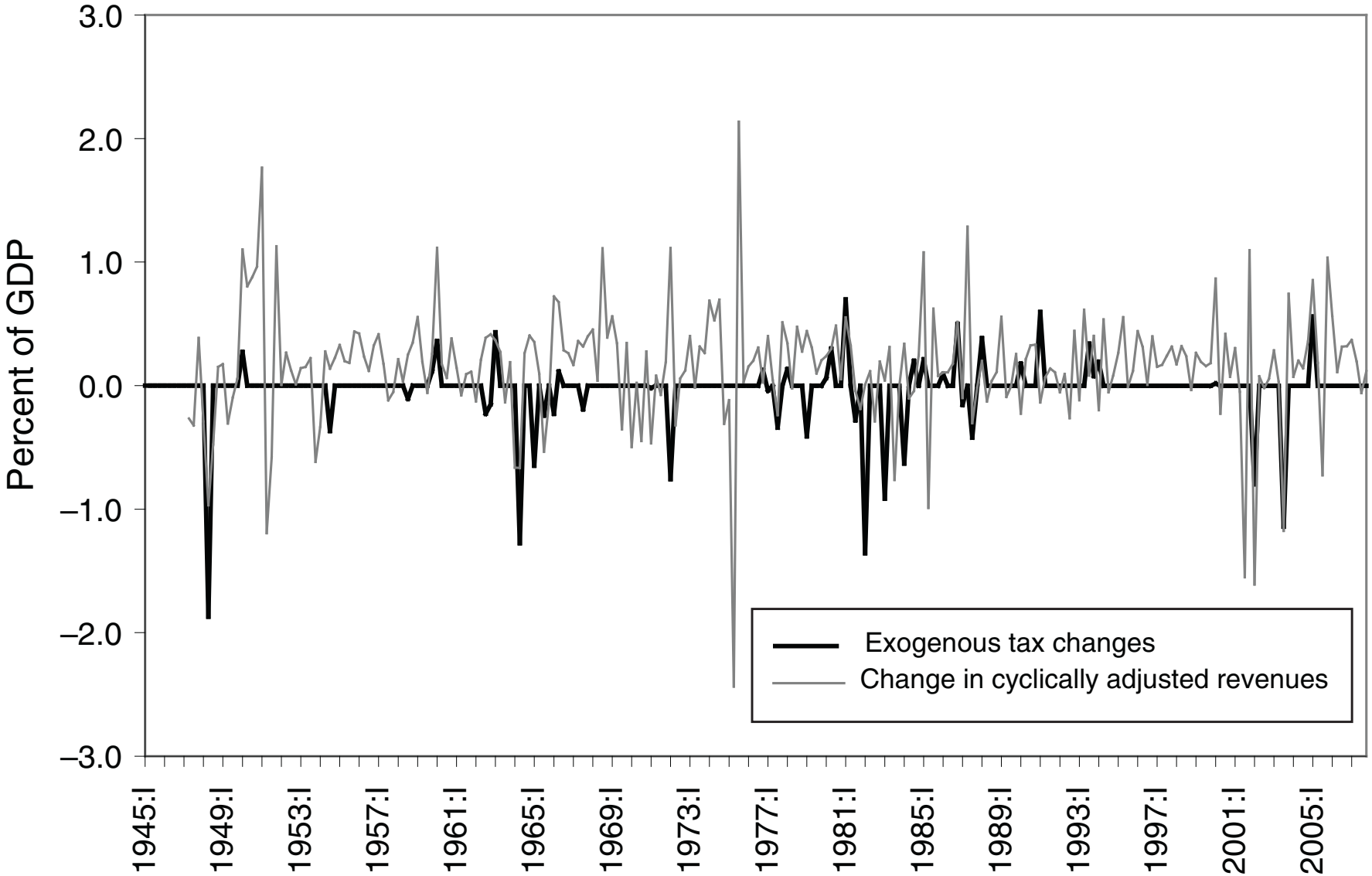
Panel A. Exogenous and all legislated tax changes



Panel B. Long-run and deficit-driven tax changes



Panel A. Exogenous tax changes and the change in cyclically adjusted revenues



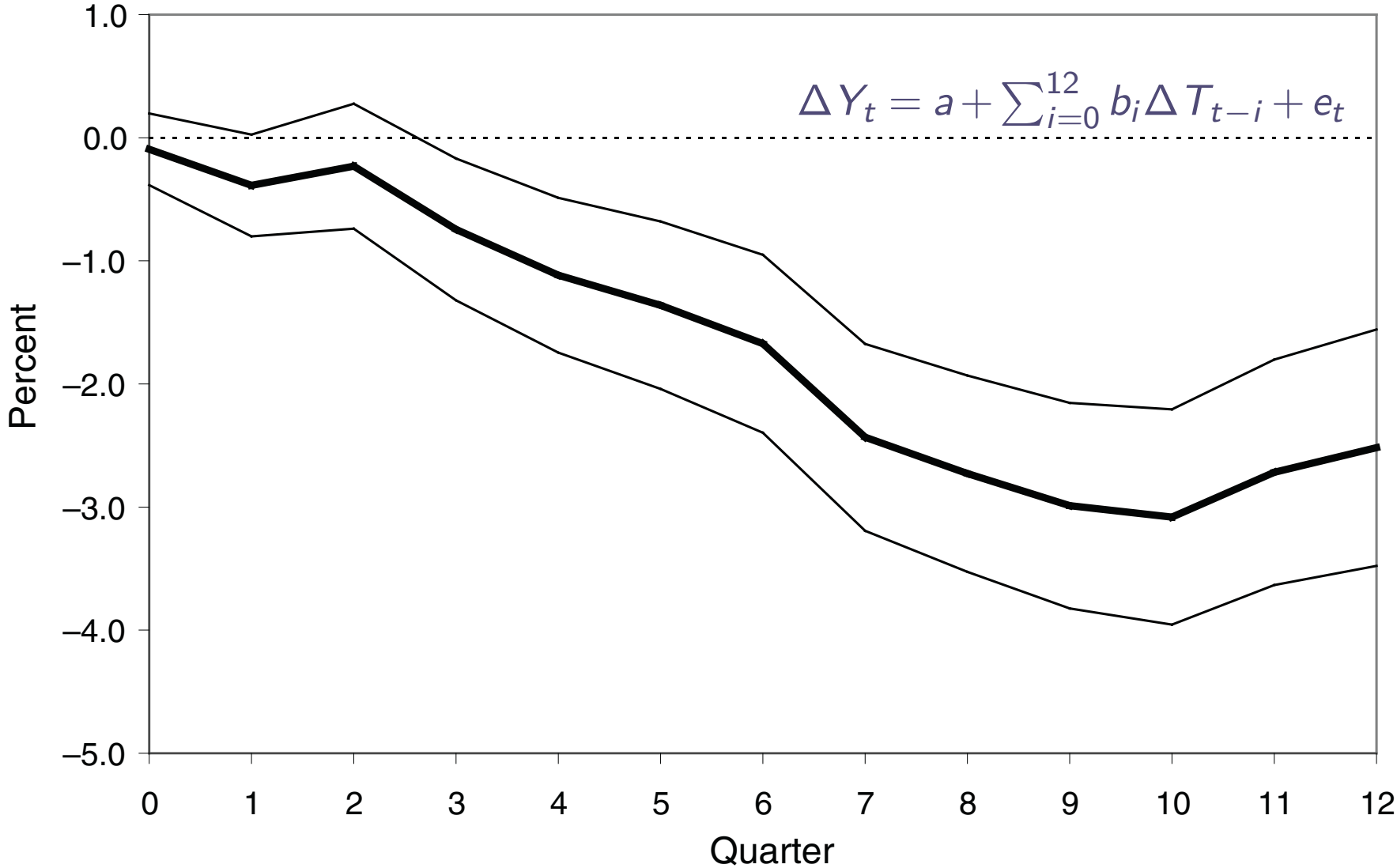


FIGURE 4. ESTIMATED IMPACT OF AN EXOGENOUS TAX INCREASE OF 1 PERCENT OF GDP ON GDP
(*Single equation, no controls*)

