Bonn Summer School
Advances in Empirical Macroeconomics

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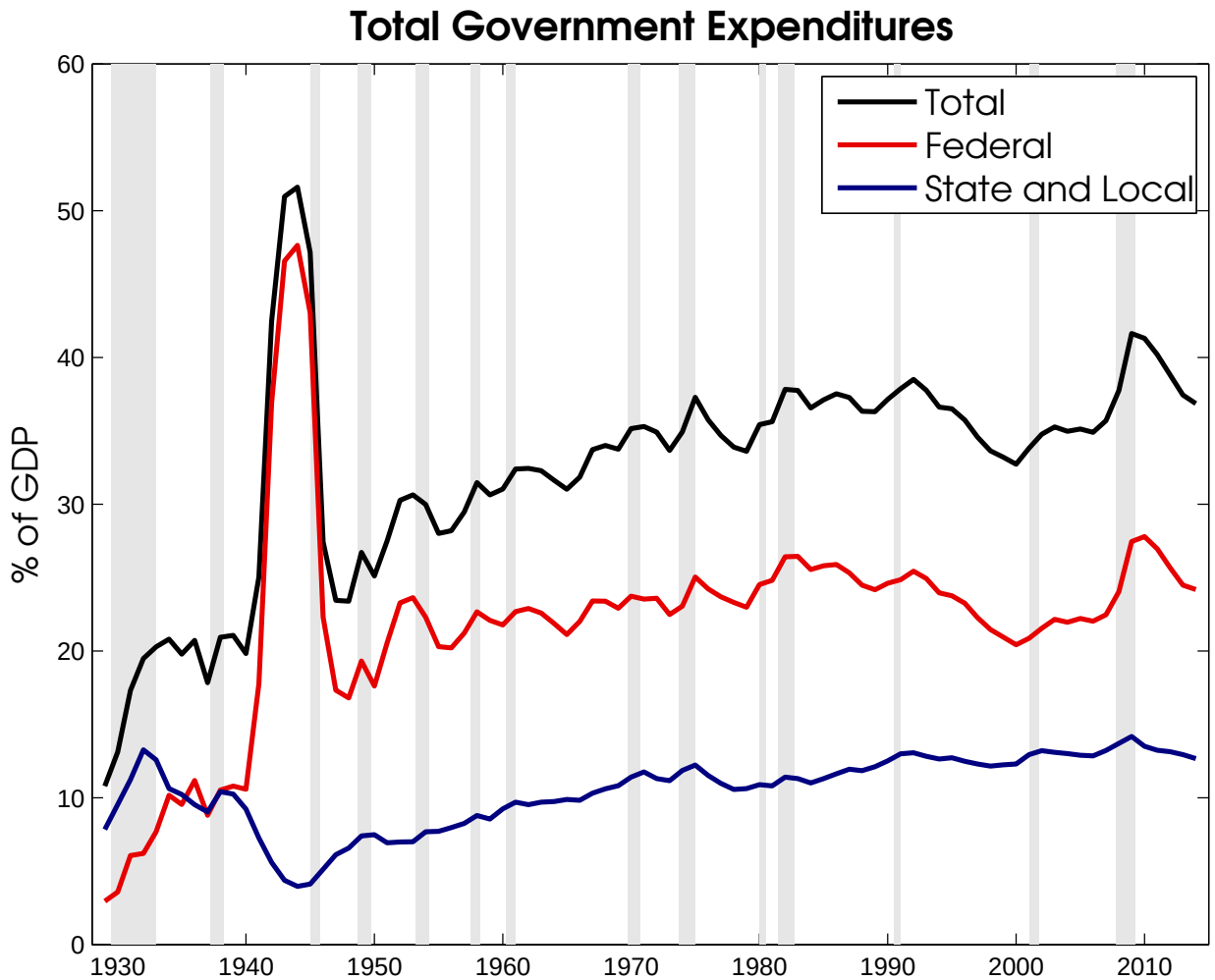
Overview

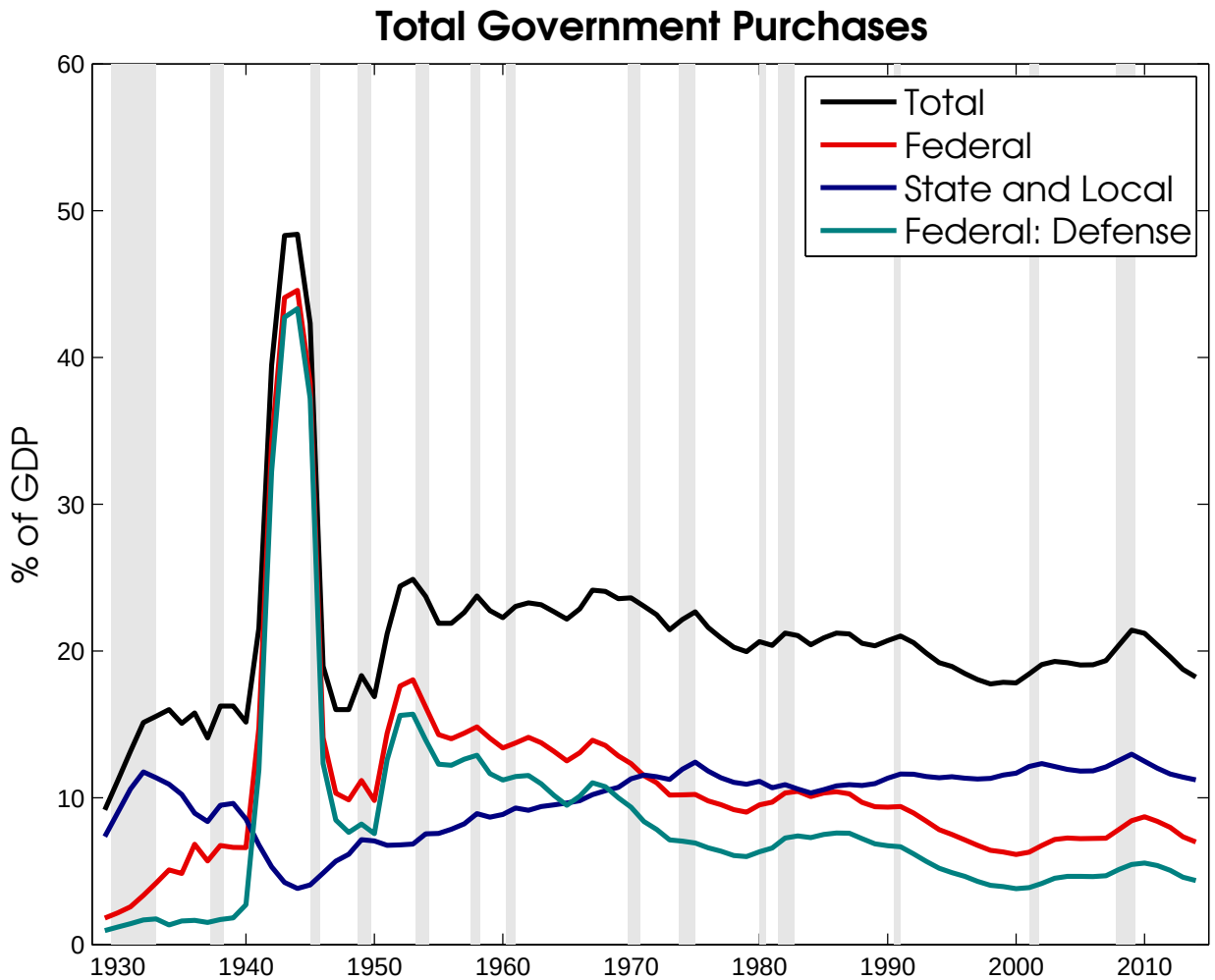
1. Estimating the Effects of Shocks Without Much Theory
   - 1.1 Structural Time Series Models
   - 1.2 Identification Strategies
2. **Applications to Fiscal Shocks**
   - 2.1 **Tax Policy Shocks**
   - 2.2 **Government Spending Shocks**
   - 2.3 **Austerity Measures**
3. Two Difficulties in Interpreting SVARs
   - 3.1 Noninvertibility
   - 3.2 Time Aggregation
4. Systematic Tax Policy and the ZLB

Some Basic Facts about US Fiscal Policy

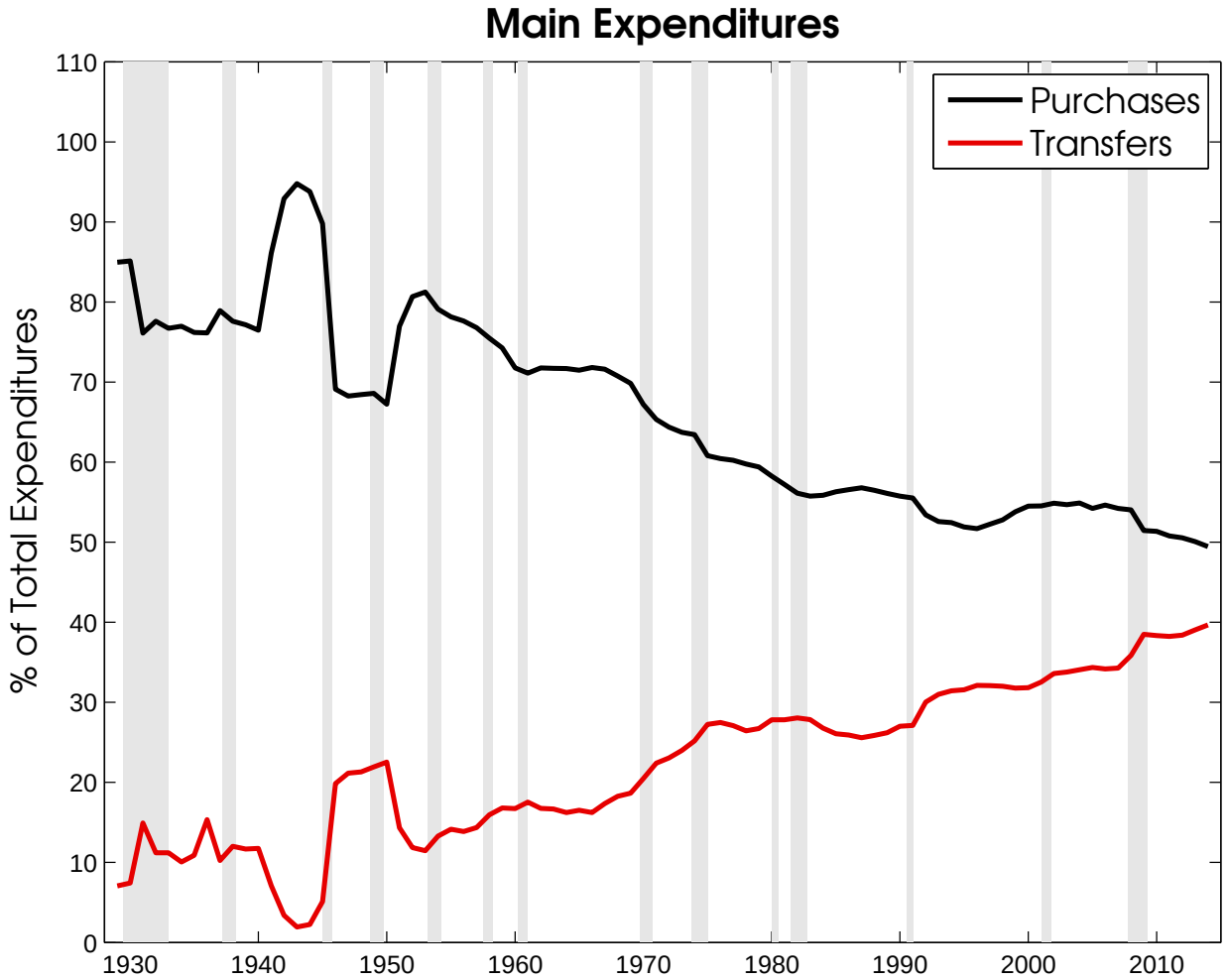
Government Outlays

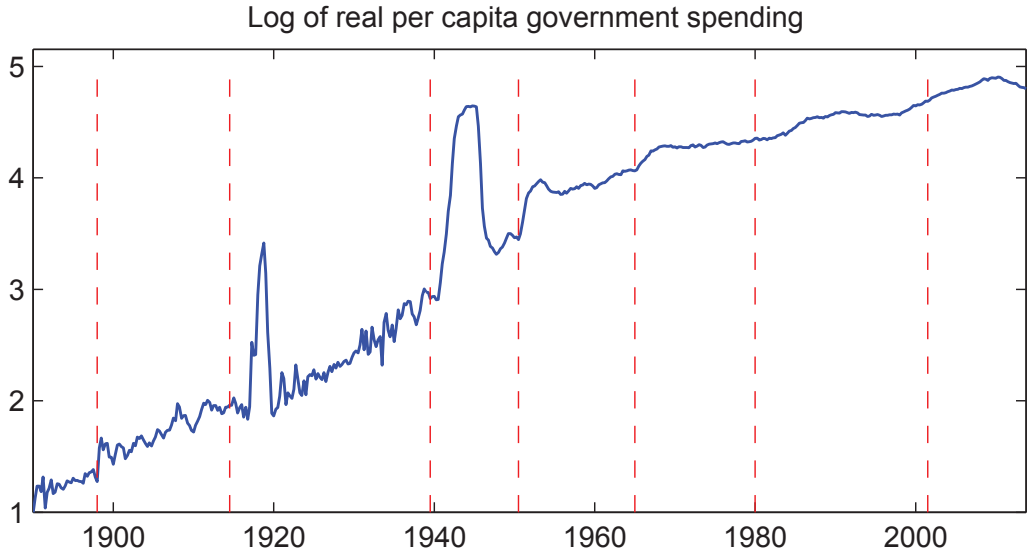


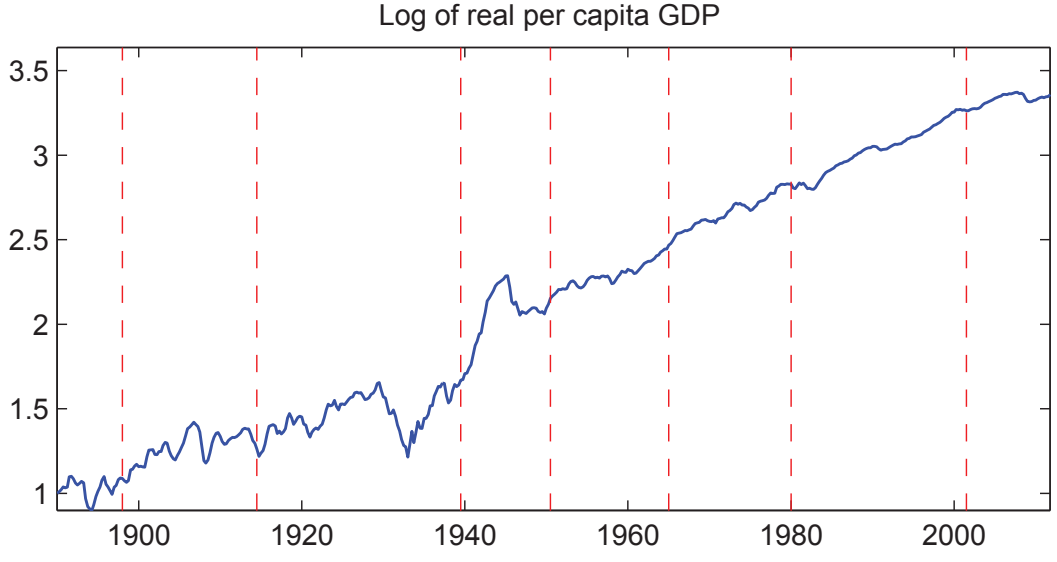
Government Purchases



Composition of Total Expenditures







Graph from Ramey and Zubairy (2014)

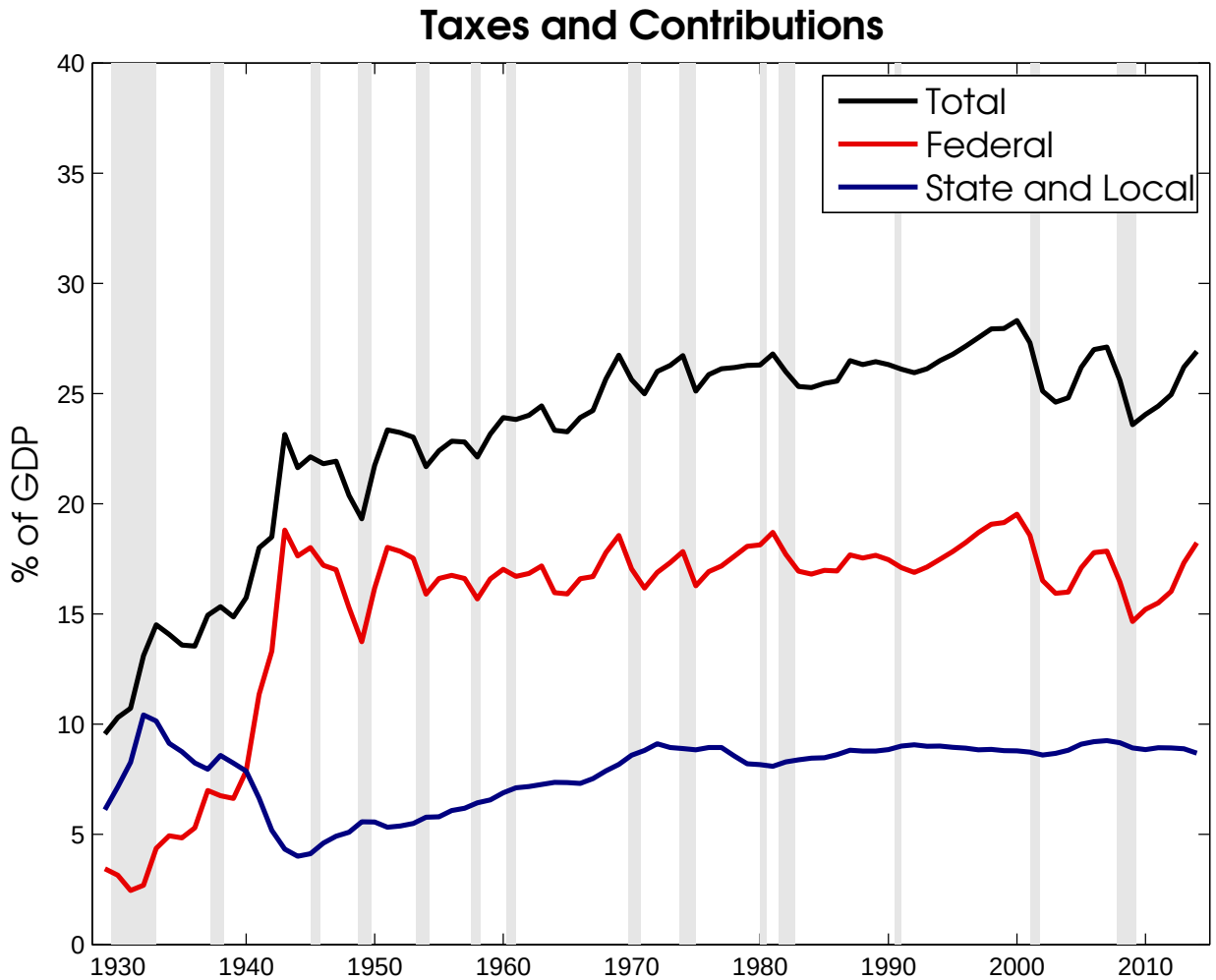
Identifying variation for the US is predominantly military spending during wars.

Difficult to learn about 'stimulus' spending

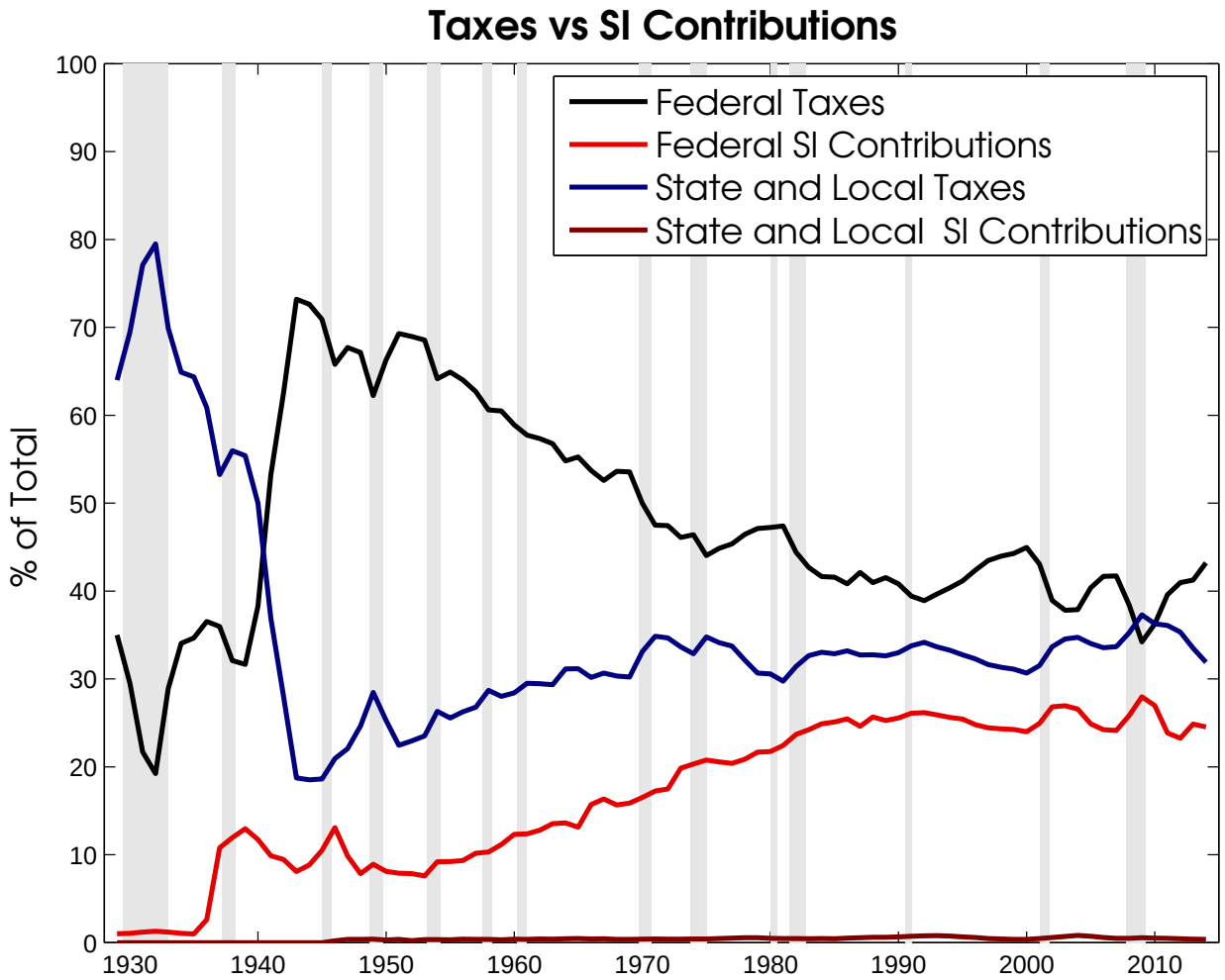
In the US, stimulus is about tax and transfers.
e.g. ARRA 2009: $43 billion out of $800 billion in purchases between 2009 and 2013.

Still interesting, e.g. to guide our models.

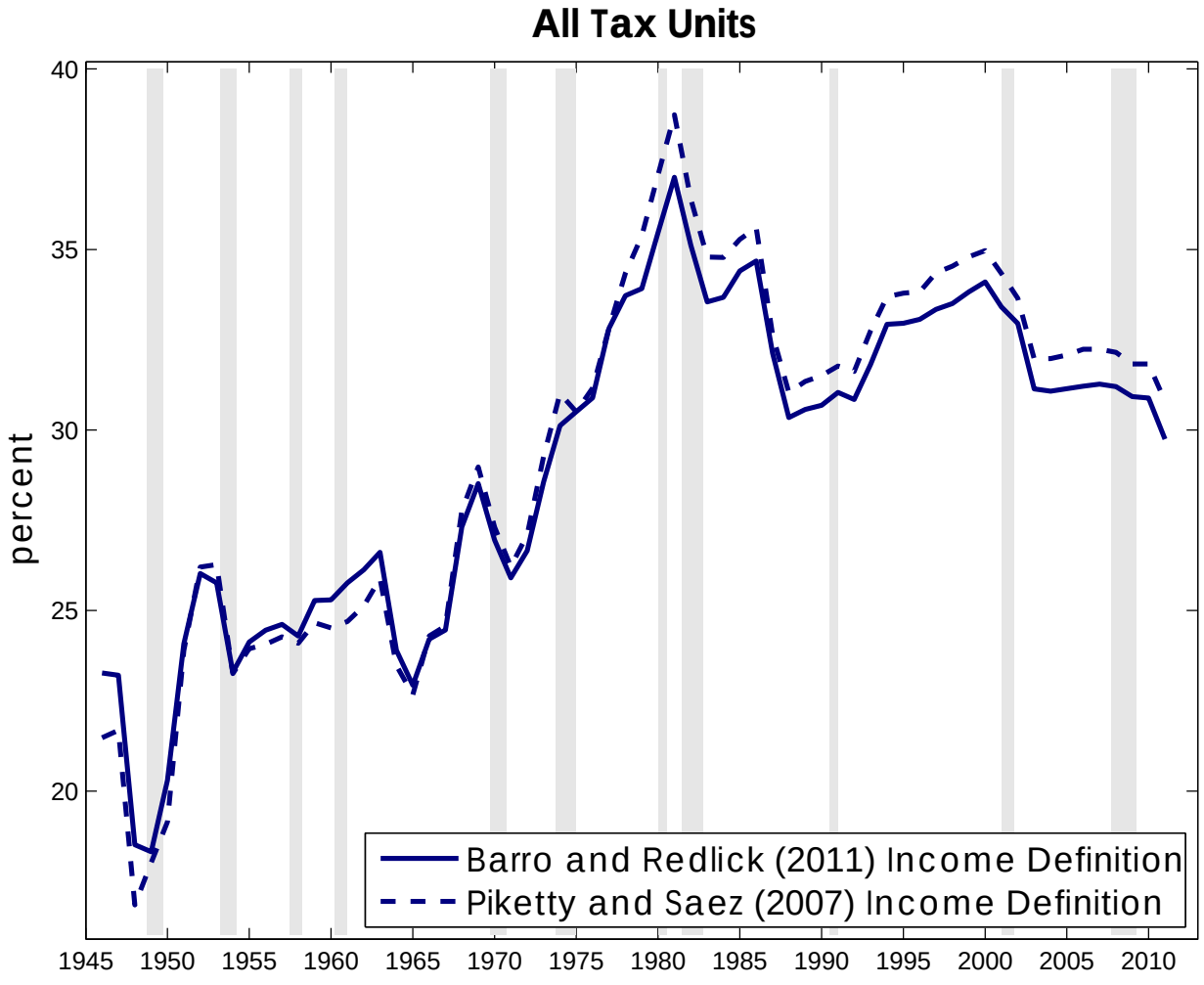
Receipts from Taxes and Contributions



Composition of Taxes and Contributions

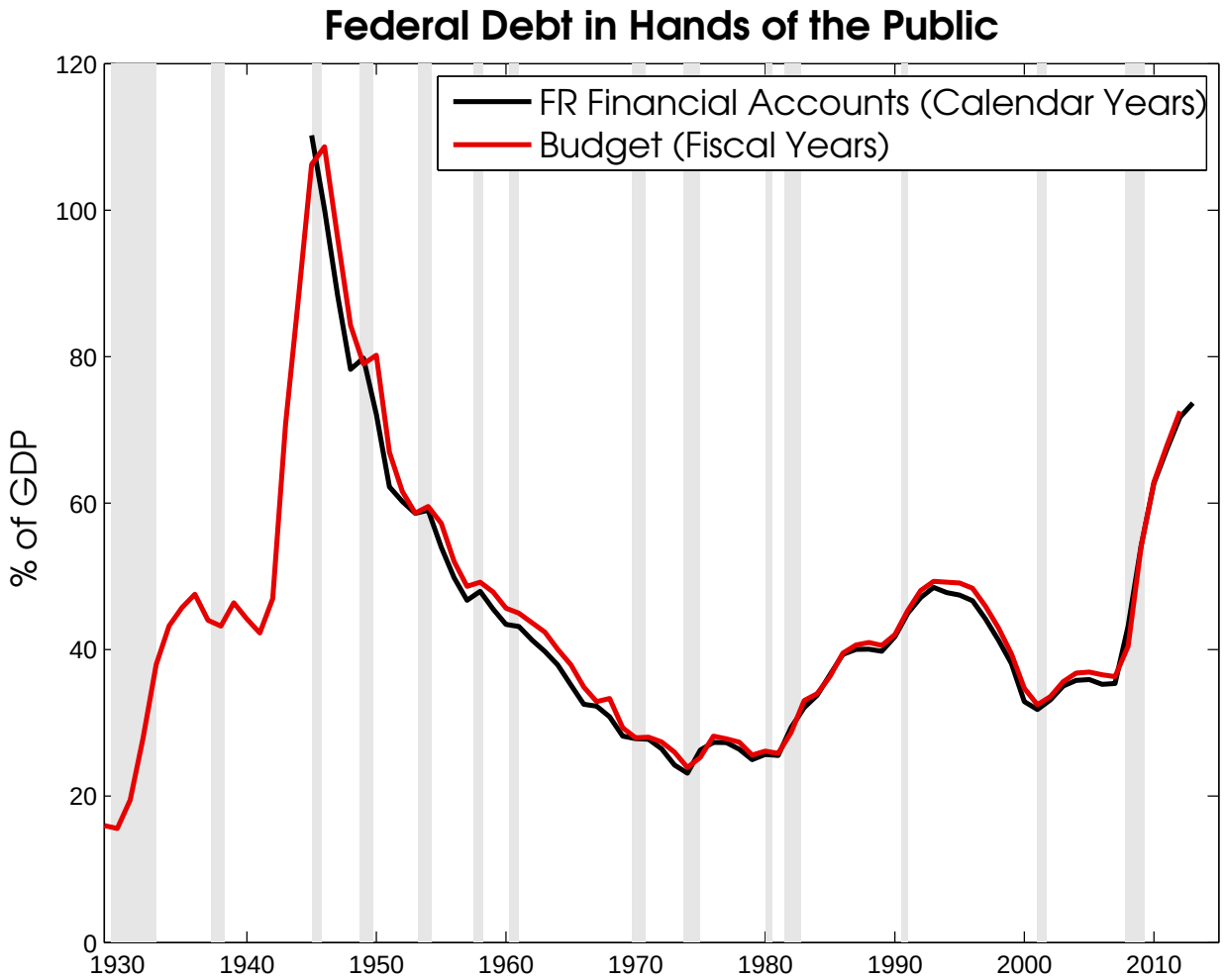


Marginal Tax Rates



Average Marginal Tax Rates 1946-2012: Federal Individual Income Tax and Social Security Contributions

Government Debt



2.1 Tax Policy Shocks

A Reconciliation of Recent Evidence on Tax Policy Shocks

Personal versus Corporate Tax Shocks

Marginal Tax Rate Shocks

A Reconciliation of Recent Evidence on Tax Policy Shocks

Based on Mertens and Ravn, 2014, A Reconciliation of SVAR and Narrative Estimates of Tax Multipliers, Journal of Monetary Economics

Matlab codes and data available on my webpage.

See also Ramey, 2015, Macroeconomic Shocks and Their Propagation, Handbook of Macroeconomics, for additional analysis (LP-IV approach)

What happens to output following a tax cut?

Recent estimates of "peak multipliers" for the US in reduced form models using aggregate data:

Study	Identification	Innovation to	Peak	Period
Blanchard and Perotti (QJE 2002)	SVAR, Coefficients	Total Revenues/GDP	**0.78**	6-th quarter
Mountford and Uhlig (JAE 2009)	SVAR, Sign	Total Revenues/GDP	**3.41**	12-th quarter
Romer and Romer (AER 2010)	Narrative	Total Liabilities/GDP	**3.08**	10-th quarter
Mertens and Ravn (AEJ/EP 2012a)	VARX, Narrative	Total Liabilities/GDP	**2.00**	10-th quarter
Favero and Giavazzi (AEJ/EP 2012)	VARX, Narrative	Total Liabilities/GDP	**1.00**	10-th quarter

Outline:

1. Replicate existing studies for the same sample.
2. Estimate tax multipliers using SVAR with narrative data as a proxy.
3. Reconcile results based on proxy SVAR results.

Debate on Tax Multiplier, see also:

Charhour, Schmitt-Grohé and Uribe (2012), Perotti (2012), Caldara and Kamps (2012).

Blanchard Perotti Structural Vector Autoregression

Observables $z_t = [T_t, G_t, Y_t]'$, sample 1950Q1-2006Q4

T_t : Log Real Federal Tax Revenues per capita
G_t : Log Real Federal Government Spending on Final Goods per capita
Y_t : Log Real GDP per capita

VAR representation:

$$z_t \quad = \quad \alpha' d_t + \delta' \mathbf{Z_{t-1}} + \mathcal{D} e_t,$$

where $\mathbf{Z_{t-1}} = [z'_{t-1}\ , ...,\ z'_{t-p}]'$, d_t are deterministic terms.

$e_t = [e_t^T, e_t^G, e_t^Y]'$ is a vector of **structural shocks** with $E[e_t] = 0$, $E[e_t e_t'] = I$, $E[e_t e_s'] = 0$ for $s \neq t$.

Reduced form residuals υ_t:

$$\upsilon_t \quad = \quad \mathcal{D} e_t$$

Blanchard Perotti Structural Vector Autoregression

Estimate of $E[\upsilon_t \upsilon_t'] = \mathcal{D}\mathcal{D}'$ provides six independent restrictions, need three more.