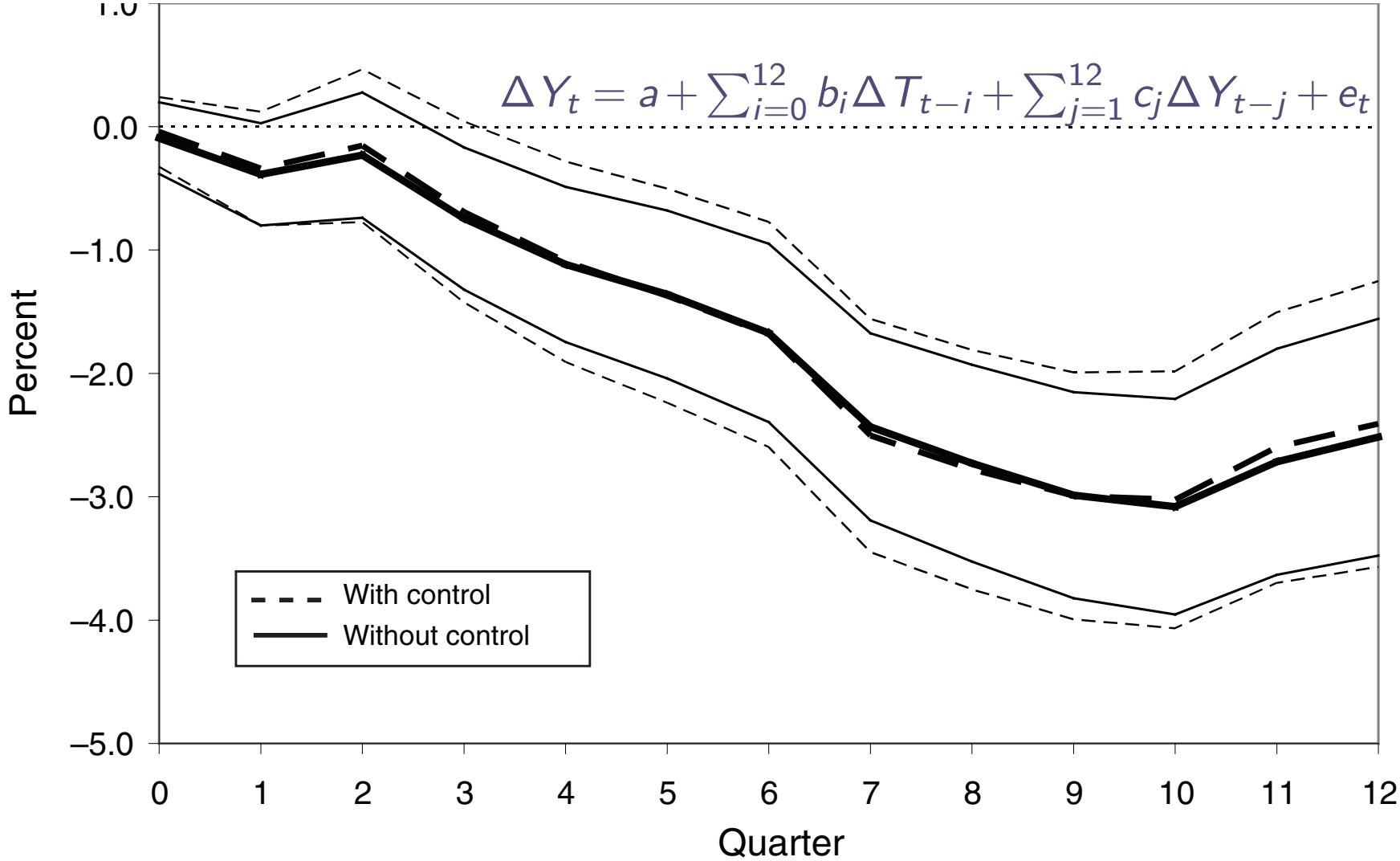


FIGURE 5. ESTIMATED IMPACT OF AN EXOGENOUS TAX INCREASE OF 1 PERCENT OF GDP ON GDP
(*Single equation, controlling for lagged GDP growth*)

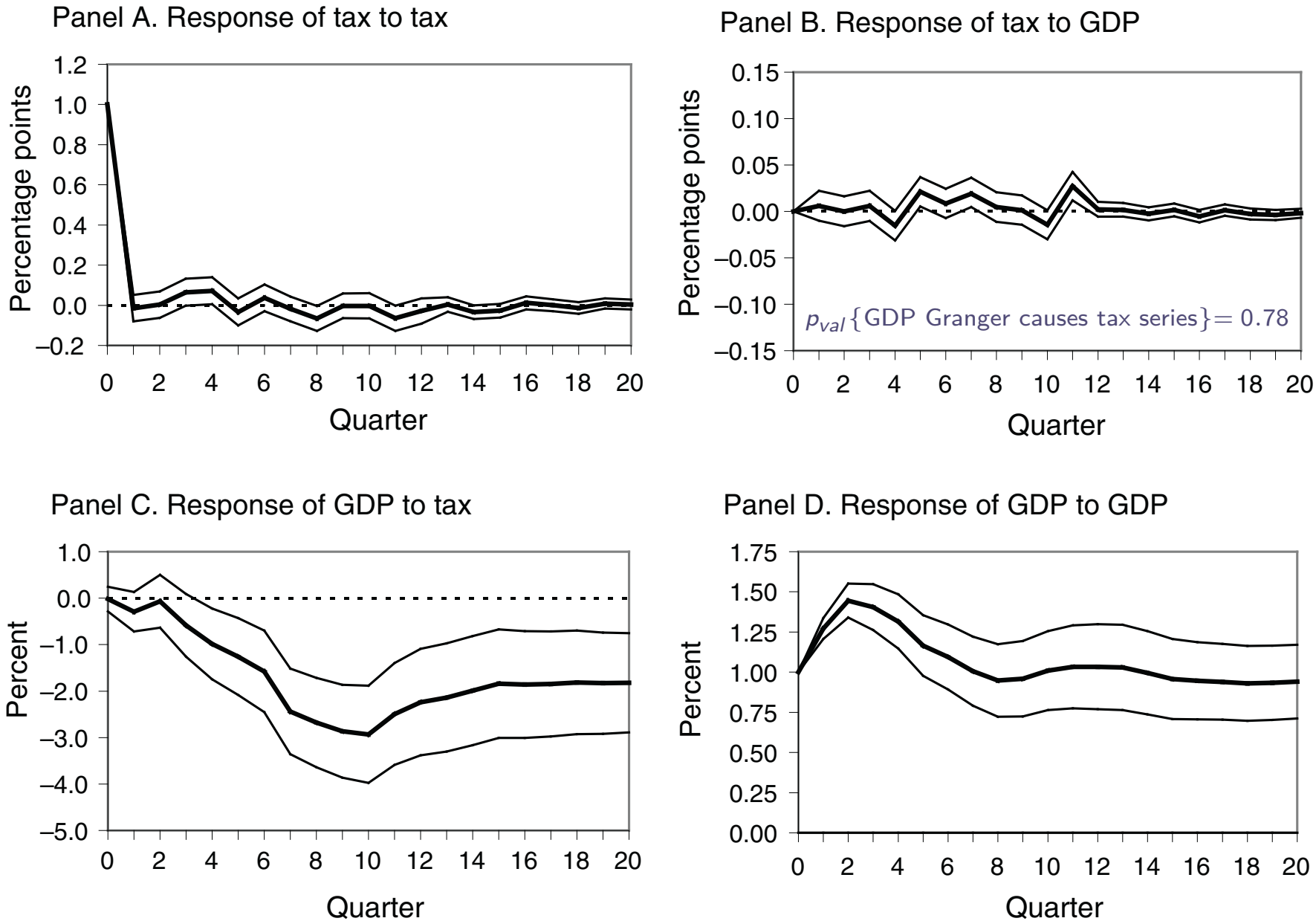
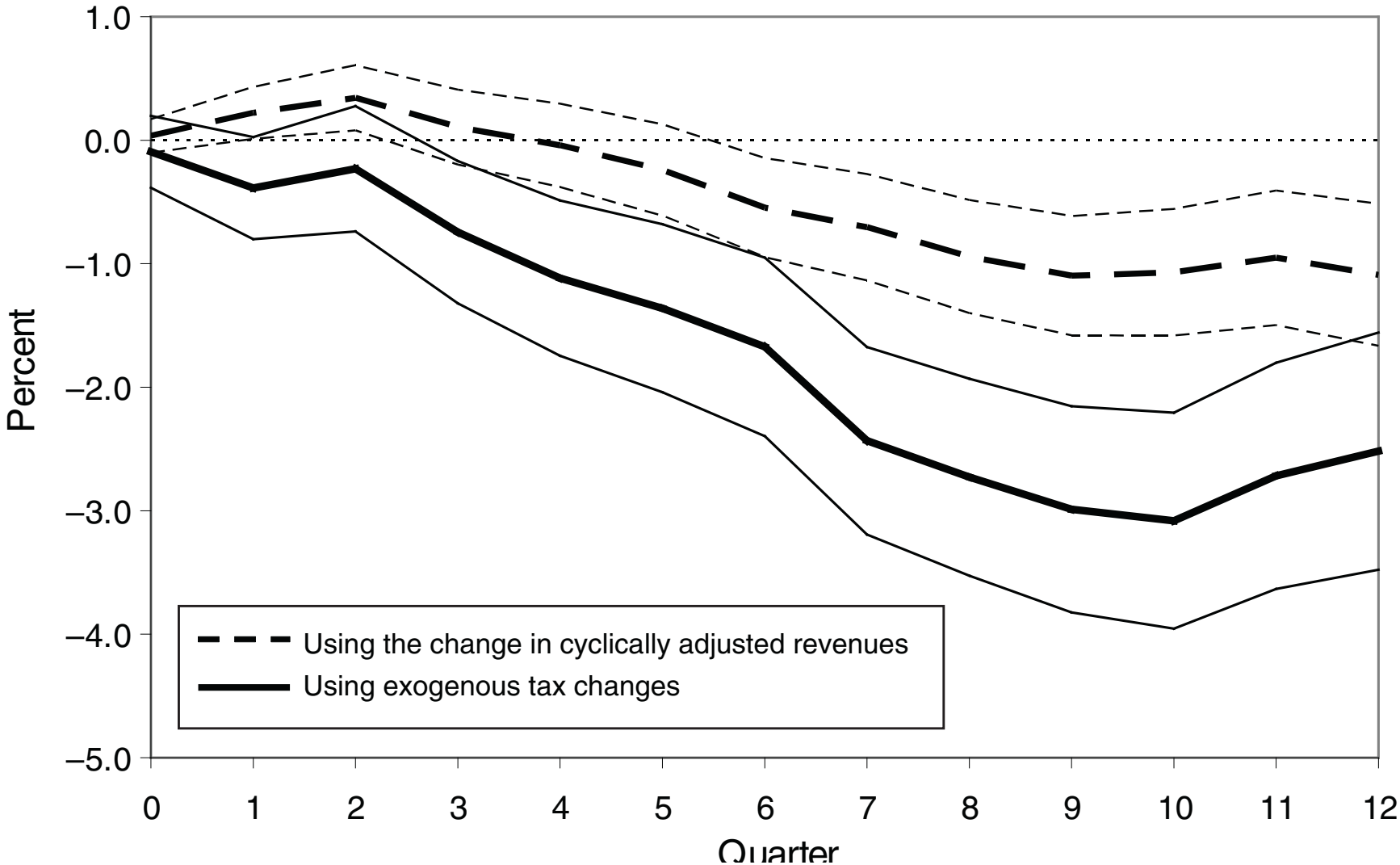
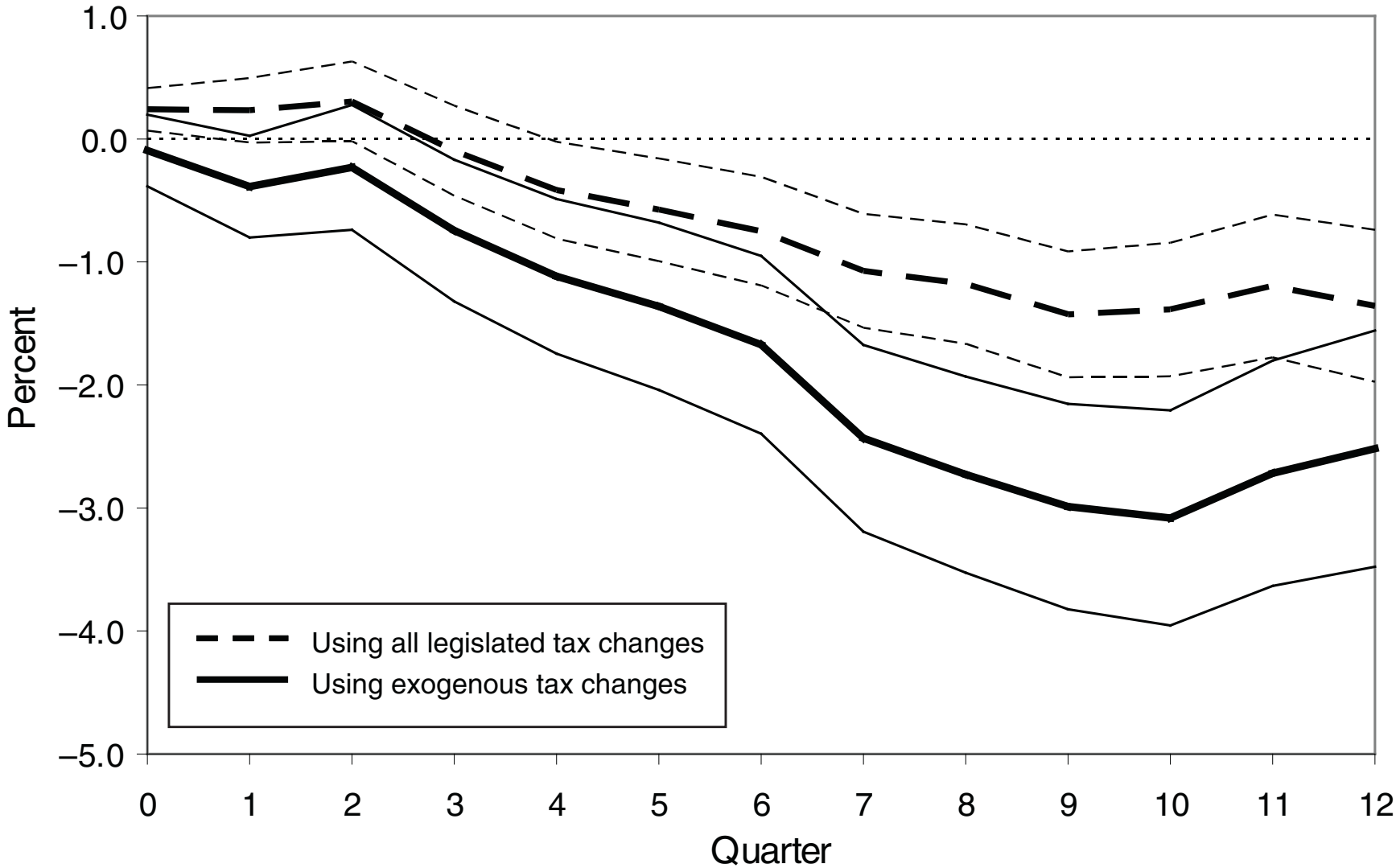


FIGURE 6. RESULTS OF A TWO-VARIABLE VAR FOR EXOGENOUS TAX CHANGES AND GDP

Does it matter?