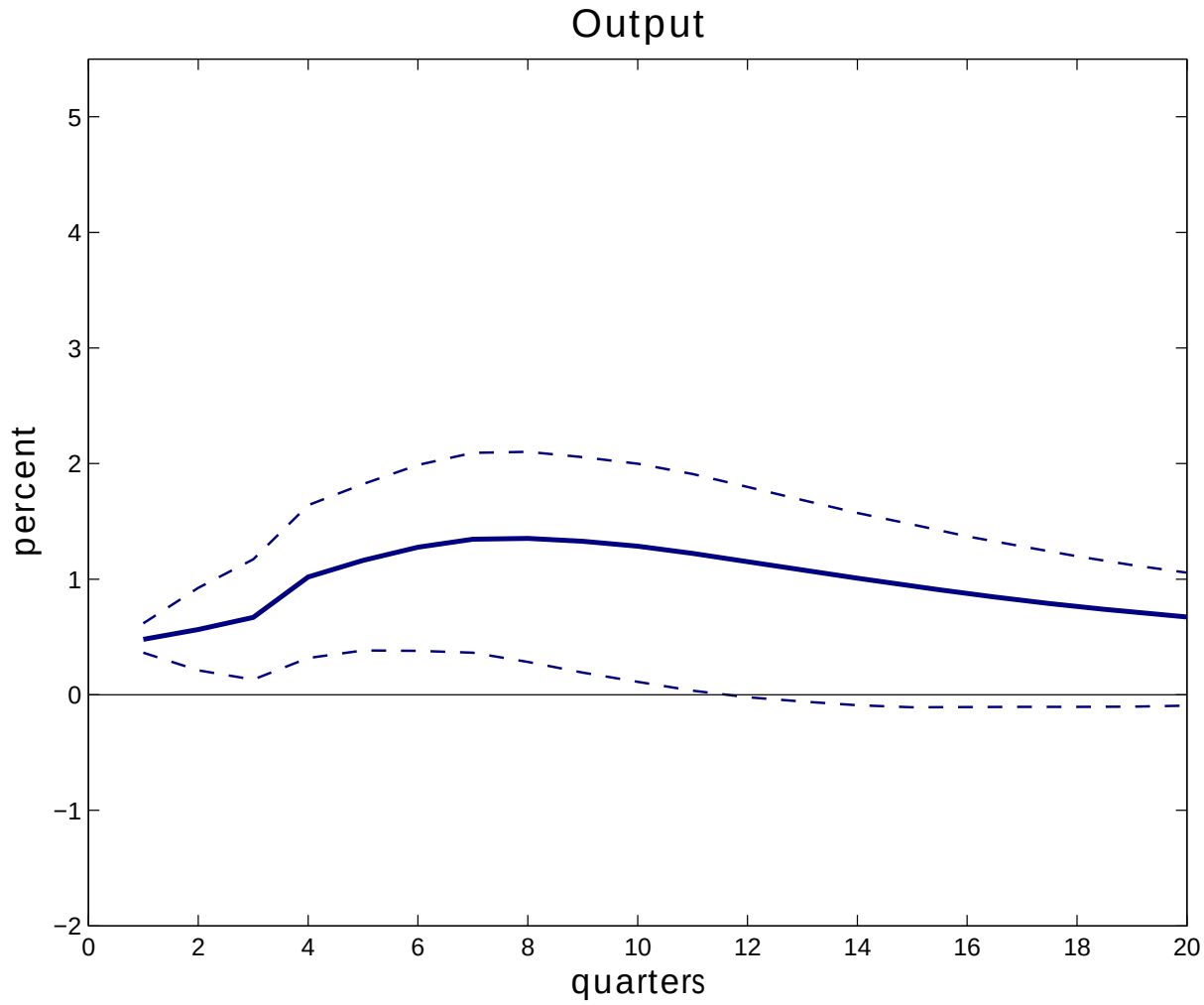
Blanchard and Perotti consider

$$\begin{aligned} \upsilon_t^T &= \theta_G \sigma_G e_t^G + \theta_Y \upsilon_t^Y + \sigma_T e_t^T \ , \\ \upsilon_t^G &= \gamma_T \sigma_T e_t^T + \gamma_Y \upsilon_t^Y + \sigma_G e_t^G \ , \\ \upsilon_t^Y &= \zeta_T \upsilon_t^T + \zeta_G \upsilon_t^G + \sigma_Y e_t^Y \ . \end{aligned}$$

and impose

- $\gamma_Y = \gamma_T = 0$ based on decision and recognition lags
- $\theta_Y = 2.08$ based on OECD estimates.

Blanchard Perotti (QJE 2002) SVAR:
1 % of GDP Cut in Tax Revenues
(95% Intervals, Recursive Wild Bootstrap)



Romer and Romer's Narrative Approach

Suppose we can measure tax shocks directly by τ_t and consider

$$\Delta Y_t = \alpha' d_t + \lambda_0 \tau_t + \lambda_1 \tau_{t-1} + ... + \lambda_k \tau_{t-k} + w_t$$

If τ_t

1. is exogenous, i.e. uncorrelated with current and lagged shocks (Assumptions A2 and A3 before)
2. contains 'perfect' observations of (a subset of) e_t^T up to scale (Assumption A1 before)

then OLS estimates of the λ's are the impulse response coefficients.

Romer and Romer (2010) classify US postwar tax reforms according to:

1. **size** as measured by the implied tax liability change
2. **motivation**:
   - Endogenous; Countercyclical: "A tax action designed to return output growth to normal"
   - Endogenous; Spending: "Tax change motivated by a change in government spending" both correlated with current economic conditions
   - Exogenous; Long-Run: "A tax change motivated by fairness, efficiency, incentives, belief in smaller government"
   - Exogenous; Deficit: "A tax change designed to reduce an inherited budget deficit"
3. The **dates** at which:
   - the tax act was signed by the President
   - the tax change was implemented

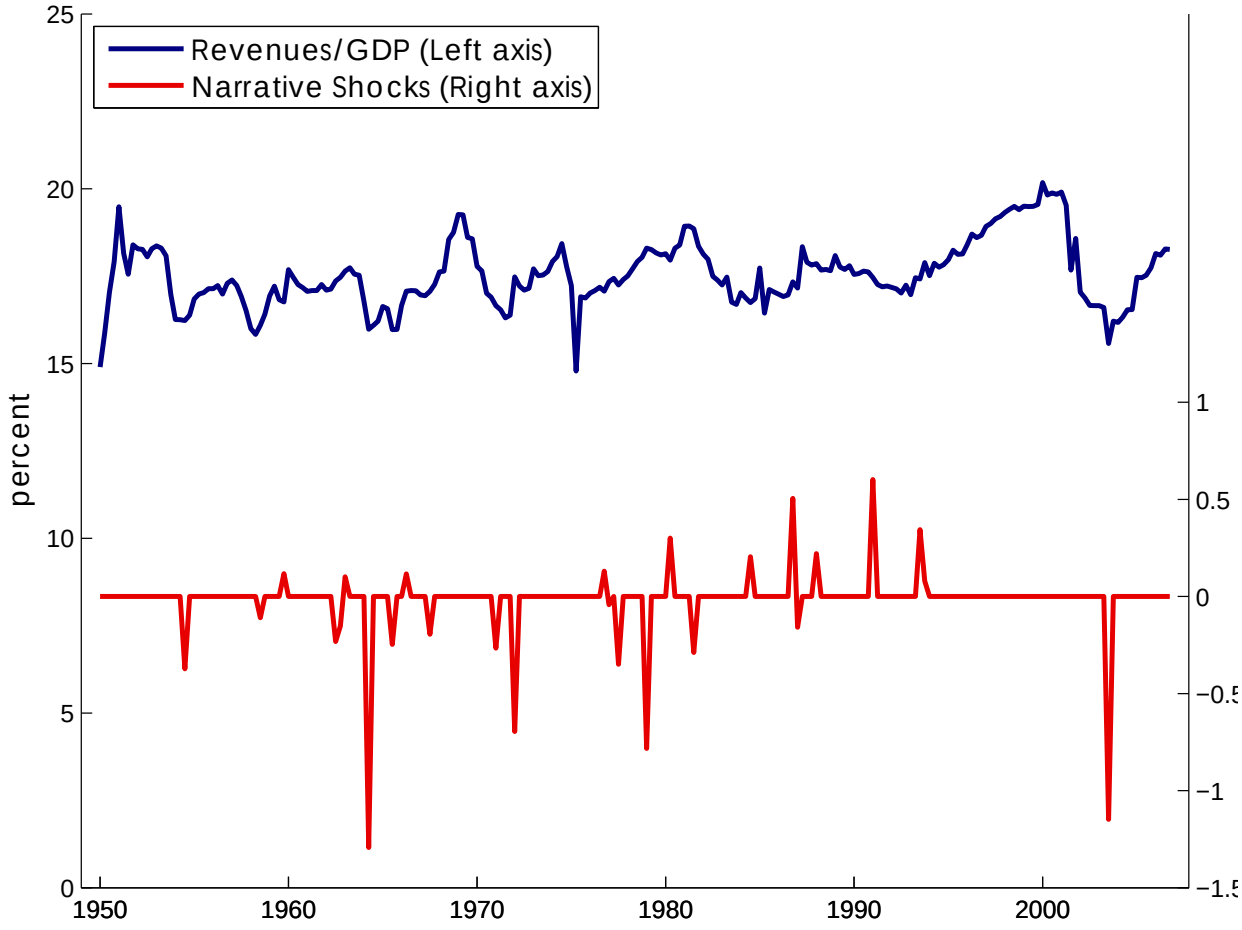
Romer and Romer's Narrative Approach

Obtaining τ_t

1. Romer and Romer (2010) record 50 legislative actions for 1947-2007 concerning federal tax code.
2. Projected liability changes at implementation dates (73 obs)

   Economic Report, Budget, Treasury Reports, Congressional Record, CBO, ...

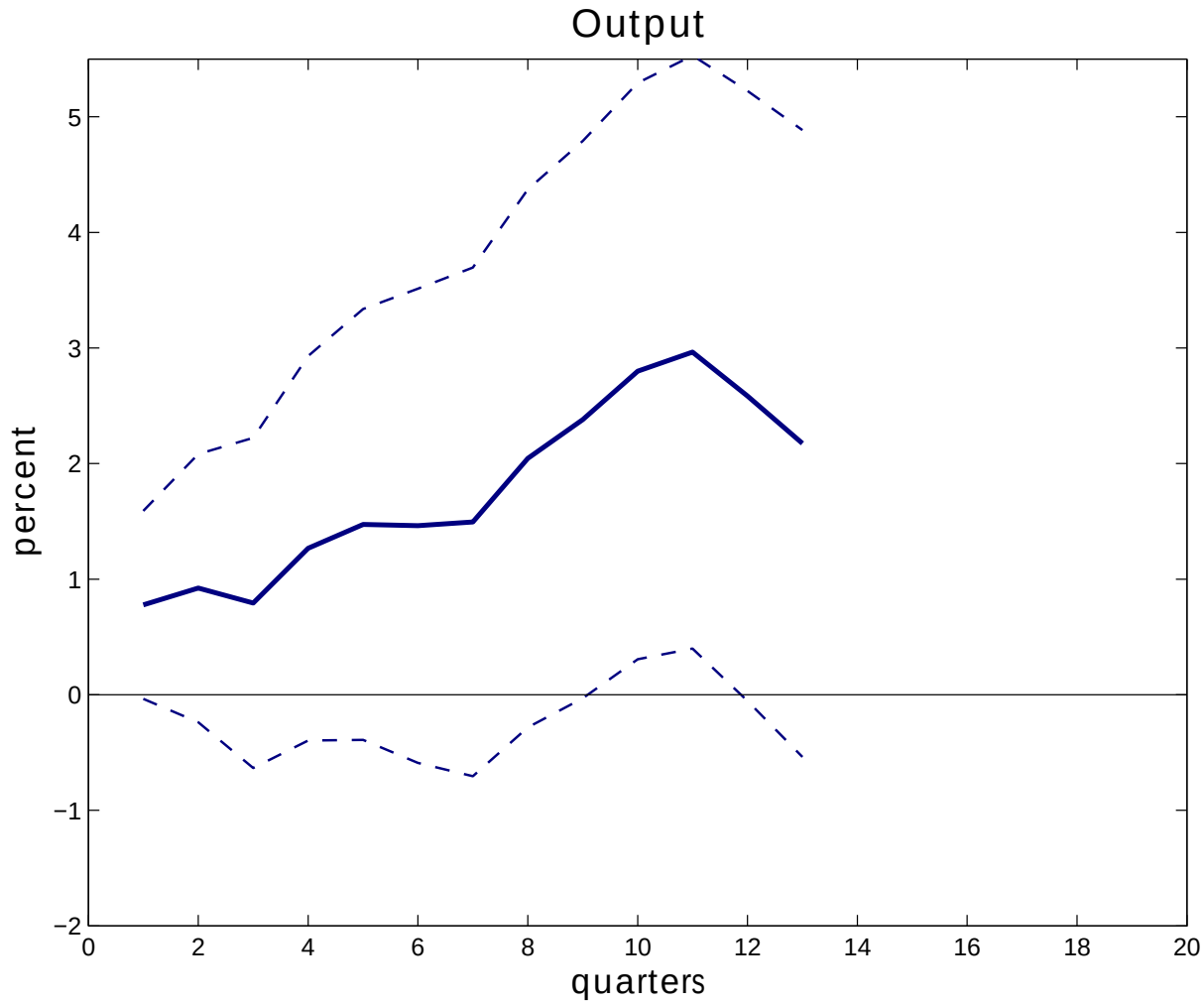
3. Retain 'exogenous' shocks (A2), cfr. Romer and Romer (2009), (48 obs)
4. Retain 'unanticipated' shocks (A1), cfr. Mertens and Ravn (2011,2012), (26 obs)
5. Divide tax liability changes by (lagged) GDP.


Revenues/GDP (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

Romer and Romer (AER 2010) :

Unit Innovation to τ_t

(± 2 Asymptotic SE bands)



Other Narrative Specifications (VARX)

Favero and Giavazzi (2012):

$$z_t = \alpha' d_t + \delta' \mathbf{Z}_{t-1} + \lambda_0 \tau_t + \upsilon_t$$

Mertens and Ravn (2012):

$$z_t = \alpha' d_t + \delta' \mathbf{Z}_{t-1} + \lambda_0 \tau_t + \lambda_1 \tau_{t-1} + ... + \lambda_k \tau_{t-k} + \upsilon_t$$

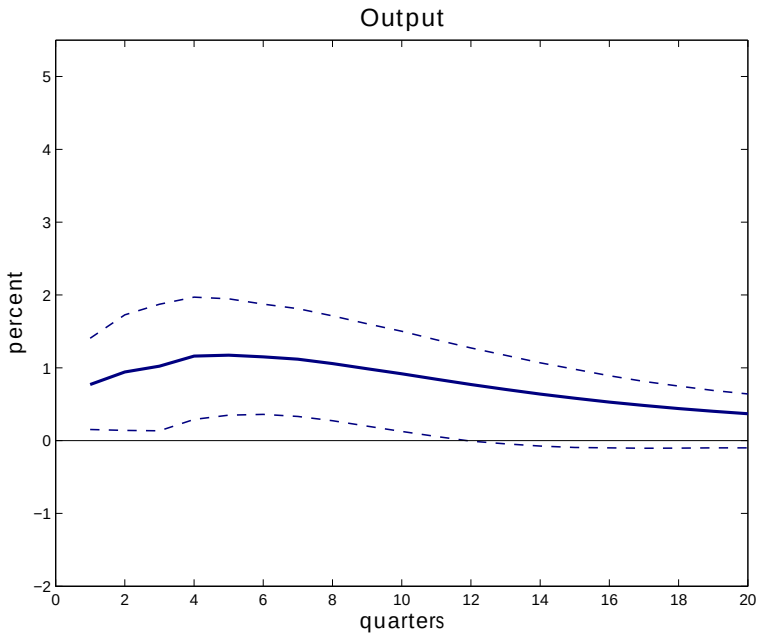
Rely on the same assumptions as Romer and Romer, i.e. τ_t

1. is exogenous, i.e. uncorrelated with current and lagged shocks
2. contains 'perfect' observations of (a subset of) e_t^T up to scale

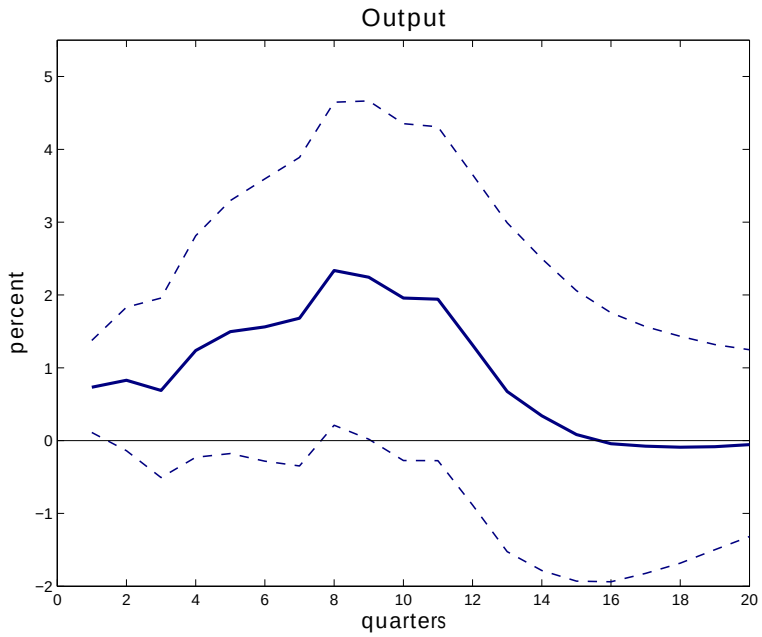
See A1-A3 before.