Does it matter?



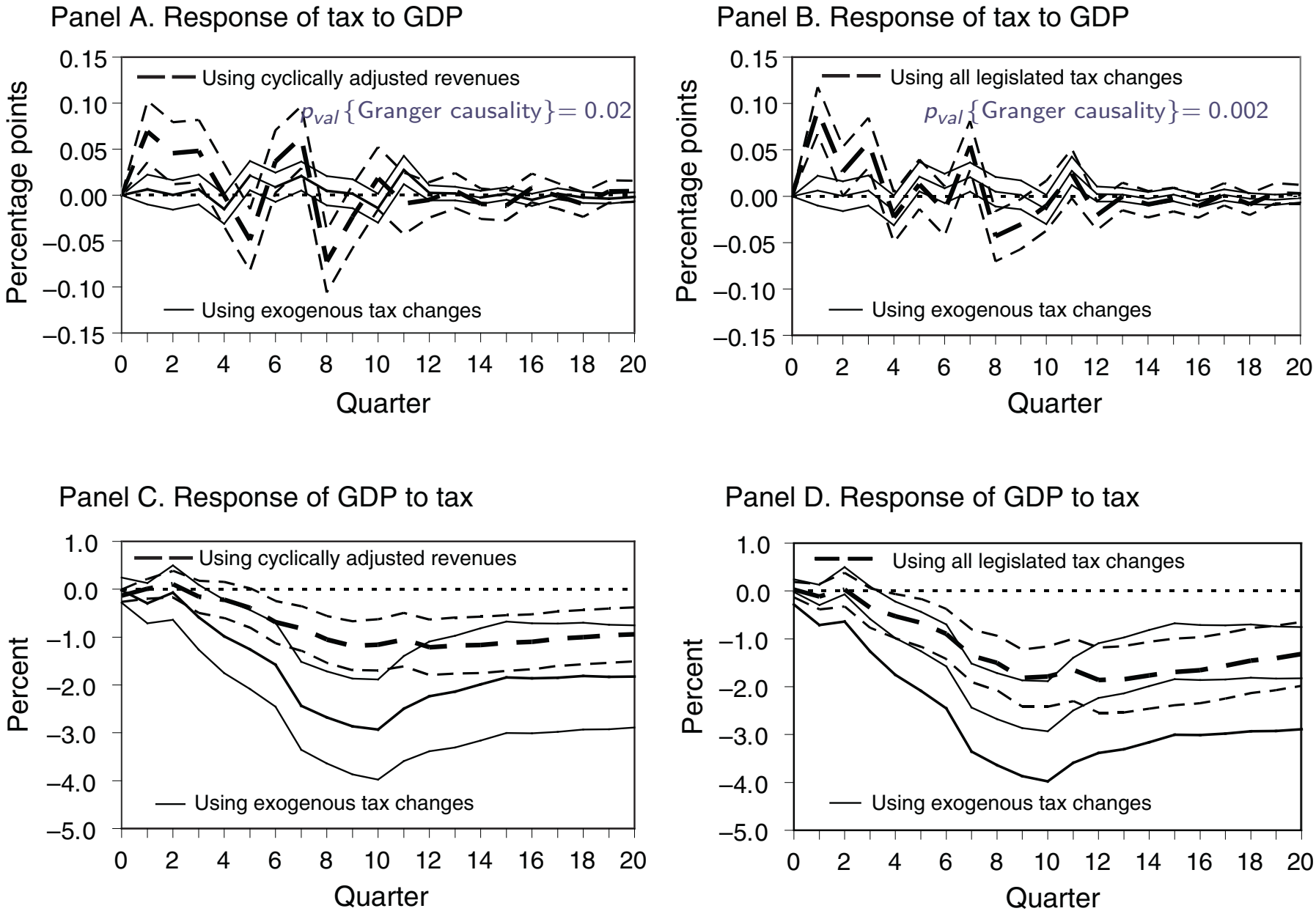


FIGURE 8. RESULTS OF TWO-VARIABLE VARS FOR BROADER MEASURES OF TAX CHANGES AND GDP

Table 1—Effect of Including Additional Variables in the VAR

Third variable in VAR (sample period)	Maximum contractionary impact on GDP of a tax increase of 1% of GDP (standard error)	Maximum impact in VAR without third variable (standard error)	*p*-value for exclusion of third variable in tax equation
Government spending (1950:I–2007:IV)	−2.75% (1.07)	−2.93% (1.05)	1.000
Relative price of oil (1950:I–2007:IV)	−2.54 (1.07)	−2.93 (1.05)	0.896
Romer and Romer dummy (1950:I–2007:IV)	−2.32 (0.96)	−2.93 (1.05)	0.792
Federal funds rate (1953:I–2007:IV)	−2.18 (0.80)	−2.76 (1.52)	0.023
Romer and Romer shock (1972:I–1996:IV)	−3.61 (0.90)	−2.72 (1.42)	0.004
Republican president dummy (1950:I–2007:IV)	−3.07 (1.00)	−2.93 (1.05)	0.008

Notes: All VARs include the new measure of exogenous tax changes and log real GDP. See text for the description and data source for the various third variables. The VARs include 12 lags.

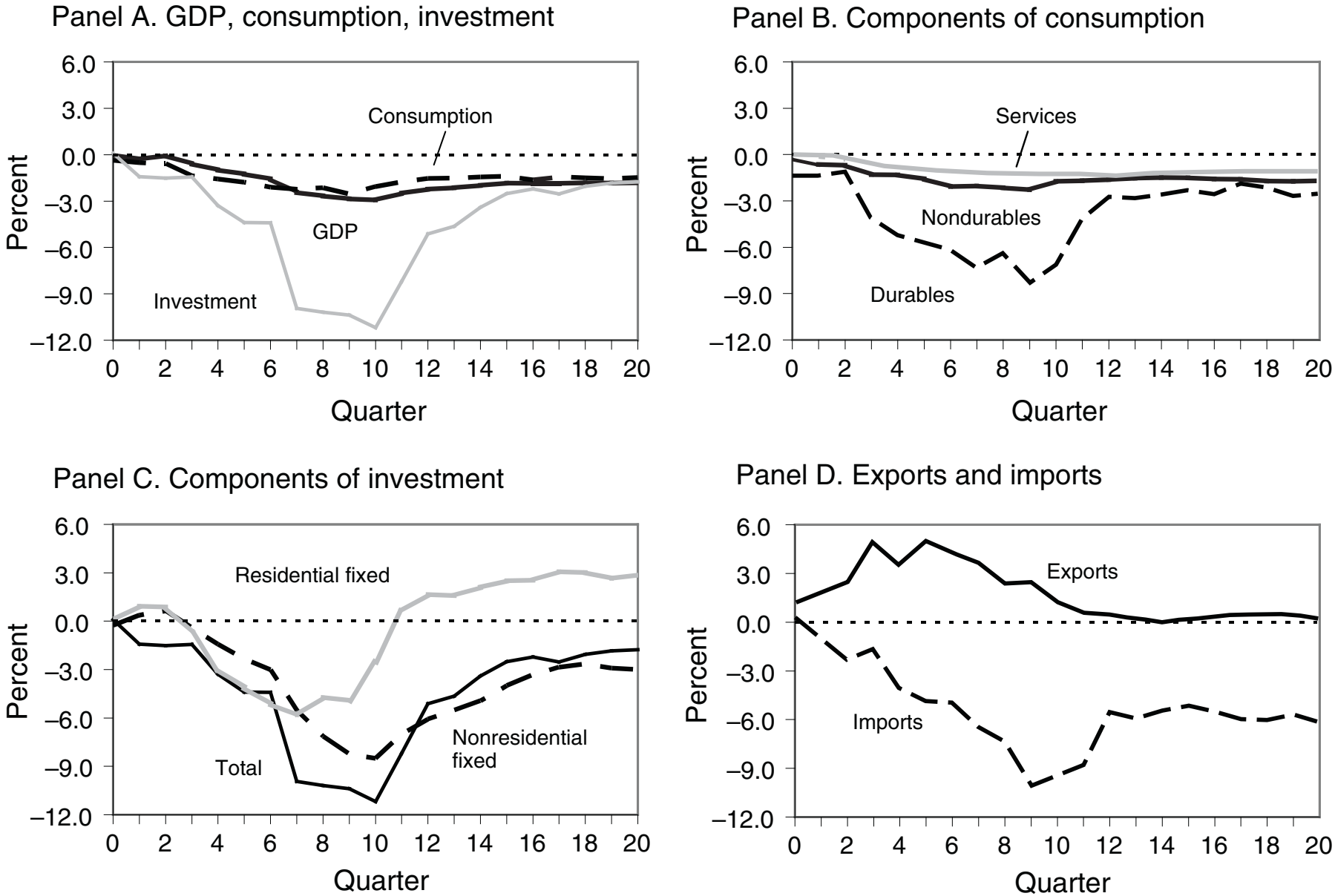


FIGURE 14. ESTIMATED IMPACT OF AN EXOGENOUS TAX INCREASE OF 1 PERCENT OF GDP ON THE COMPONENTS OF GDP
(*Three-variable VARs*)

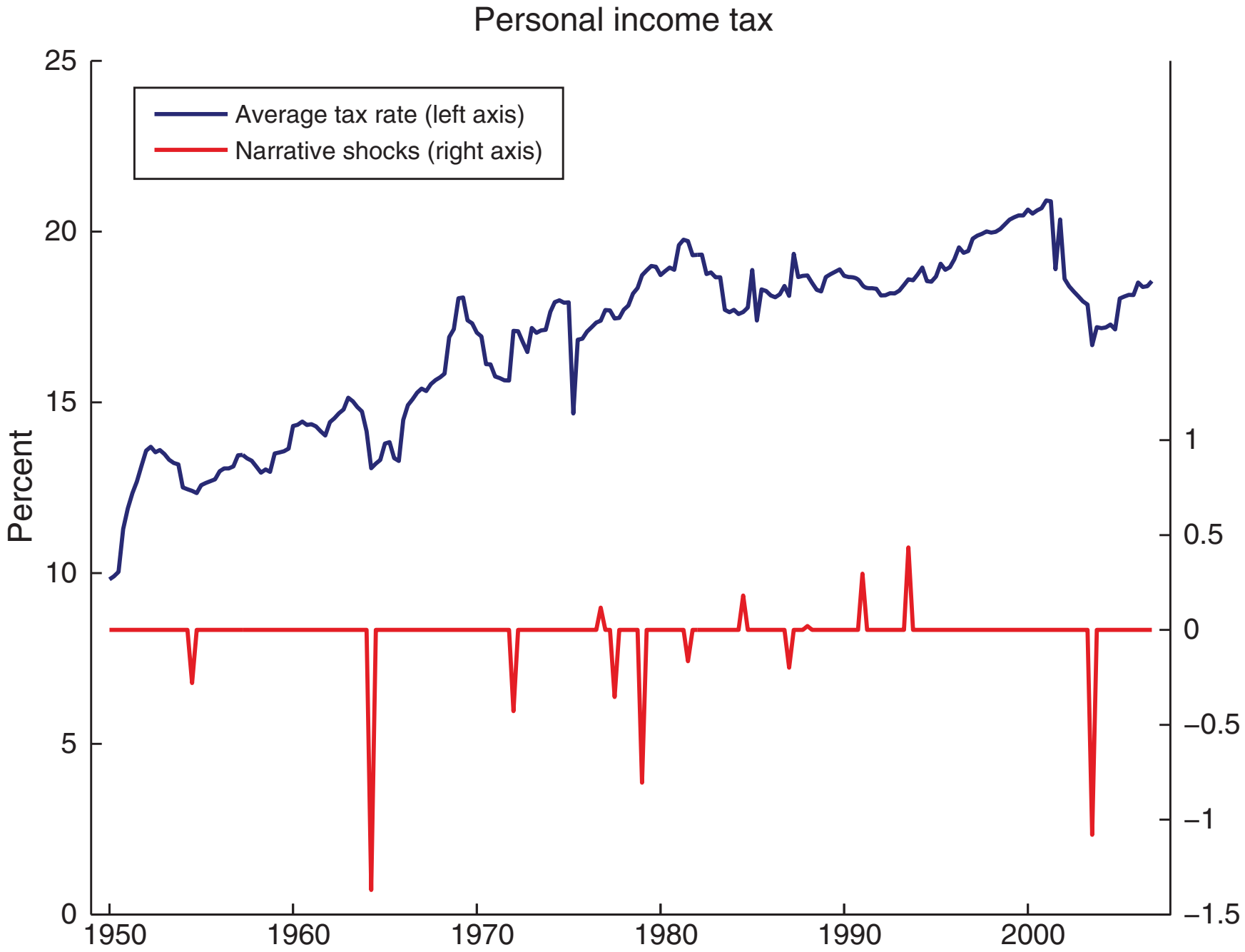
Discussion

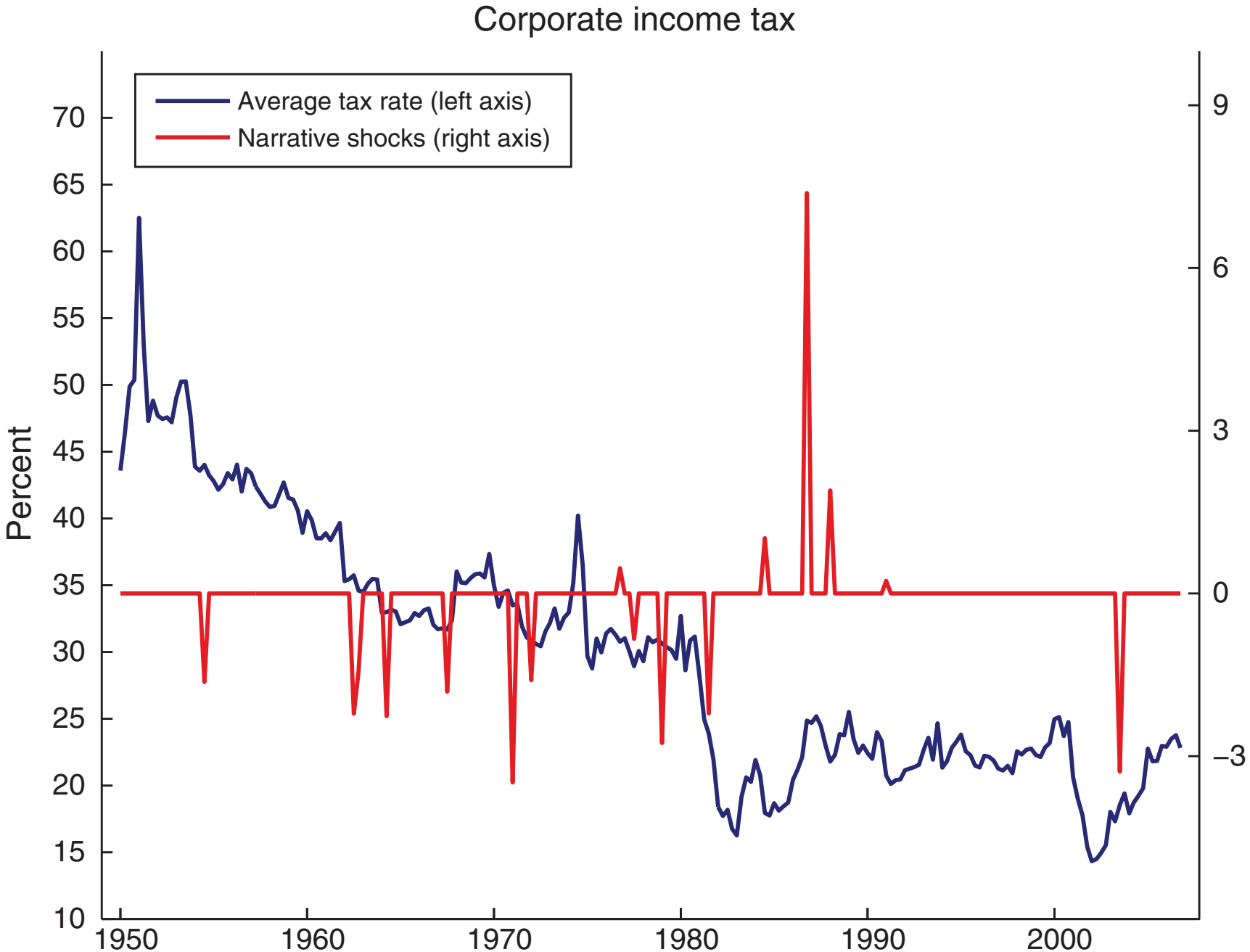
- Are 12 lags enough (Favero and Giavazzi AEJ Policy 2012).