Other Narrative Specifications:
Unit Innovation to τ_t
(95% Intervals, Recursive Wild Bootstrap)

Favero and Giavazzi (2012)

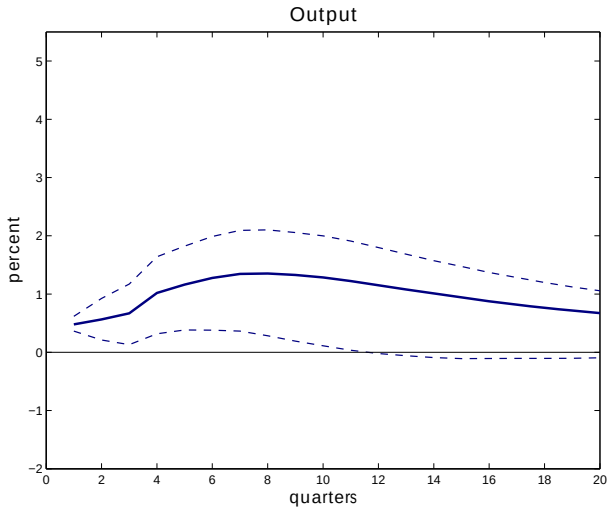


Mertens and Ravn (2012a)

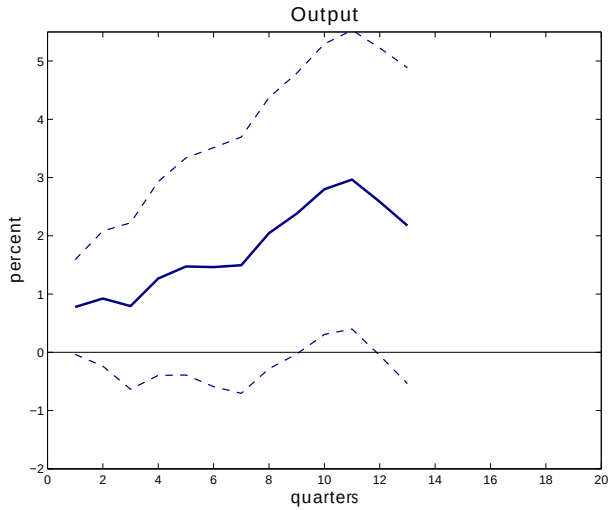


Results very similar to original papers.

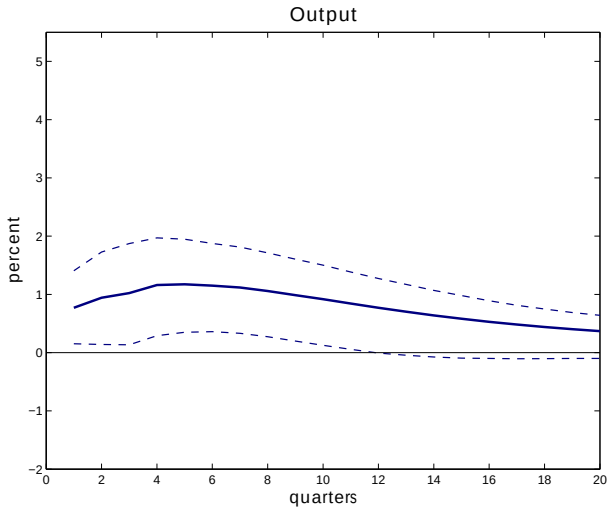
Blanchard and Perotti (2002)



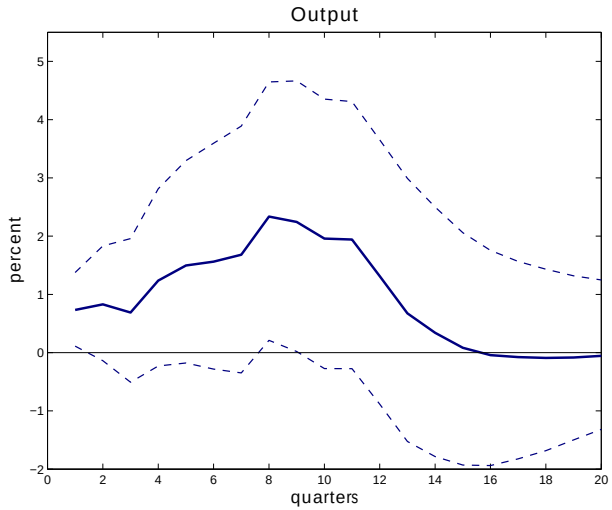
Romer and Romer (2010)



Favero and Giavazzi (2012)



Mertens and Ravn (2012a)



For discussion of Mountford and Uhlig (2009), see Caldara and Kamps (2012).

Proxy SVAR

Consider again **VAR representation:**

$$z_t \quad = \quad \alpha' d_t + \delta' \mathbf{Z_{t-1}} + \mathcal{D} e_t,$$

Assumptions: proxy m_t is available that satisfies

$$E[m_t e_t^T] = \phi \neq 0 \ , \tag{A1}$$

$$E[m_t e_t^G] = 0 \ , \ E[m_t e_t^Y] = 0 \ . \tag{A2}$$

Use standardized narrative observations τ_t as the proxy.

Weaker assumptions than narrative studies:

1. m_t must be relevant ($\phi \neq 0$), but not perfectly correlated with e_t^T
2. m_t must be uncorrelated with contemporaneous shocks, but not lagged shocks (no A3)

Identification assumptions imply that

$$\phi \mathcal{D}_T = E[\upsilon_t m_t]$$

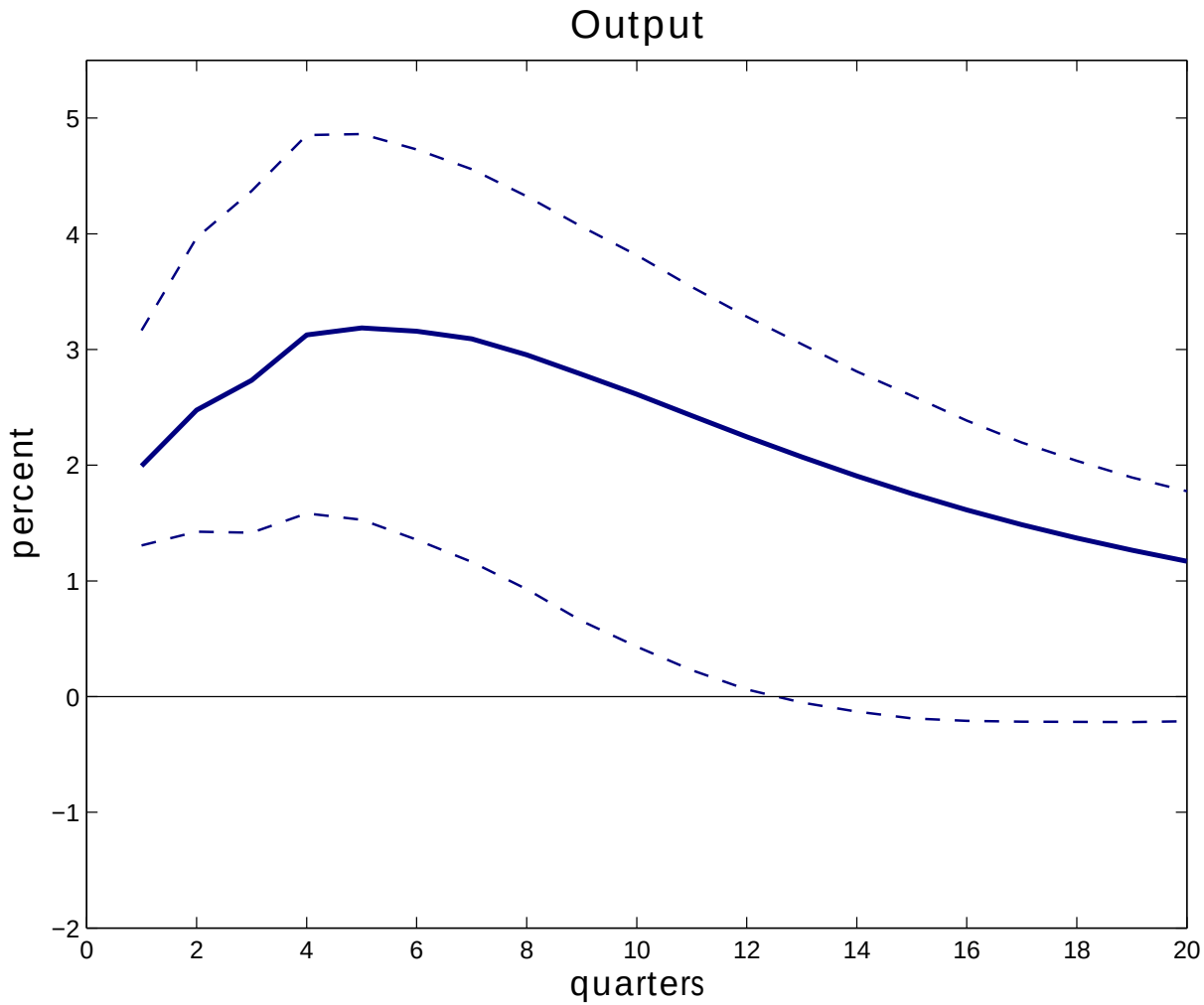
where $\mathcal{D}_T$ is column of $\mathcal{D}$ associated with e_t^T.

Two exogeneity conditions suffice to partially identify impulse response to tax shock (extends to higher VAR dimensions).

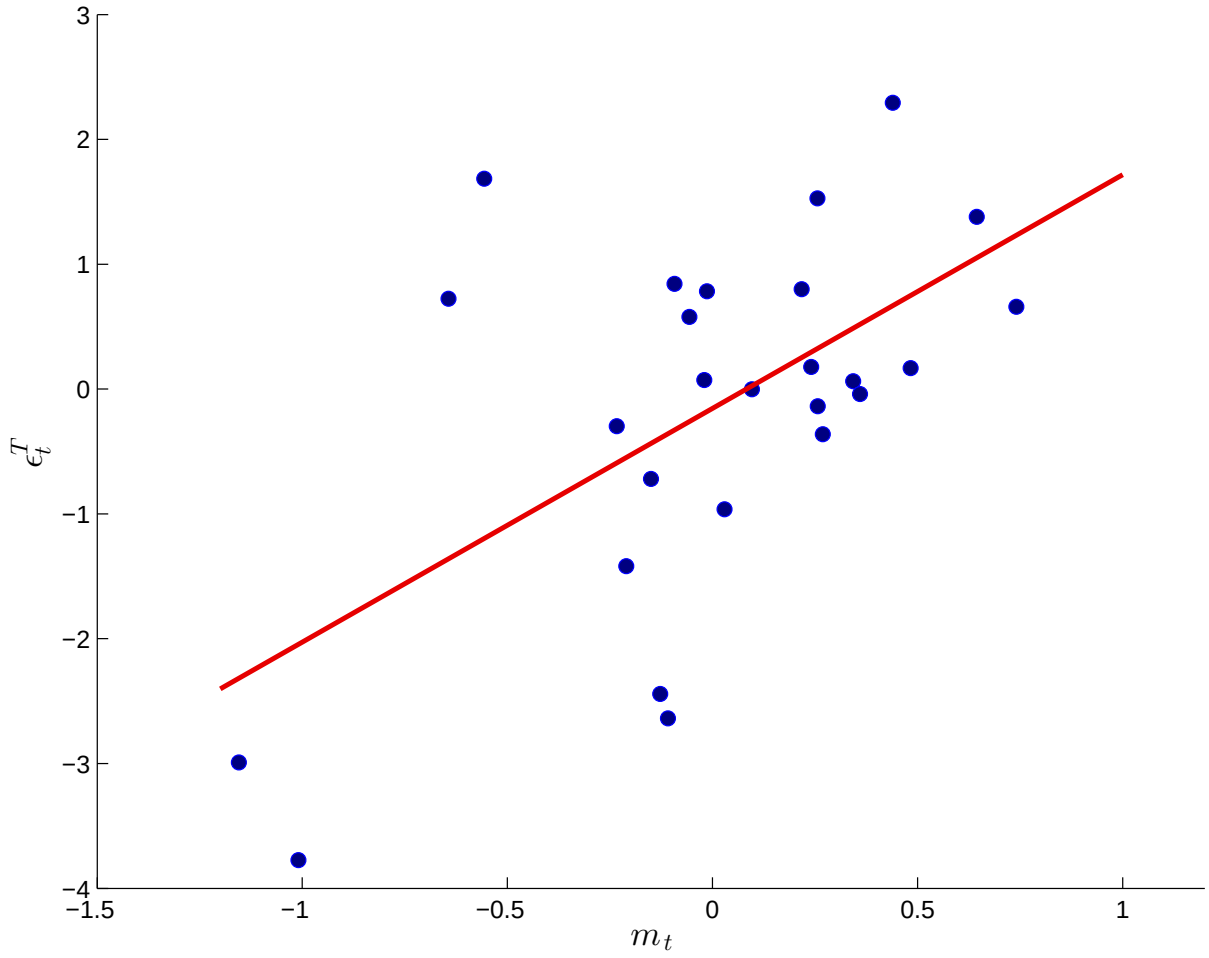
Implementation is straightforward:

1. Estimate VAR, obtain υ_t
2. Regress υ_t on m_t
3. Rescale the coefficients to achieve desired size of the shock.

Proxy SVAR:
1 % of GDP Cut in Tax Revenues
(95% Intervals, Recursive Wild Bootstrap)



Proxy vs Identified Tax Shock



$R^2 = 0.34$

Extensions and Robustness

- Different Trend Assumptions ▸ graphs
- Alternative Narrative Measures ▸ graphs
- Including 'Fiscal Foresight' Variables ▸ graphs
- Larger VAR Systems with Debt, Monetary Variables ▸ graphs
- Subsample Stability ▸ graphs
- Government Spending Shocks ▸ graphs

What happens to output following a tax cut?

Study	Identification	Innovation to	Peak	Period
Blanchard and Perotti (QJE 2002)	SVAR, Coefficients	Total Revenues/GDP	0.78	6-th quarter
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Mertens and Ravn (AEJ/EP 2012)	VARX, Narrative	Total Liabilities/GDP	**2.00**	10-th quarter
Favero and Giavazzi (AEJ/EP 2012)	VARX, Narrative	Total Liabilities/GDP	**1.00**	10-th quarter
Mertens and Ravn (JME 2014)	proxy SVAR, Narrative	Total Revenues/GDP	**3.19**	5-th quarter

Reconciliation with Blanchard Perotti

Blanchard and Perotti (2002) and proxy SVAR reduced forms are identical.

Difference must be in 'structural' coefficients of

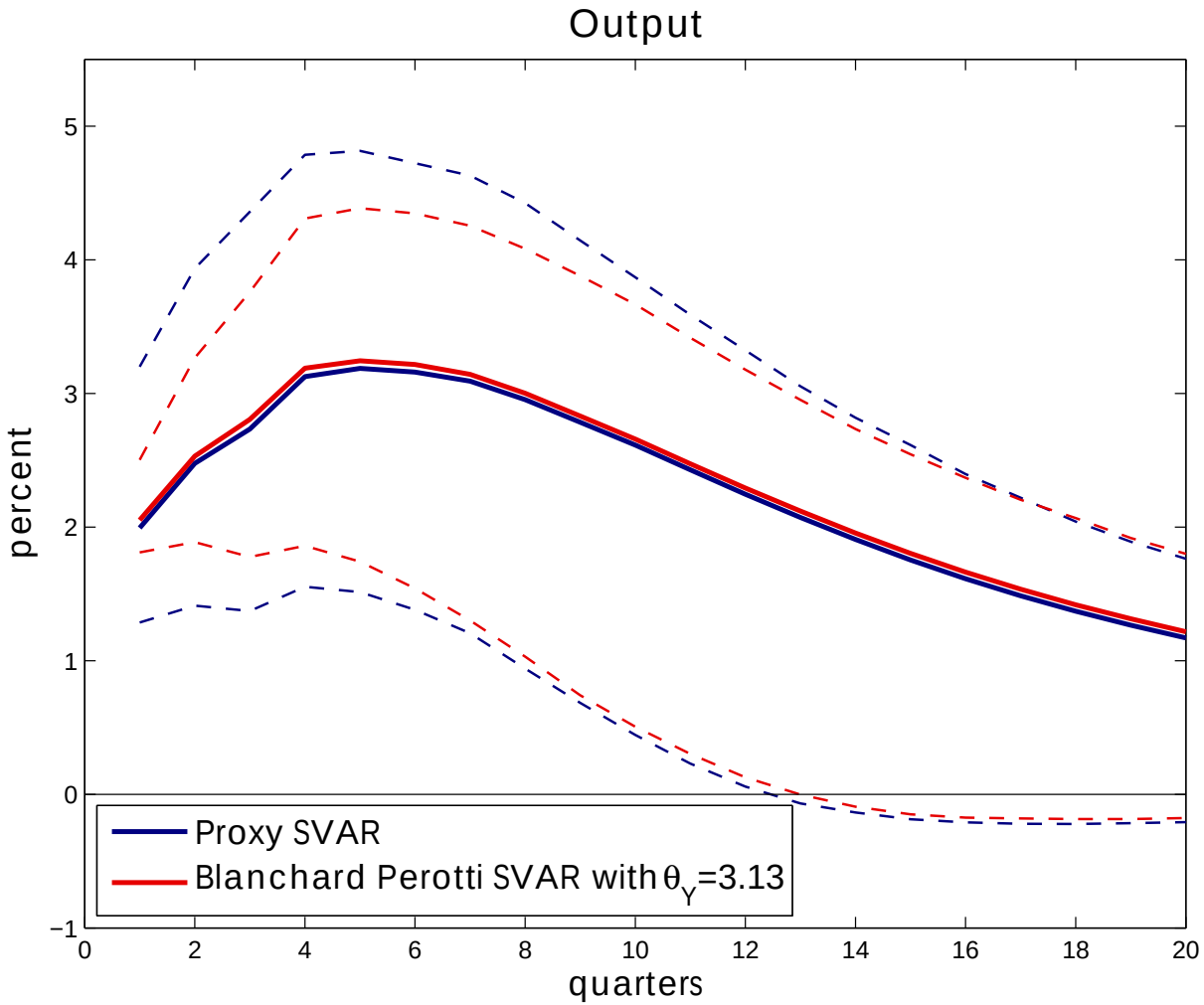
$$\begin{aligned} v_t^T &= \theta_G \sigma_G e_t^G + \theta_Y v_t^Y + \sigma_T e_t^T \ , \\ v_t^G &= \gamma_T \sigma_T e_t^T + \gamma_Y v_t^Y + \sigma_G e_t^G \ , \\ v_t^Y &= \zeta_T v_t^T + \zeta_G v_t^G + \sigma_Y e_t^Y \ . \end{aligned}$$

To estimate these in the proxy SVAR, we need one more condition: $\gamma_Y = 0$

Equation		Proxy SVAR	Blanchard-Perotti SVAR	
		Benchmark	$\theta_Y = 2.08$	$\theta_Y = 3.13$
Tax Revenue	θ_G	-0.20 $[-0.35, -0.07]$	-0.06 $[-0.12, -0.03]$	-0.13 $[-0.19, -0.09]$
	θ_Y	3.13 $[2.73, 3.55]$	2.08 –	3.13 –
	$\sigma_T \times 100$	2.54 $[2.23, 2.62]$	2.24 $[2.04, 2.19]$	2.56 $[2.34, 2.51]$
Spending	γ_T	0.06 $[-0.06, 0.17]$	0 –	0 –
	γ_Y	0 –	0 –	0 –
	$\sigma_G \times 100$	2.35 $[2.12, 2.30]$	2.36 $[2.13, 2.31]$	2.36 $[2.13, 2.31]$
Output	ζ_T	-0.36 $[-0.57, -0.24]$	-0.08 $[-0.11, -0.06]$	-0.36 $[-0.43, -0.31]$
	ζ_G	0.10 $[0.06, 0.13]$	0.07 $[0.06, 0.09]$	0.10 $[0.07, 0.12]$
	$\sigma_Y \times 100$	1.54 $[1.21, 1.93]$	0.97 $[0.89, 0.98]$	1.54 $[1.37, 1.64]$

Values in parenthesis are 95% percentiles computed using 10,000 bootstrap replications.