- External validity (Perotti AEJ Policy 2012): Is the response to legislated tax changes taken for long-run or deficit reasons representative of the response to other tax changes?

Mertens and Ravn (AER, 2013) implementation

- Romer and Romer tax shocks as external instruments.
- Anticipation effects: only retain tax changes for which implementation lag is less than one quarter.
- Distinguish effects of personal income and corporate income tax changes.
- VAR in average personal income tax rate; average corporate income tax rate; log of personal income tax base; log of corporate income tax base; log of government spending; log of GDP; log of government debt.
- Narrative shocks to ACITR and APITR correlated. Arbitrary ordering.
- Subtlety with standard errors because only a few shocks. See: `https://www.dallasfed.org/-/media/documents/research/papers/2018/wp1805r1.pdf`.


Personal income tax
Average tax rate (left axis)
Narrative shocks (right axis)
Percent
25
20
15
10
5
0
1
0.5
0
−0.5
−1
−1.5
1950
1960
1970
1980
1990
2000


Corporate income tax
Average tax rate (left axis)
Narrative shocks (right axis)
Percent
70
65
60
55
50
45
40
35
30
25
20
15
10
9
6
3
0
−3
1950
1960
1970
1980
1990
2000

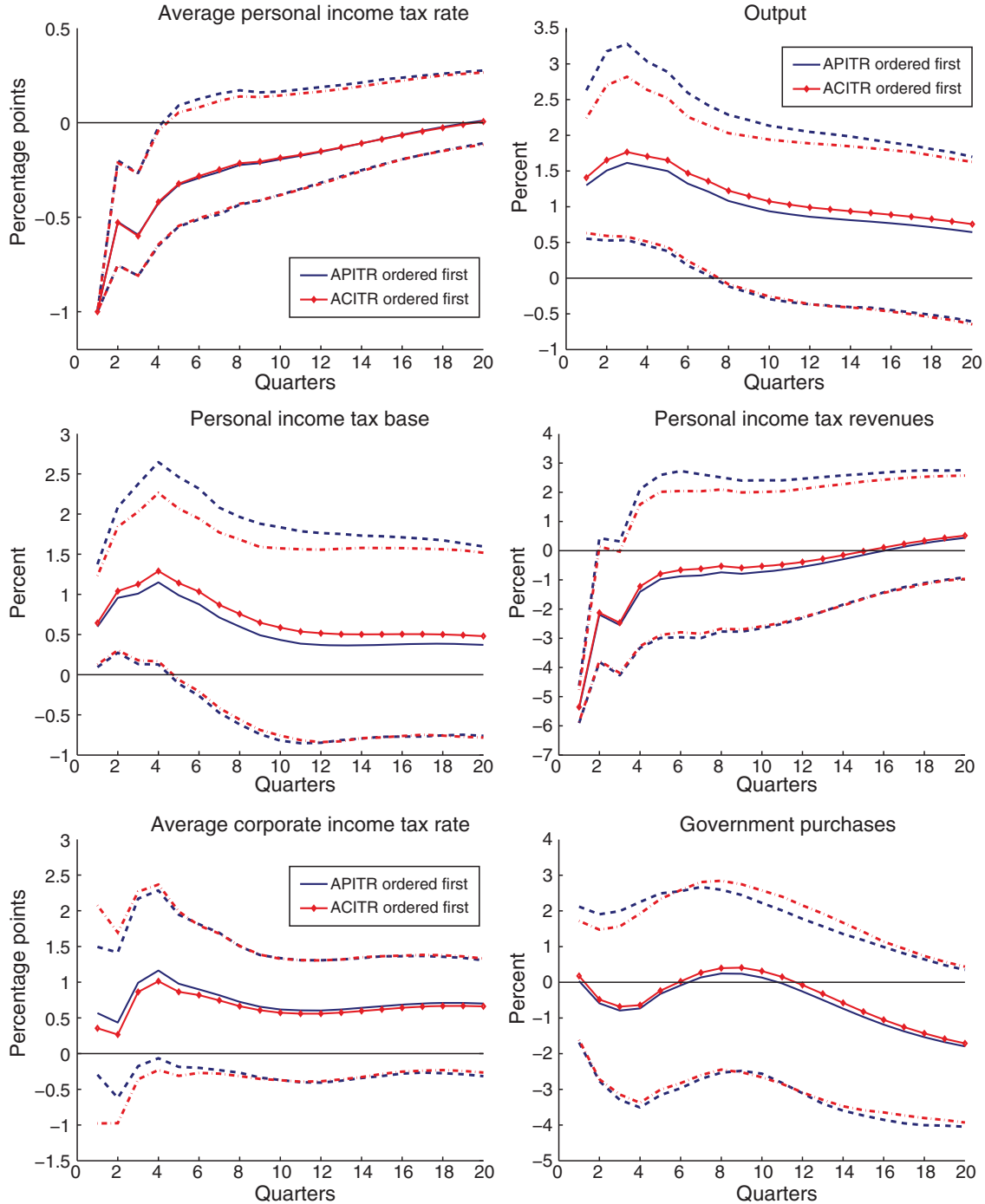


FIGURE 2. BENCHMARK SPECIFICATION: AN APITR CUT

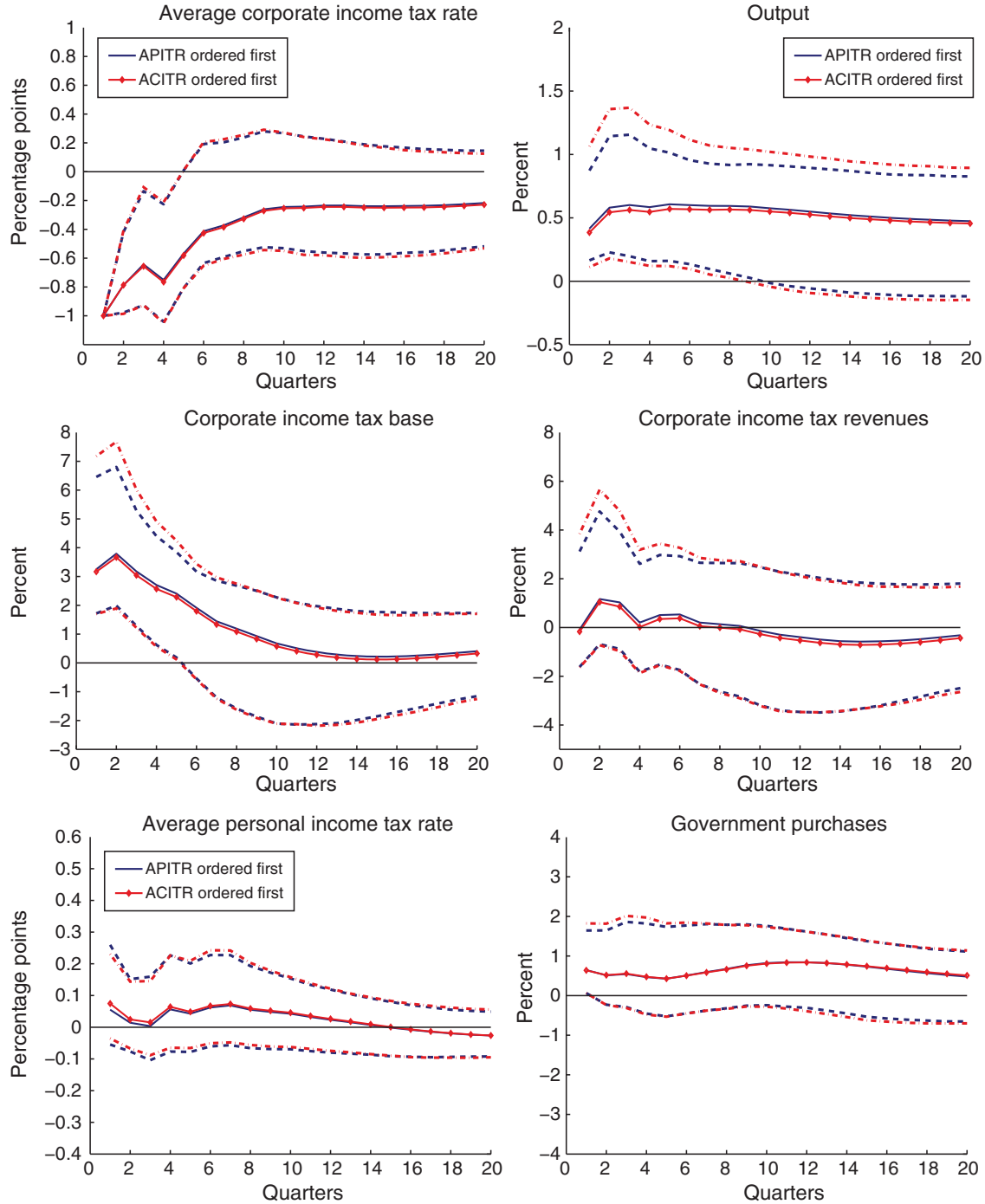


FIGURE 3. BENCHMARK SPECIFICATION: AN ACITR CUT

Outline

Overview

- Much narrative evidence of the form "most of the movement in the federal funds rate in month t due to monetary policy shock".
- Similar to external instruments in using information outside VAR, but does not require strict exclusion restriction.
- Works like sign restrictions to reduce space of admissible parameters.

Details

- VAR: $B(L)Y_t = e_t, e_t = Rv_t, Var(v_t) = \Sigma, R = A_0^{-1}$.
- Let θ denote parameters $\{R, \Sigma, B(L)\}$ and consider draw θ_j.
- Structural shocks $v_t(\theta_j)$ and IRFs $\Psi_h(\theta_j)$ unique given parameters θ_j.
- For historical episode in period τ, compare $v_\tau(\theta_j), \Psi_h(\theta_j)v_\tau(\theta_j), FEVD_{h,\tau}(\theta_j)$ to narrative evidence and discard θ_j if disagreement.
- Previous bullet is brute force approach. See paper for Bayesian implementation.

Example: oil markets

- Trivariate monthly VAR in growth rate of world crude oil production q_t, real economic activity y_t, and real oil price p_t.

- Sign restrictions:

Variable/Shock	Oil supply	Agg. demand	Oil-specific demand
Oil production	-	+	+
Economic activity	-	+	-
Oil price	+	+	+

- So far similar to Kilian (2009), Kilian and Murphy (2012).

Oil markets: narrative evidence

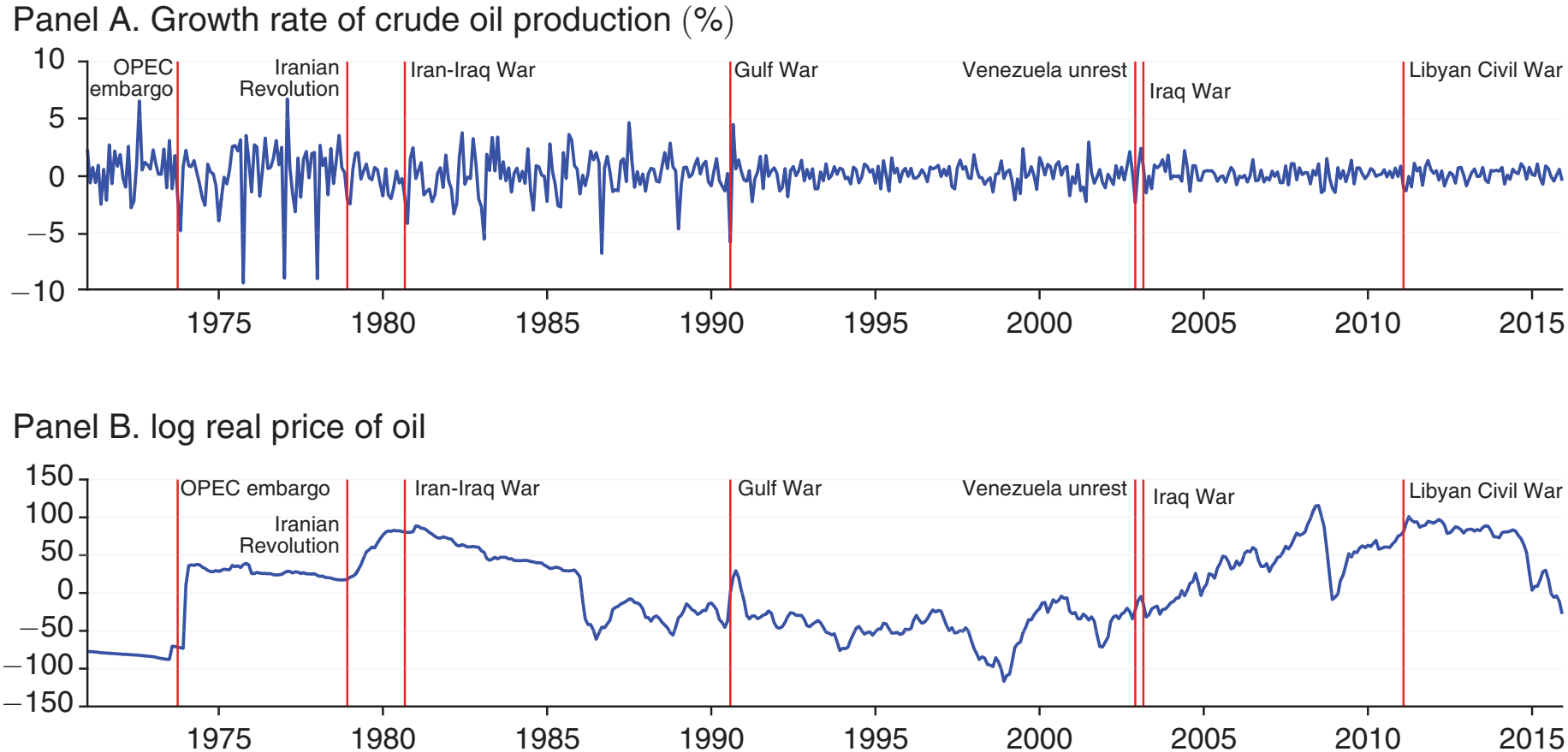


Figure 1. Chronology of Oil Supply Shocks

Notes: The vertical bars indicate major exogenous oil supply disruptions, associated with the Yom Kippur War and subsequent Arab oil embargo (October 1973), Iranian Revolution (December 1978–January 1979), the Iran-Iraq War (September–October 1980), the Persian Gulf War (August 1990), the Venezuela oil strike of December 2002, the start of the Iraq War (March 2003), and the Libyan Civil War (February 2011).