Blanchard Perotti (QJE 2002) SVAR with $\theta_Y = 3.13$



See also Caldara and Kamps (2012)

Output Elasticity of Tax Revenues: Large or Small?

Robustness:

- Robustness to alternative measures ▸ results
- High elasticities also in larger systems ▸ results

How was $\theta_Y = 2.08$ obtained?

$$\theta_Y = \sum_i \eta^i_{T,B} \eta^i_{B,Y} \frac{T_i}{T} \ .$$

$\eta^i_{T,B}$: elasticity of tax revenues to tax base:

from static evaluations of the existing tax code (OECD, IMF, FRB/US, CBO)

But: policy responses, cyclical effects on income distribution, income shifting, tax compliance, interest/dividend income and capital gains, self employed income,...

$\eta^i_{B,Y}$: elasticity of tax base to GDP

from regressions of tax bases on GDP

But: simultaneity

Other macro estimates of θ_Y:

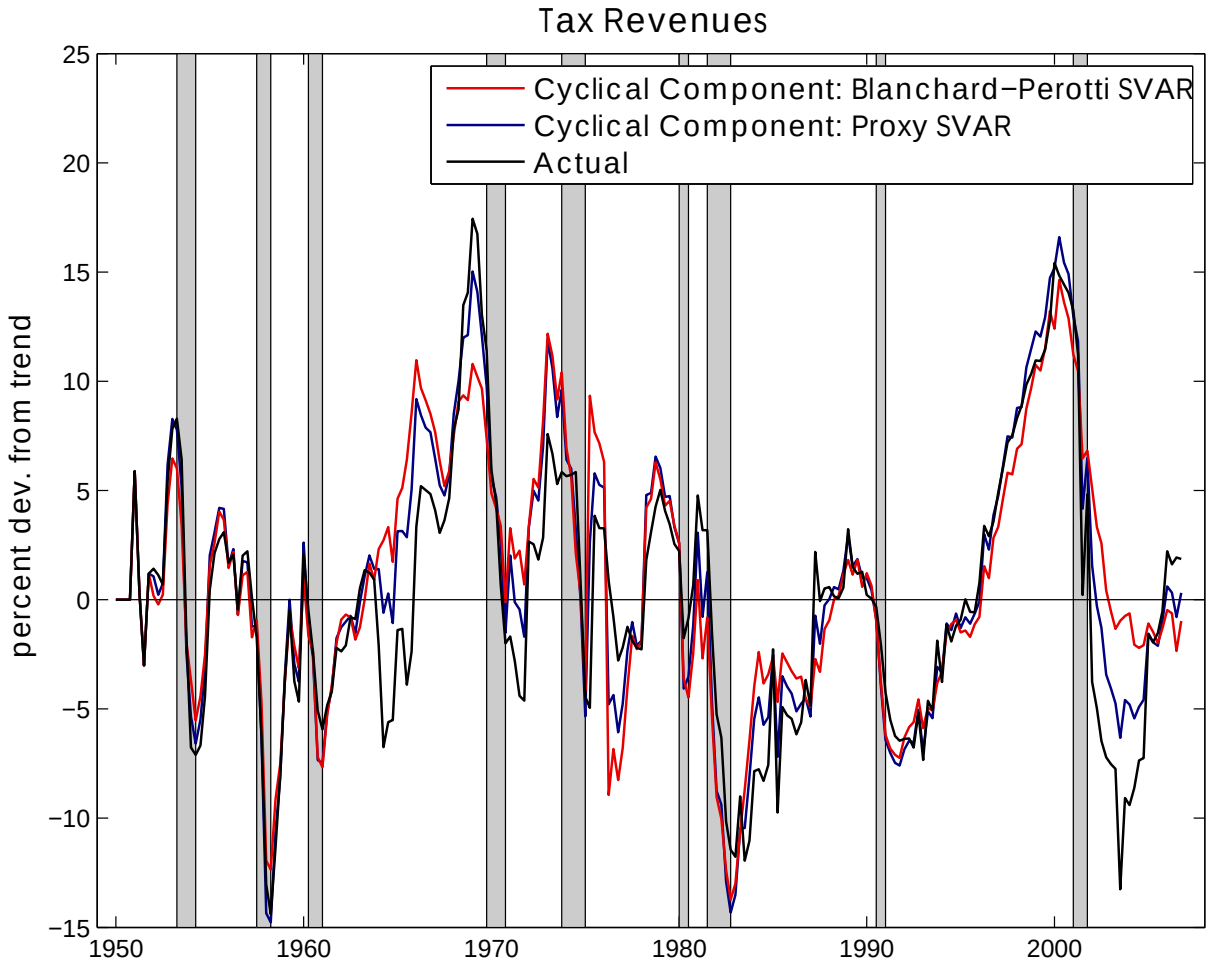
1. For the UK, Cloyne (2014) finds $\theta_Y = 1.61$ vs Perotti (2005)'s $\theta_Y = 0.76$ using OECD method
2. Caldara and Kamps (2012) show sign restrictions of Mountford Uhlig (2009) imply $\theta_Y \approx 3.00$
3. Caldara and Kamps (2012) use oil price shocks: $\theta_Y = 3.18$
4. Mertens and Ravn (2011) use technology shocks: $\theta_Y = 3.7$
5. For African countries, Brückner (2011) uses rainfall and commodity prices and finds much higher values than OECD.

Does $\theta_Y = 3.13$ generate plausible dynamics for the cyclical component of tax revenues?

We generate

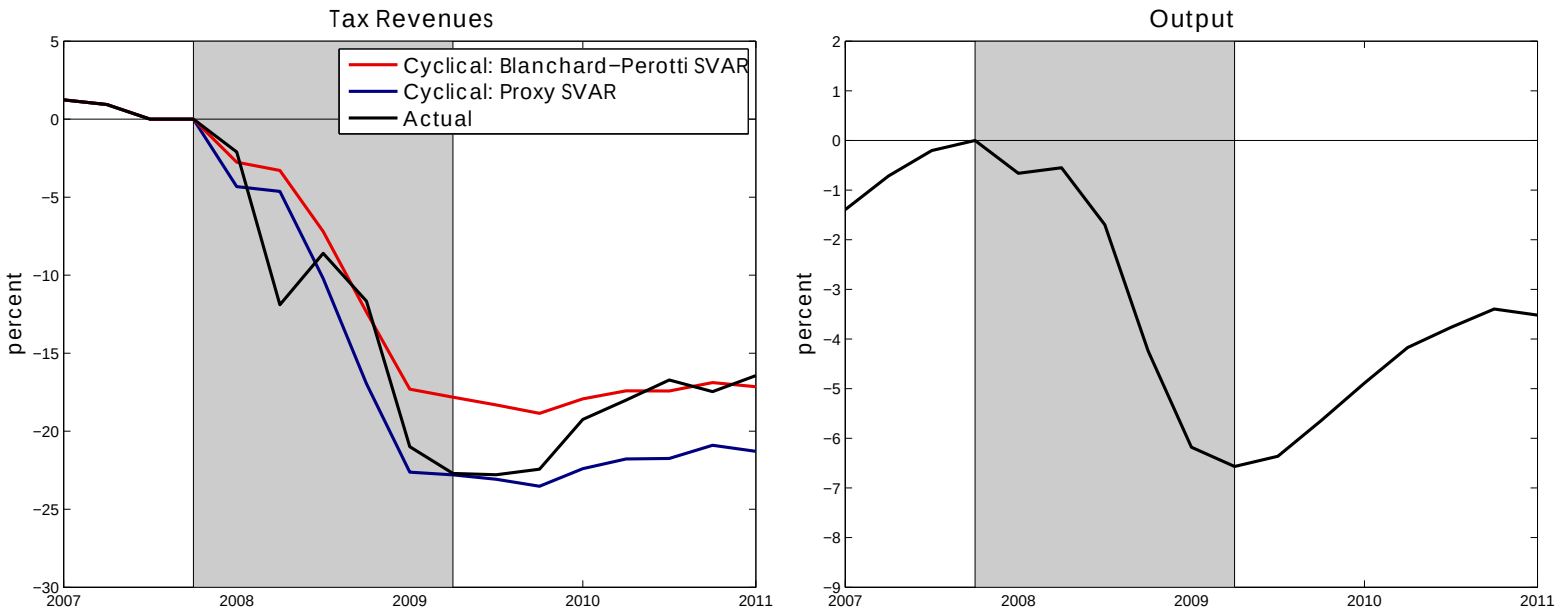
$$T_t^c = \alpha' d_t + \sum_{j=1}^{4} \delta_{TT}^j T_{t-j}^c + \sum_{j=1}^{4} \delta_{TY}^j Y_{t-j} + \sum_{j=1}^{4} \delta_{TG}^j G_{t-j} + \theta_G \sigma_G \epsilon_t^G + \theta_Y u_t^Y$$

Within the sample:



Correlation with actual tax revenues: 0.94 in the Proxy SVAR, 0.82 in the Blanchard Perotti SVAR

Out of the sample: The Great Recession



What happens to output following a tax cut?

Study	Identification	Innovation to	Peak	Period
Blanchard and Perotti (QJE 2002) Change output elasticity	SVAR, Coefficients	Total Revenues/GDP	~~0.78~~ **3.24**	~~6-th quarter~~ 5-th quarter
Mountford and Uhlig (JAE 2009) Caldara Kamps (2012)	SVAR, Sign	Total Revenues/GDP	**3.41**	12-th quarter
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Mertens and Ravn (JME 2014)	proxy SVAR, Narrative	Total Revenues/GDP	**3.19**	5-th quarter

Reconciliation with Other Narrative Studies

Proxy SVAR does not require perfect correlation of tax narrative with true shocks.

Consider a measurement equation

$$\tau_t = \nu + m_t = \nu + \phi e_t^T + \upsilon_t$$

Potential sources of error:

- Additive measurement error υ_t: many judgement calls when producing narrative accounts
- Scaling ϕ: liability projections typically assume unchanged tax base

Estimate the reliability of m_t

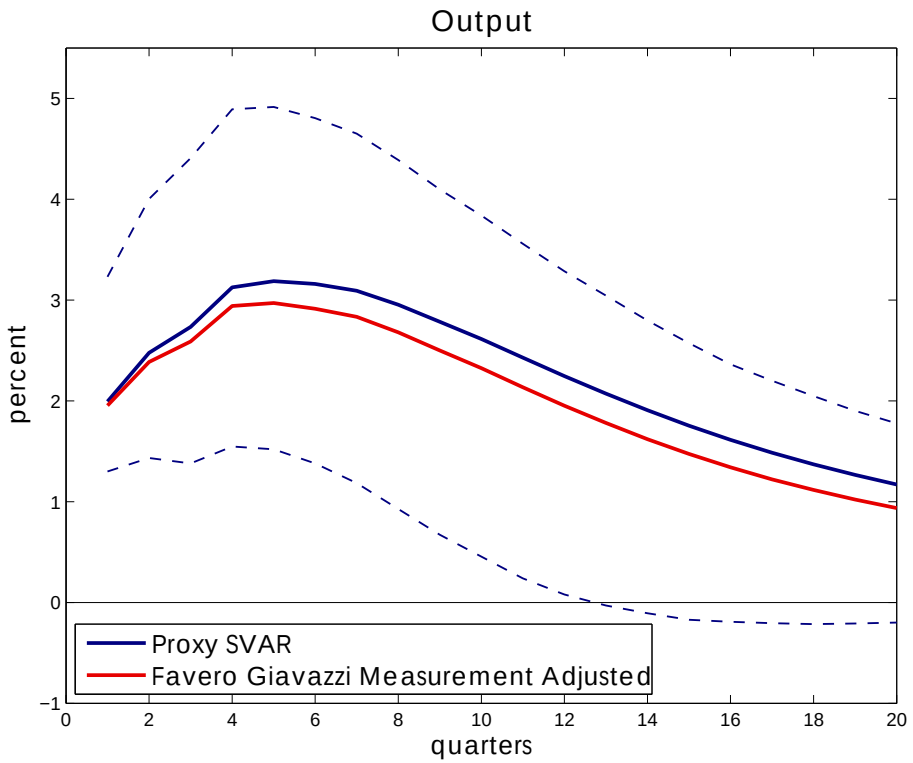
$$\Lambda = \left(\phi^2 \sum_{t=1}^{T} \mathbf{1}_t \left(e_t^T \right)^2 + \sum_{t=1}^{T} \mathbf{1}_t \left(m_t - \phi e_t^T \right)^2 \right)^{-1} \phi^2 \sum_{t=1}^{T} \mathbf{1}_t \left(e_t^T \right)^2 .$$

where $\mathbf{1}_t$ is an indicator function for a nonzero observation of m_t.
We obtain a value of 0.57. ▸ Other Measures

In Favero and Giavazzi (2012) both scaling and additive error imply proportional attenuation bias in λ_0

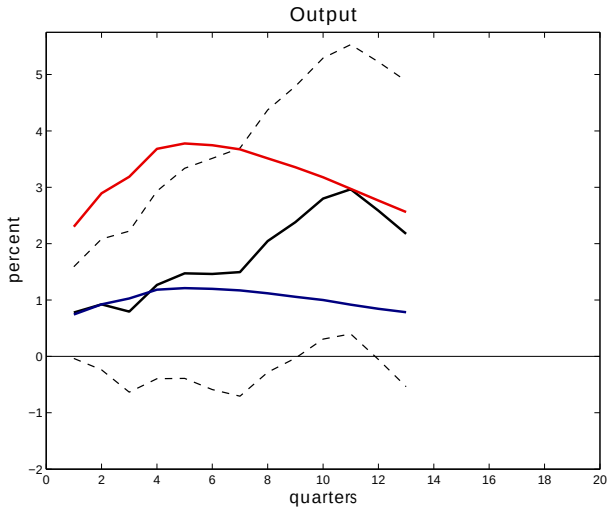
$$Z_t = \alpha' d_t + \delta' \mathbf{Z}_{t-1} + \lambda_0 \tau_t + v_t$$

Suggests easy fix: rescale such that T_t drops by 1% of GDP.

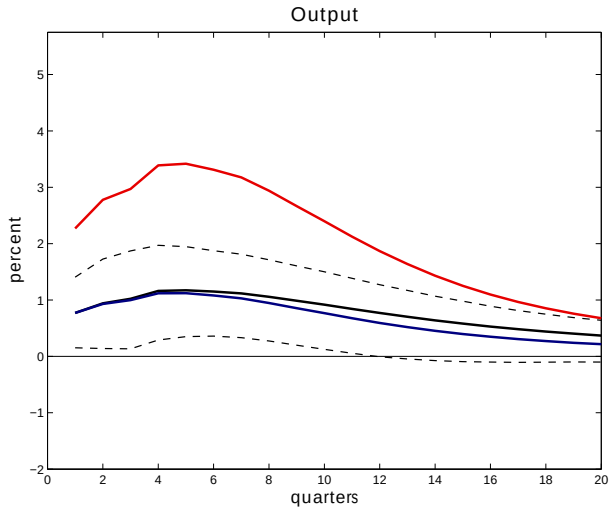


More complicated in Romer and Romer (2010) and Mertens and Ravn (2012): simulations

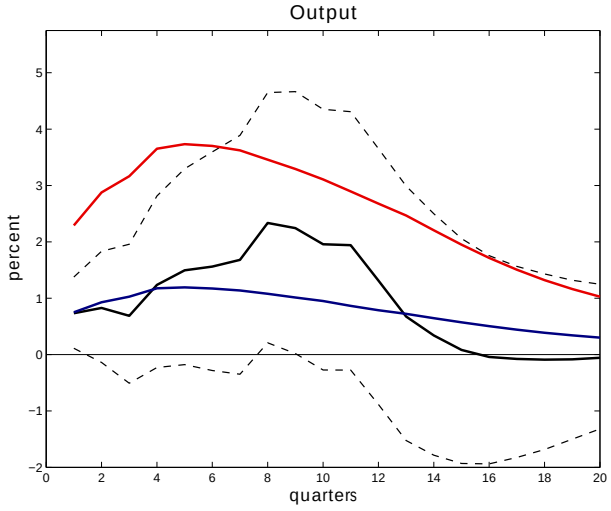
Romer and Romer (2010)

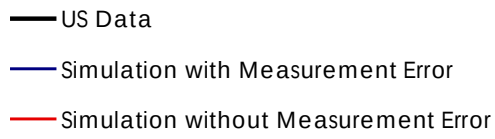


Favero and Giavazzi (2012)



Mertens and Ravn (2012)





What happens to output following a tax cut?

Study	Identification	Innovation to	Peak	Period
Blanchard and Perotti (QJE 2002) Change output elasticity	SVAR, Coefficients	Total Revenues/GDP	~~0.78~~ **3.24**	~~6-th quarter~~ 5-th quarter
Mountford and Uhlig (JAE 2009) Caldara Kamps (2012)	SVAR, Sign	Total Revenues/GDP	**3.41**	12-th quarter
Romer and Romer (AER 2010) Simulated measurement errors	Narrative	Total Liabilities/GDP	3.08 **3.77**	10-th quarter 5-th quarter
Mertens and Ravn (AEJ/EP 2012) Simulated measurement errors	VARX, Narrative	Total Liabilities/GDP	2.00 **3.73**	10-th quarter 5-th quarter
Favero and Giavazzi (AEJ/EP 2012) Rescaled for measurement error	VARX, Narrative	Total Liabilities/GDP	~~1.00~~ **2.97**	~~10-th quarter~~ 5-th quarter
Mertens and Ravn (JME 2014)	proxy SVAR, Narrative	Total Revenues/GDP	**3.19**	5-th quarter

What happens to output following a tax cut?

Study	Identification	Innovation to	Peak	Period
Blanchard and Perotti (QJE 2002)	SVAR, Coefficients	Total Revenues/GDP	~~0.78~~	~~6-th quarter~~
Change output elasticity			**3.24**	5-th quarter
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Caldara Kamps (2012)				
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Simulated measurement errors			**3.73**	5-th quarter
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Rescaled for measurement error			**2.97**	5-th quarter
Mertens and Ravn (JME 2014)	proxy SVAR, Narrative	Total Revenues/GDP	**3.19**	5-th quarter

Personal versus Corporate Tax Shocks

Based on Mertens and Ravn, 2013, The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States, American Economic Review

Matlab codes and data available on my webpage.

Outline

- Benchmark Specification and Identification
- Discussion and robustness
- Results for other macro aggregates
  - Interaction with monetary policy
  - Labor market
  - Consumption and investment

Benchmark VAR specification

Sample 1950:Q1-2006:Q4

Seven variables in z_t

- T_t^{PI}, T_t^{CI}: Average Tax Rates (NIPA)
- $\ln(B_t^{PI})$,$\ln(B_t^{CI})$: Tax Bases (NIPA) , real per capita
- $\ln(G_t)$: Government spending on final goods , real per capita
- $\ln(DEBT_t)$: Government debt, real per capita
- $\ln(GDP_t)$: Output, real per capita

Log levels

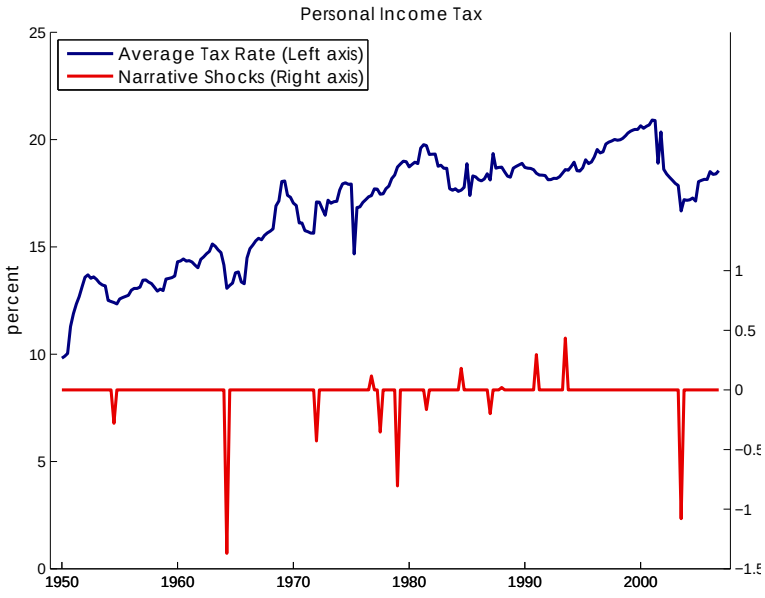
Four lags (Akaike)

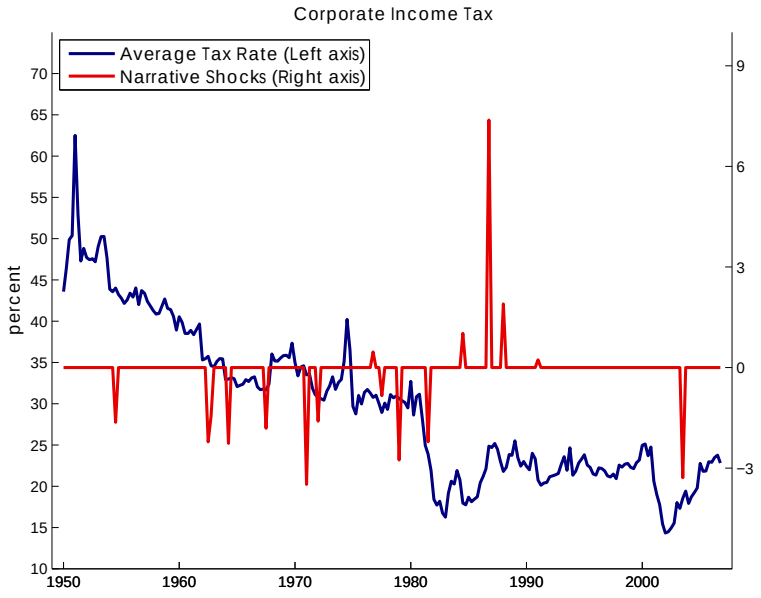
Proxy Variables m_t for Tax Shocks e_{1t}

1. Romer and Romer (2009)'s record of 50 legislative actions for 1947-2007 concerning federal tax code.
2. Projected liabilities changes at implementation dates (73 obs)

   Economic Report, Budget, Treasury Reports, Congressional Record, CBO, ...
3. Exogenous (A2), cfr. Romer and Romer (2009), (48 obs)
4. Unanticipated (A1), cfr. Mertens and Ravn (2011), (27 obs)
5. Categorized into individual income (13 obs), payroll (2 obs), corporate (16 obs) and other (13 obs) using historical records.
6. Personal Income (13 obs) and Corporate Income (16 obs) measures:

$$\Delta T_t^{i,narr} = \frac{\text{Tax } i \text{ Liability Change}_t}{\text{Tax Base}_{t-1}}$$


Personal Income Tax
Average Tax Rate (Left axis)
Narrative Shocks (Right axis)
percent
25
20
15
10
5
0
1
0.5
0
−1
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

What is Identified by the Proxies

Correlation between tax changes m_t is 0.42, hence unlikely to measure exogenous variation in just a single tax.

$$\begin{aligned} \upsilon_{1t} &= \eta\upsilon_{2t} + S_1 e_{1t} \\ \upsilon_{2t} &= \zeta\upsilon_{1t} + S_2 e_{2t} \end{aligned}$$

υ_{1t} : reduced form tax rate innovations
υ_{2t} : reduced form innovations to other variables
e_{1t}: structural tax shocks
e_{2t}: other structural shocks

Need to identify $\mathcal{D}_1 = \begin{bmatrix} \mathcal{D}_{11} \\ \mathcal{D}_{21} \end{bmatrix} = \begin{bmatrix} I + \eta(I - \zeta\eta)^{-1}\zeta \\ (I - \zeta\eta)^{-1}\zeta \end{bmatrix} S_1$

Covariance restrictions identify $\mathcal{D}_{21}{\mathcal{D}_{11}}^{-1}$ and $S_1 S_1'$, but not S_1.

Additional Restriction

$$\begin{aligned} v_{1t} &= \eta v_{2t} + S_1 e_{1t} \\ v_{2t} &= \zeta v_{1t} + S_2 e_{2t} \end{aligned}$$

We can obtain response to any linear combination of shocks e_{1t}.

Meaningful IR's using a harmless zero restriction in S_1:

- S_1 upper triangular,

  first column is shock to personal tax that leaves 'cyclically adjusted' corporate tax innovations unchanged

- S_1 lower triangular,

  second column is shock to corporate tax that leaves 'cyclically adjusted' personal tax innovations unchanged

$$\begin{aligned} \upsilon_{1t} &= \eta\upsilon_{2t} + S_1 e_{1t} \\ \upsilon_{2t} &= \zeta\upsilon_{1t} + S_2 e_{2t} \end{aligned}$$

IV Implementation:

1. ζ: υ_{2t} on υ_{1t} with instruments m_t
2. η: υ_{1t} on υ_{2t} with instruments $\upsilon_{2t} - \zeta\upsilon_{1t}$
3. $S_1 S_1'$: covariance of $\upsilon_{1t} - \eta\upsilon_{2t}$
4. S_1: Choleski decomposition of $S_1 S_1'$

Benchmark VAR specification

Sample 1950:Q1-2006:Q4

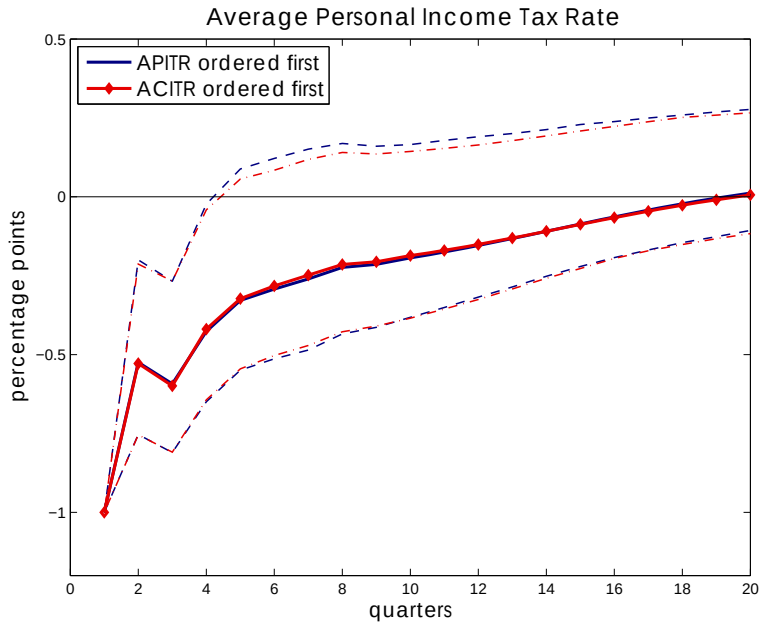
Seven variables in Y_t

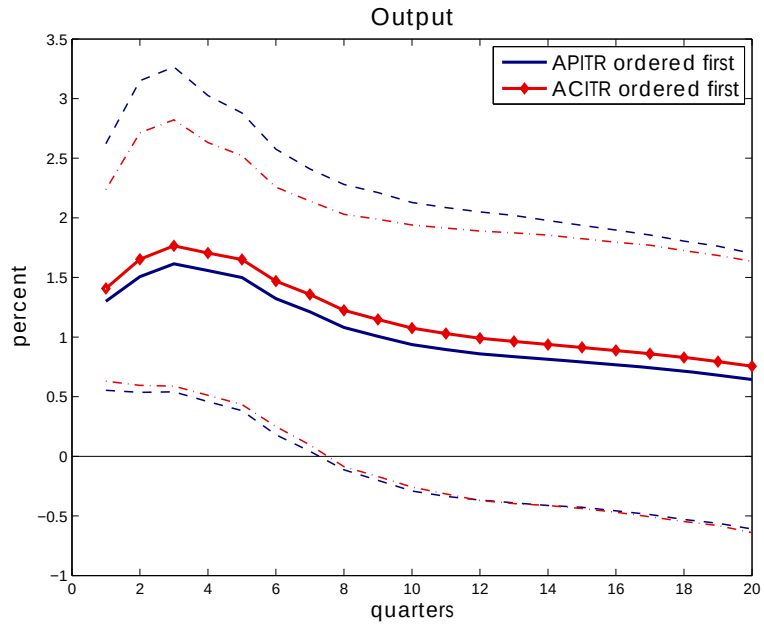
- T_t^{PI}, T_t^{CI}: Average Tax Rates (NIPA)
- $\ln(B_t^{PI})$,$\ln(B_t^{CI})$: Tax Bases (NIPA) , real per capita
- $\ln(G_t)$: Government spending on final goods , real per capita
- $\ln(DEBT_t)$: Government debt, real per capita
- $\ln(GDP_t)$: Output, real per capita

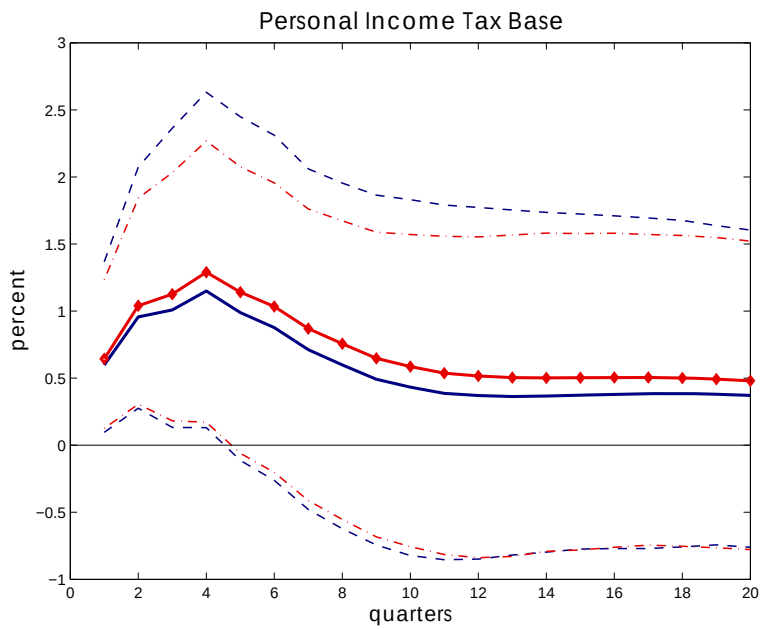
Log levels

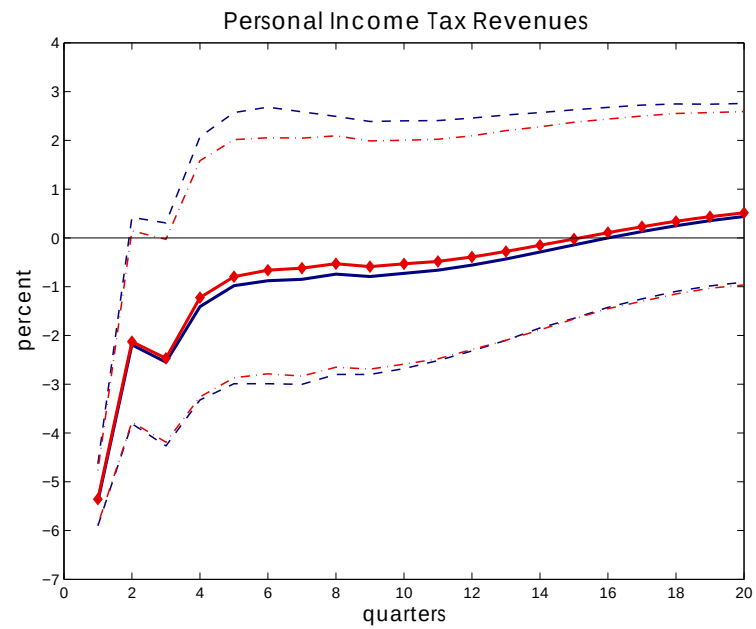
Four lags (Akaike)

One PP Cut in **Average Personal Income Tax** Rate (95% Confidence Intervals)