Narrative Restrictions

1. "The oil supply shock must take negative values in December 1978-January 1979, September-October 1980, August 1990, December 2002, March 2003 and February 2011."
2. "For the periods specified by Restriction 1, oil supply shocks are the most important contributor to the observed unexpected movements in oil production growth. In other words, the absolute value of the contribution of oil supply shocks is larger than the absolute value of the contribution of any other structural shock."
3. "For the periods corresponding to September-October 1980 (outbreak of the Iran-Iraq War) and August 1990 (outbreak of the Persian Gulf War), aggregate demand shocks are the least important contributor to the observed unexpected movements in the real price of oil. In other words, the absolute value of the contribution of aggregate demand shocks is smaller than the absolute contribution of any other structural shock."

Oil markets: narrative evidence

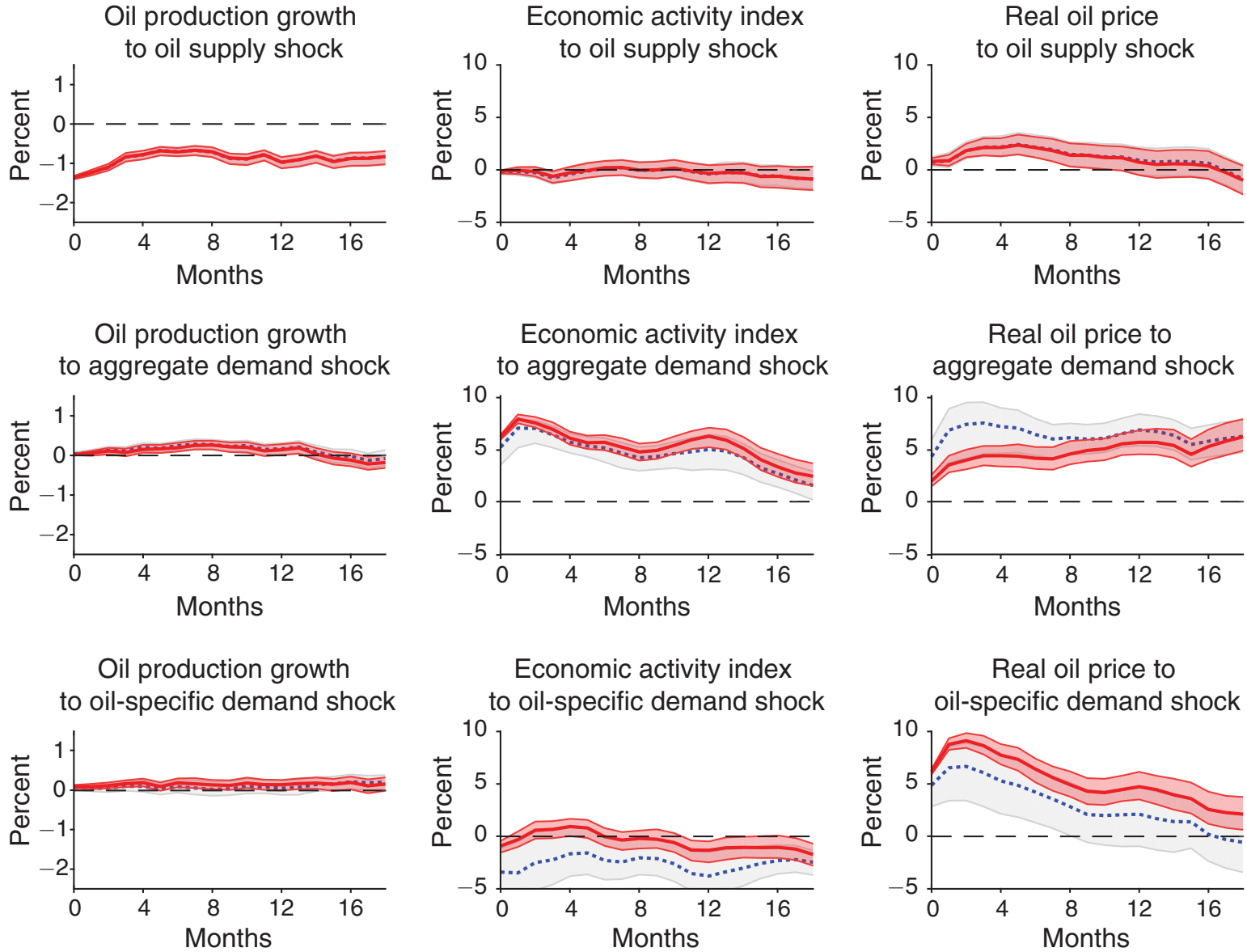


Figure 2. IRFs with and without Narrative Sign Restrictions

Notes: The light shaded area represents the 68 percent (point-wise) HPD credible sets for the IRFs and the dotted

Oil markets: specific episodes

Table 2—Probability of Violating the Narrative Sign Restrictions

	Restriction 1 %	Restriction 2 %	Restriction 3 %	Any restriction %
Iranian Revolution	20	2.9	–	21
Iran-Iraq War	0	0	46	46
Gulf War	0	0	93	93
Venezuela unrest	0	0	–	0
Iraq War	43	21	–	53
Libyan Civil War	4.6	1	–	5
Any Episodes	42	24	93	98

Miscellaneous research advice

1. Talk to each other.

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2. Stay organized.
   - Topic folders, subfolders within topic folder, programming files, etc.
   - Track your steps so at the end with "one click" you can go from raw data to published tables and figures (ideally).

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4. Don't run a regression if you can't describe the data generating process (DGP) under which the regression is valid and informative.

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4. Don't run a regression if you can't describe the data generating process (DGP) under which the regression is valid and informative.
5. Write cleanly. May want to read: `https://faculty.chicagobooth.edu/john.cochrane/research/papers/phd_paper_writing.pdf`.

Miscellaneous research advice

1. Talk to each other.
2. Stay organized.
   - Topic folders, subfolders within topic folder, programming files, etc.
   - Track your steps so at the end with "one click" you can go from raw data to published tables and figures (ideally).
3. First commandment of applied research: know thy data.
   - How collected? Precise variable definitions? Read documentation.
4. Don't run a regression if you can't describe the data generating process (DGP) under which the regression is valid and informative.
5. Write cleanly. May want to read: `https://faculty.chicagobooth.edu/john.cochrane/research/papers/phd_paper_writing.pdf`.
6. Be purposeful in topic selection, in specification, and in writing.
   - Don't do X just because ABC did X, unless point is contrast with ABC.

Miscellaneous presentation advice

1. Keep slides clean.
   - Ideally one line per bullet.
   - Text, figures, and tables legible from the back of the room.
   - Model yourself on other presentation slides, not teaching slides.
2. Adapt presentation to presentation slot:
   - Rule of thumb: two minutes per slide.
   - Explain everything or tell us what we can gloss over.
   - Lunch presentation different format and objective from job talk.
3. Practice: I have seen senior professors give a paper multiple times using *exactly* the same "script".