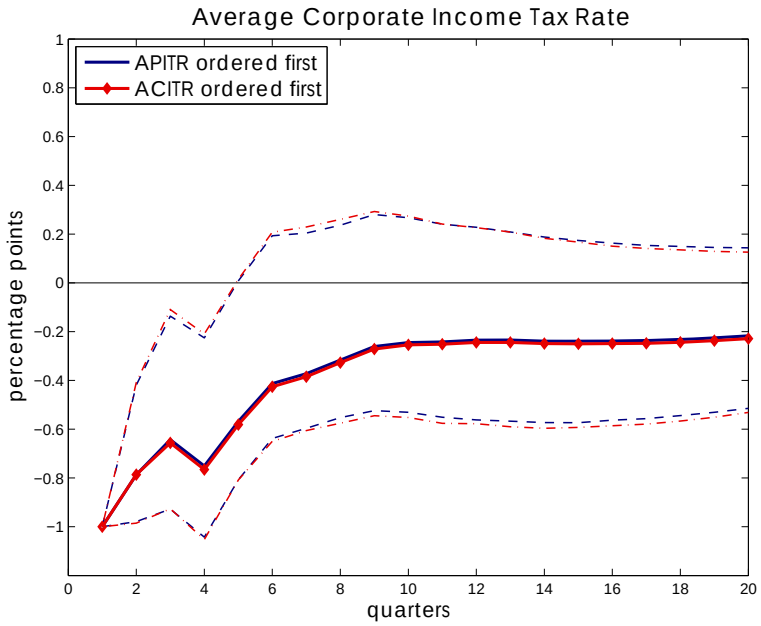


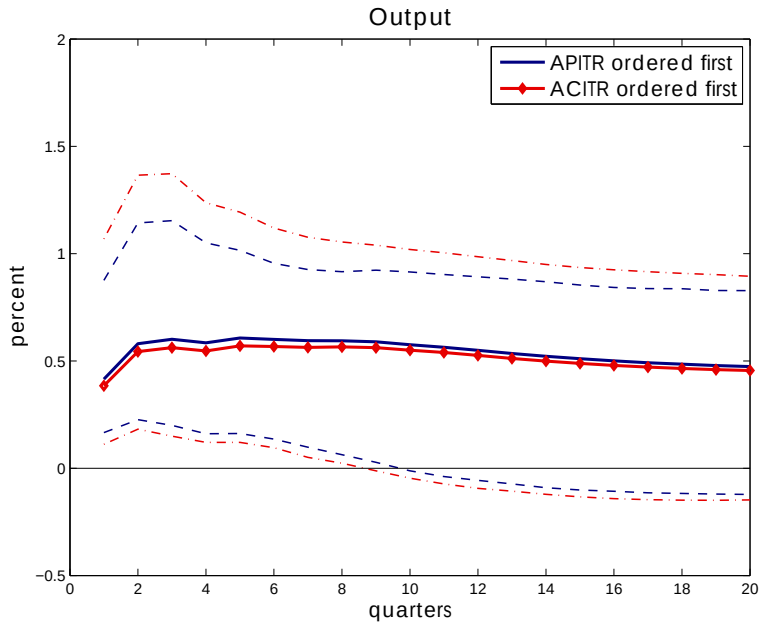


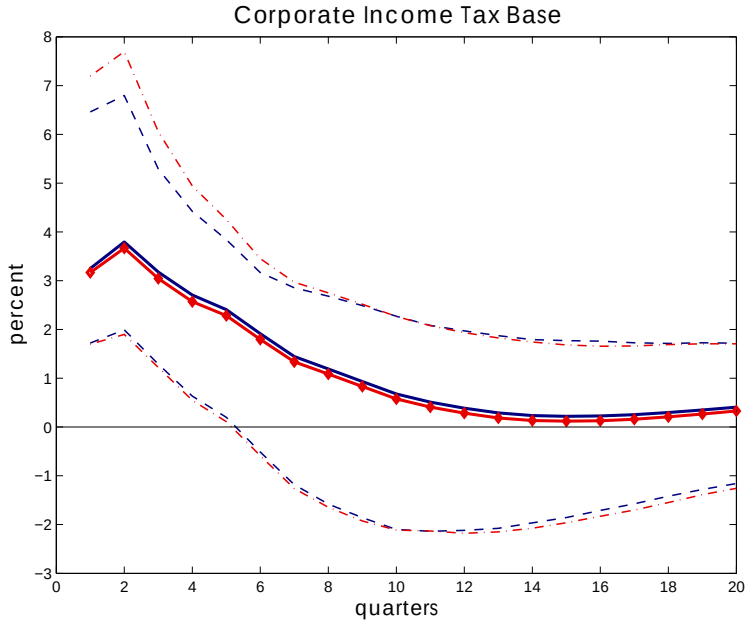


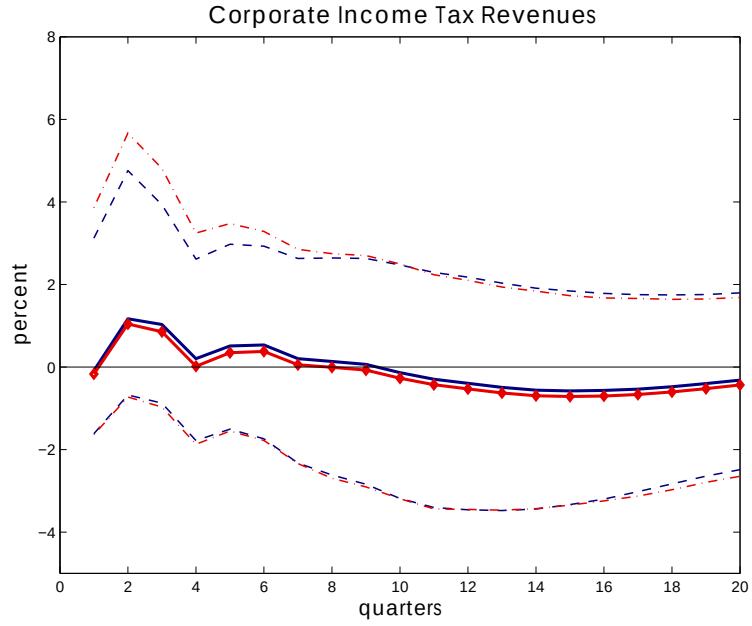


One PP Cut in **Average Corporate Income Tax** Rate (95% Confidence Intervals)









Response of other variables, graphs

Reliability matrix has eigenvalues 0.30 $[0.16, 0.48]$ and 0.69 $[0.47, 0.97]$.

Principal components of m_t have correlation with e_{1t} of 0.55 and 0.83.

What if we ignore correlation between m_t? graphs

What if we use 'traditional' restrictions? graphs

Effects of Tax Changes on Other Macro Variables

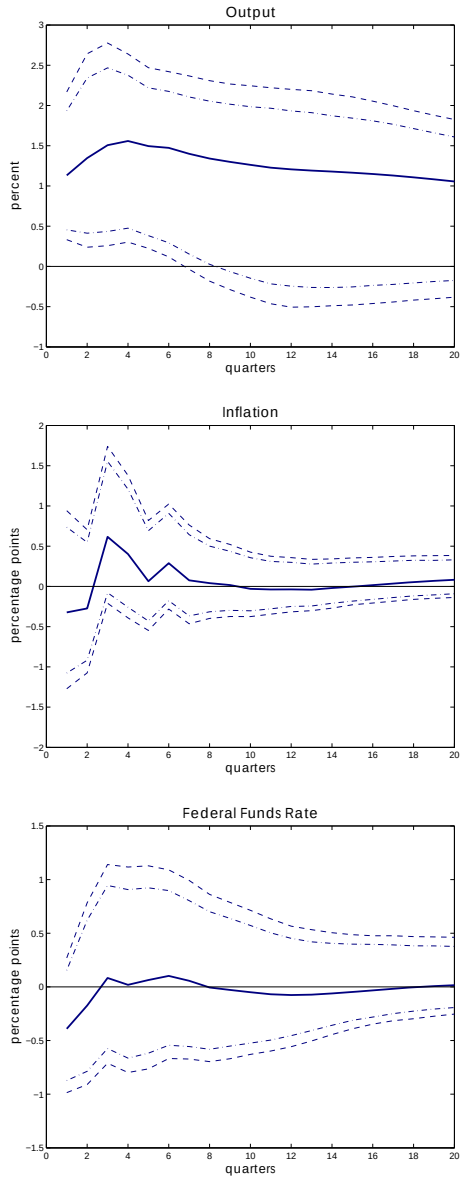
Alternative VAR systems:

- Fixed set of five baseline variables:
  T_t^{PI}, T_t^{CI}, $\ln(G_t)$, $\ln(DEBT_t)$, $\ln(GDP_t)$
- Varying set of additional variables

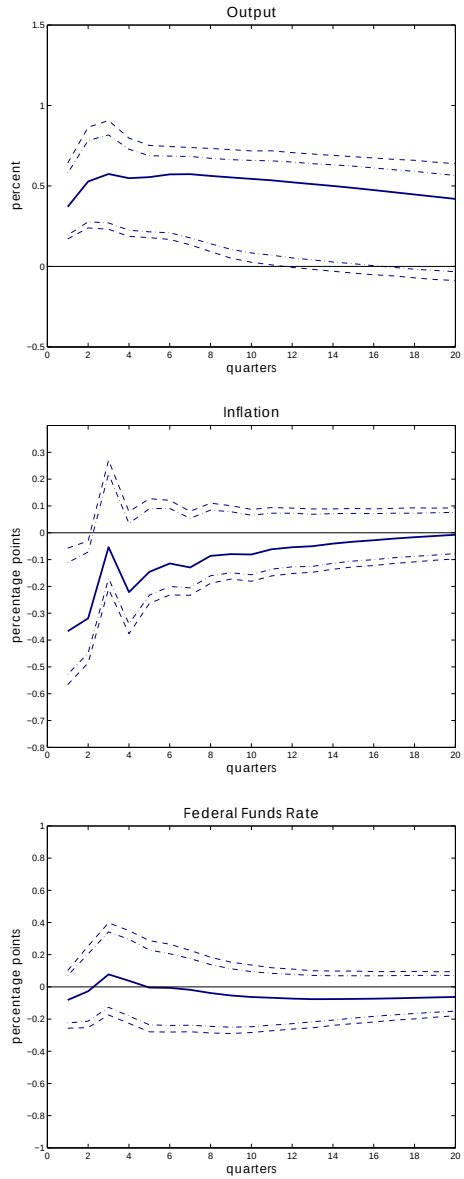
We consider:

1. **Monetary policy and inflation**:
   Federal funds rate, nonborrowed reserves, PCE price index
2. **Labor market**:
   Hours per worker, employment/population, labor force/population
3. **Consumption and investment**:
   Nondurables/services, durable purchases, personal income
   Nonresidential and residential investment, corporate profits

(A) Personal Income Tax Cut

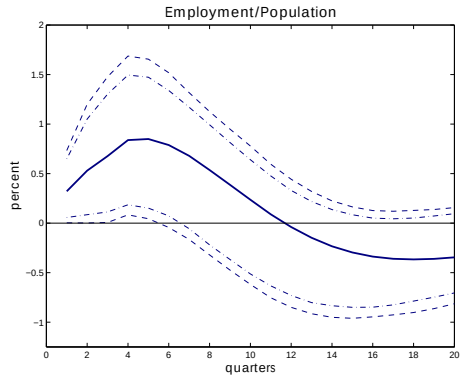


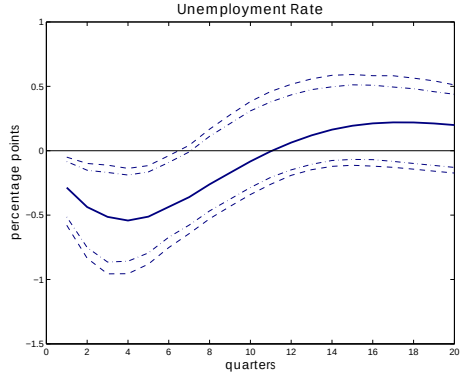
(B) Corporate Income Tax Cut



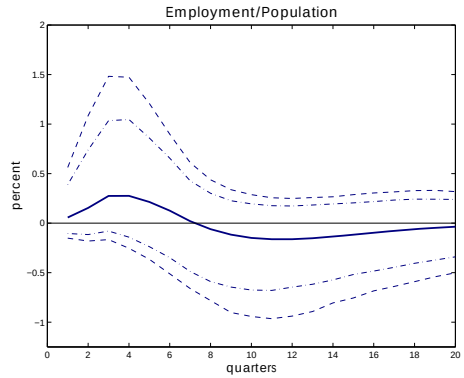
▸ Government Debt ▸ Other Inflation Measures

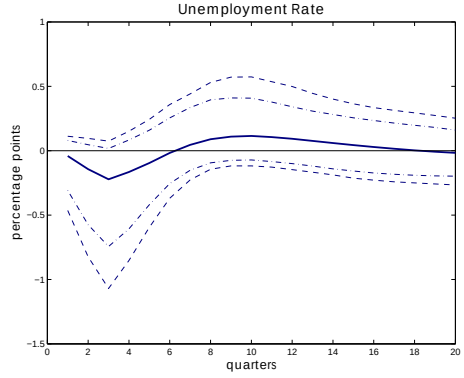
(A) Personal Income Tax Cut





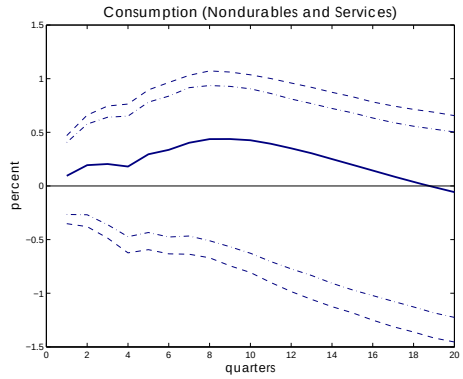
(B) Corporate Income Tax Cut

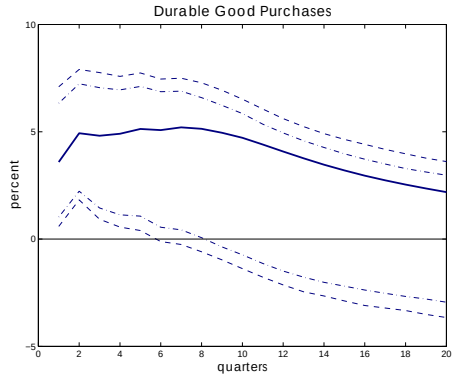


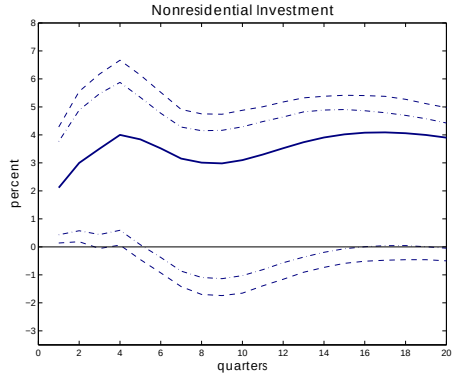


▸ Labor Force Participation ▸ Private vs. Public Sector Employment

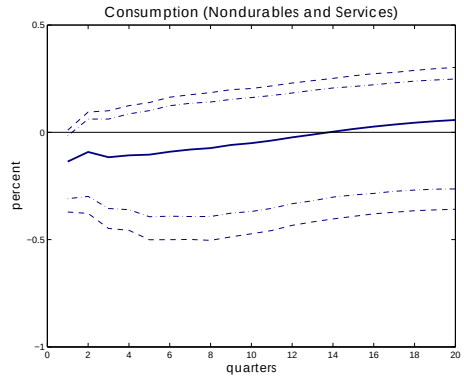
(A) Personal Income Tax Cut

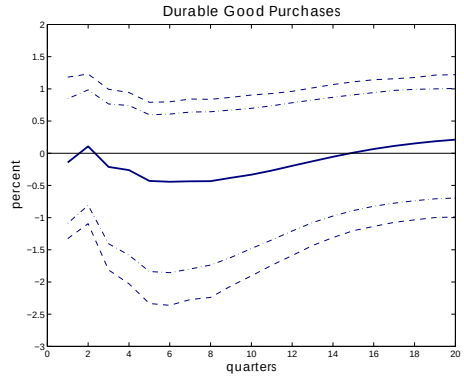


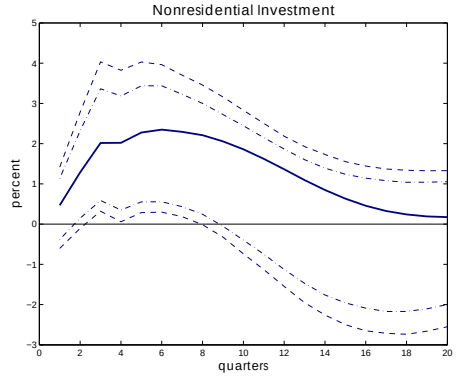




(B) Corporate Income Tax Cut







▸ Residential Investment

Some Implications

- No systematic response of monetary policy.
  CI tax cuts are disinflationary.
- Unanticipated Tax Stimulus:

  PI tax cuts lead to job creation, increases in consumption and investment, but have negative budgetary impact

  CI tax cuts primarily affect investment and seem to have no strong budgetary impact.
- Raising revenues:

  PI tax hikes generate revenues but are costly in terms of job losses and lower activity.

  CI tax hikes unlikely to generate significant revenues.

Marginal Tax Rate Shocks

Based on revision Mertens, 2013, Marginal Tax Rates and Income: New Time Series Evidence, NBER Working Paper 19171

(revision available soon)

What is the effect of **marginal tax rate changes** on economic activity?

Macro studies all look at average tax rates.

Blanchard and Perotti (2002); Mountford and Uhlig (2009); Romer and Romer (2010); Mertens and Ravn (2012, 2013, 2014)

Important exception: Barro and Redlick (2011)

Large empirical literatures outside of macro looking at marginal tax rate changes:

- Labor Supply

  Blundell & MaCurdy (1999); Moffitt and Wilhelm (2000); Keane (2011); Keane and Rogerson (2012); Chetty, Guren, Manoli, Weber (2011, 2012),...

- Public finance

  Lindsey (1987), Feenberg and Poterba (1993), Feldstein (1995), Slemrod (1996), Auten and Carroll (1999), Goolsbee (1999), Gruber and Saez (2002), Saez (2004), Giertz (2010), Saez, Slemrod & Giertz (2012),...

Simple Motivating Framework

Agent $i \in [0,1]$ has labor supply

$$h_{it} = h\left((1 - T'(e_{it}))w_{it}/x_{it}\right)^{\epsilon}$$

$e_{it} = w_{it}h_{it}$, w_{it}/x_{it} (detrended) real wage, ϵ labor supply elasticity.

Suppose the tax schedule is:

$$T(e_{it}) \quad = \quad e_{it} - (1 - \tau_t)\frac{(e_{it}/\bar{e}_t)^{1-\gamma}}{1-\gamma}\bar{e}_t \quad , \quad 0 \leq \gamma < 1$$

where $\bar{e}_t = \left(\int_0^1 e_{it}^{1-\gamma} di\right)^{1/(1-\gamma)}$, tax progressivity γ

Economy-wide **average marginal tax rate** (AMTR):

$$\tau_t = 1 - \int_0^1 (e_{it}/\bar{e}_t)\,(1 - T'(e_{it}))di$$

For any subset $S \subseteq [0, 1]$,

$$\Delta \ln(e_t^s) \quad = \quad \epsilon \Delta \ln(1 - \tau_t^s) + r_t^s$$

where $\tau_t^s = 1 - \int_S (e_{it}/\bar{e}_t^s(1 - T'(e_{it}))di)$ is the **AMTR for** S

r_t^s are non-tax determinants of earnings growth.

In reality, tax liability is based on reported taxable income.

Capital income, tax avoidance/evasion

So, ϵ interpreted more broadly as the **tax elasticity of income**

Moreover, tax reforms almost have certainly general equilibrium effects on wages end returns to saving.

Focus:

Income (reported to tax authorities) as outcome variable.

Aggregate causal effects, not a structural parameter (directly).

Macro Time Series Approach

- Dynamics
- General Equilibrium Effects
- Expectations

Existing **Average Marginal Tax Rate** (AMTR) measures:

- Barro and Sahasakul (1983, 1986), Barro and Redlick (2011)
- Saez (2004)

New extended annual series for 1946-2012 based on

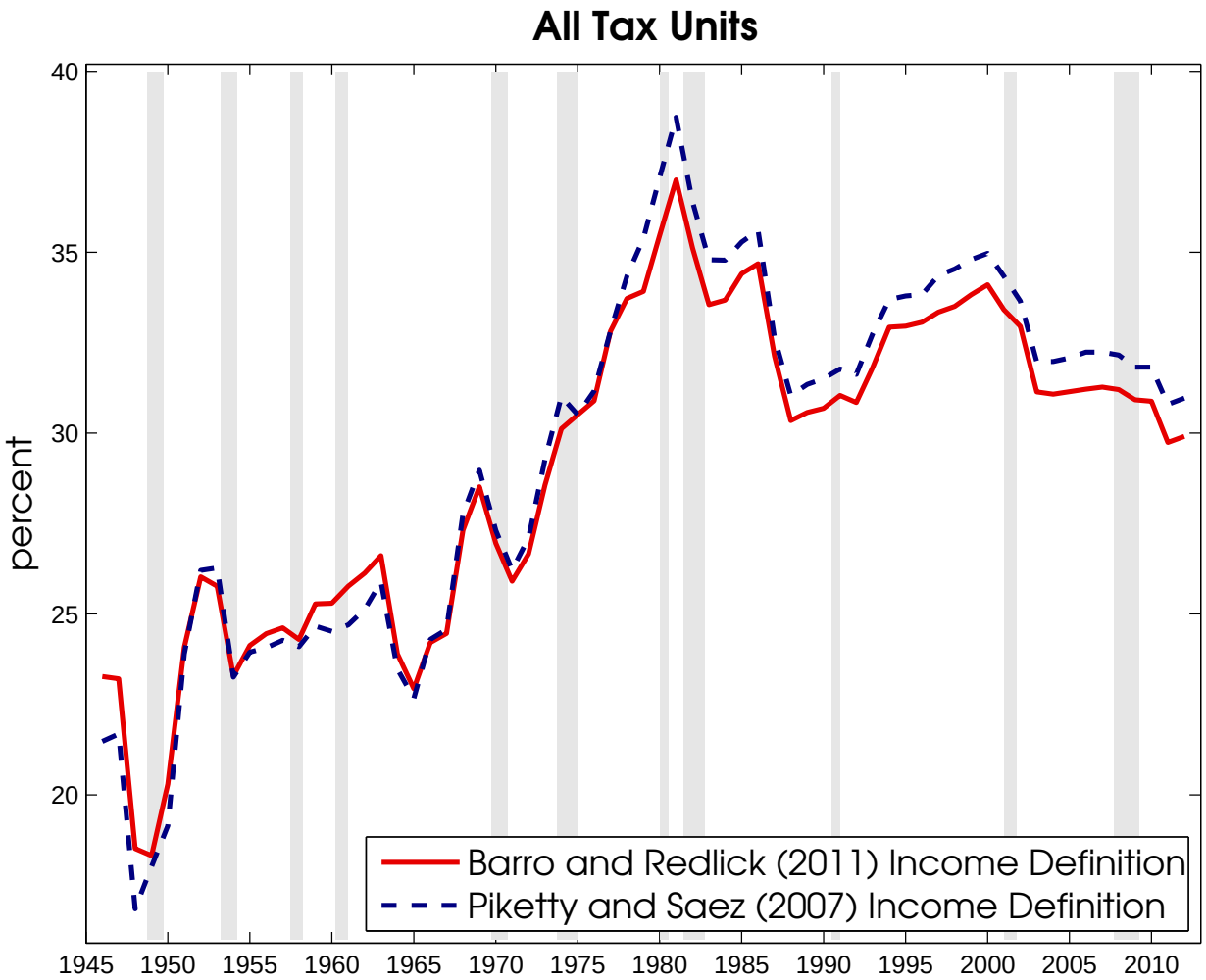
- IRS micro data, IRS Statistics of Income
- Social Security Administration Annual Statistical Supplement
- Federal Hospital Insurance Board of Trustees Annual Report

Includes: Federal Individual Income Tax, Federal Insurance Contributions (OASDI and HI)

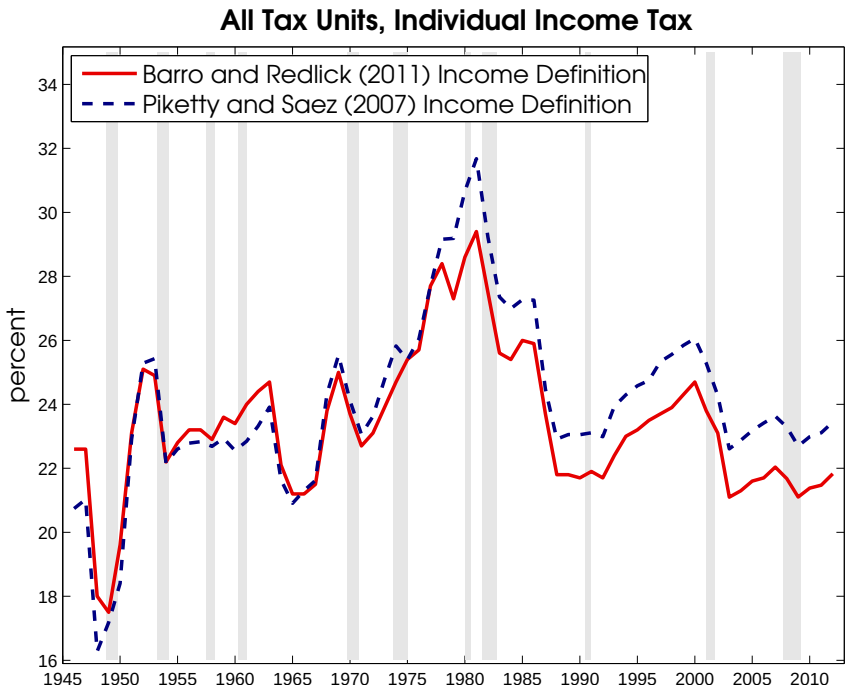
Excludes: State Income Taxes, FUTA, Railroad Retirement, ...

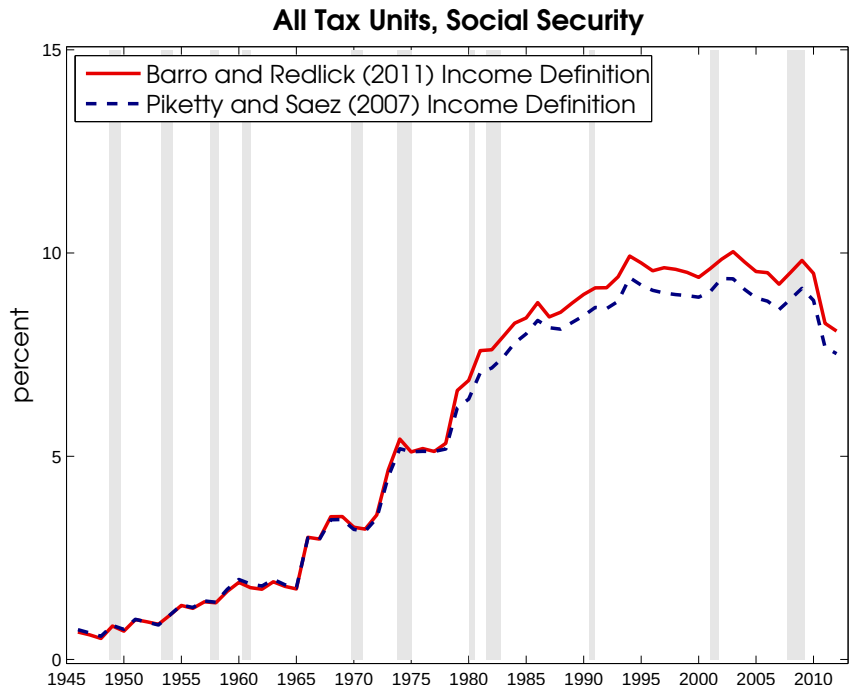
Income defined as in Piketty and Saez (2007):
All market income (per tax unit) excluding govt. transfers and capital gains

Average Marginal Tax Rates

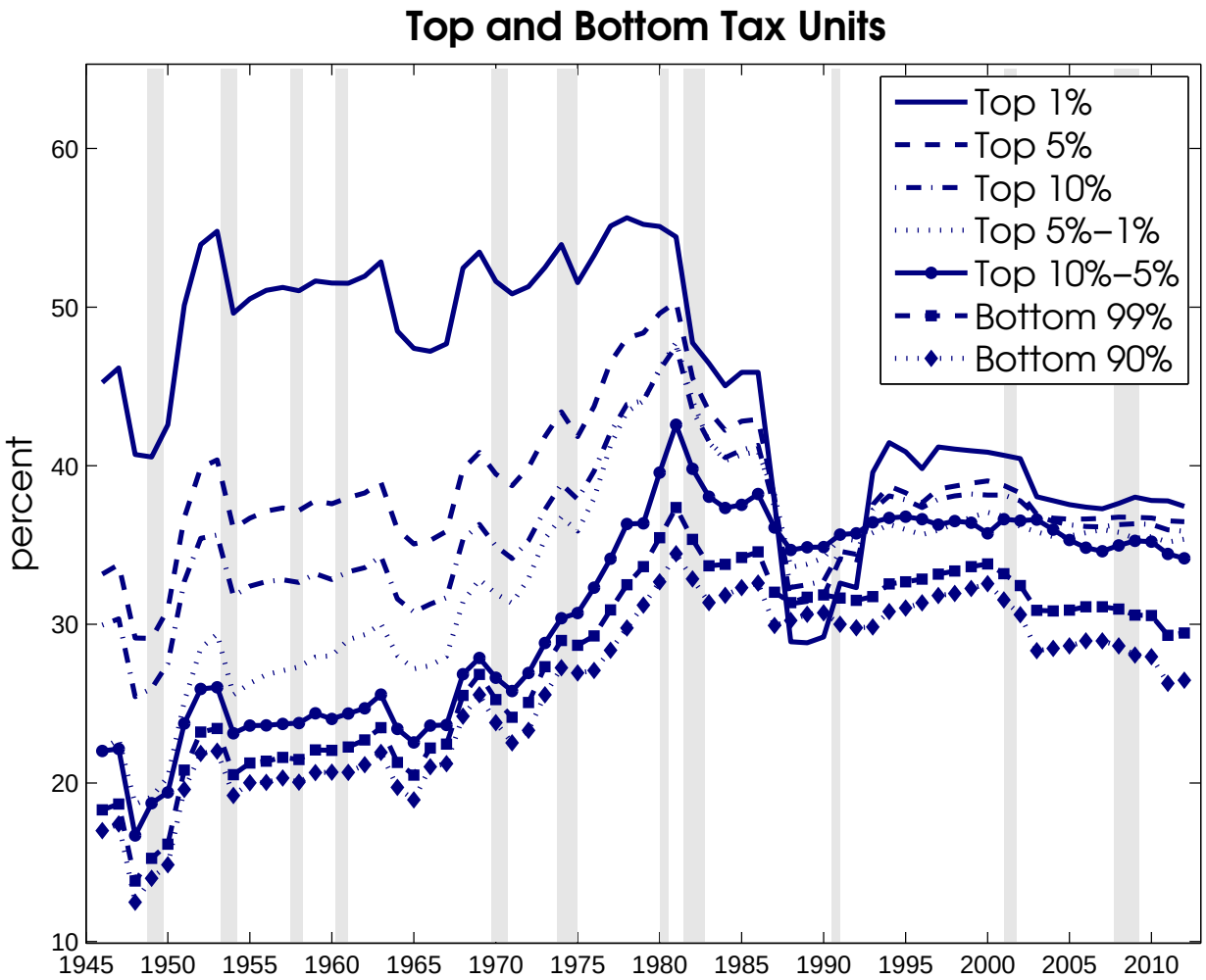


Average Marginal Tax Rates

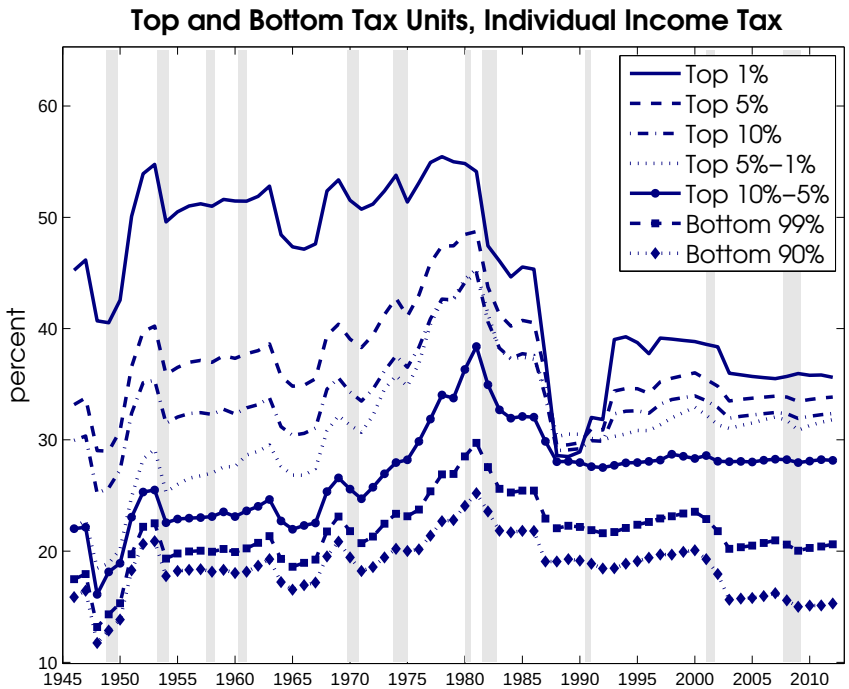


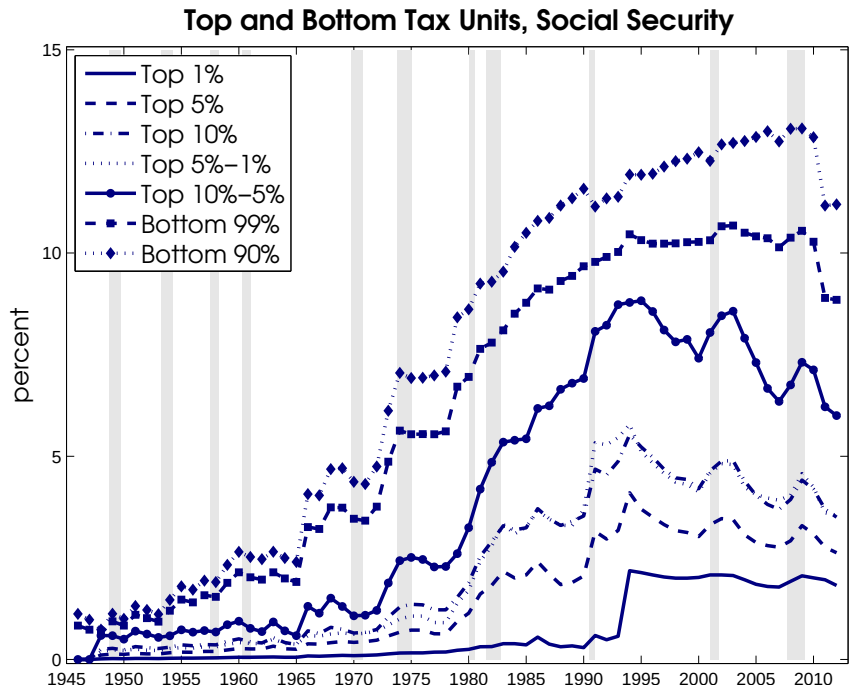


Average Marginal Tax Rates

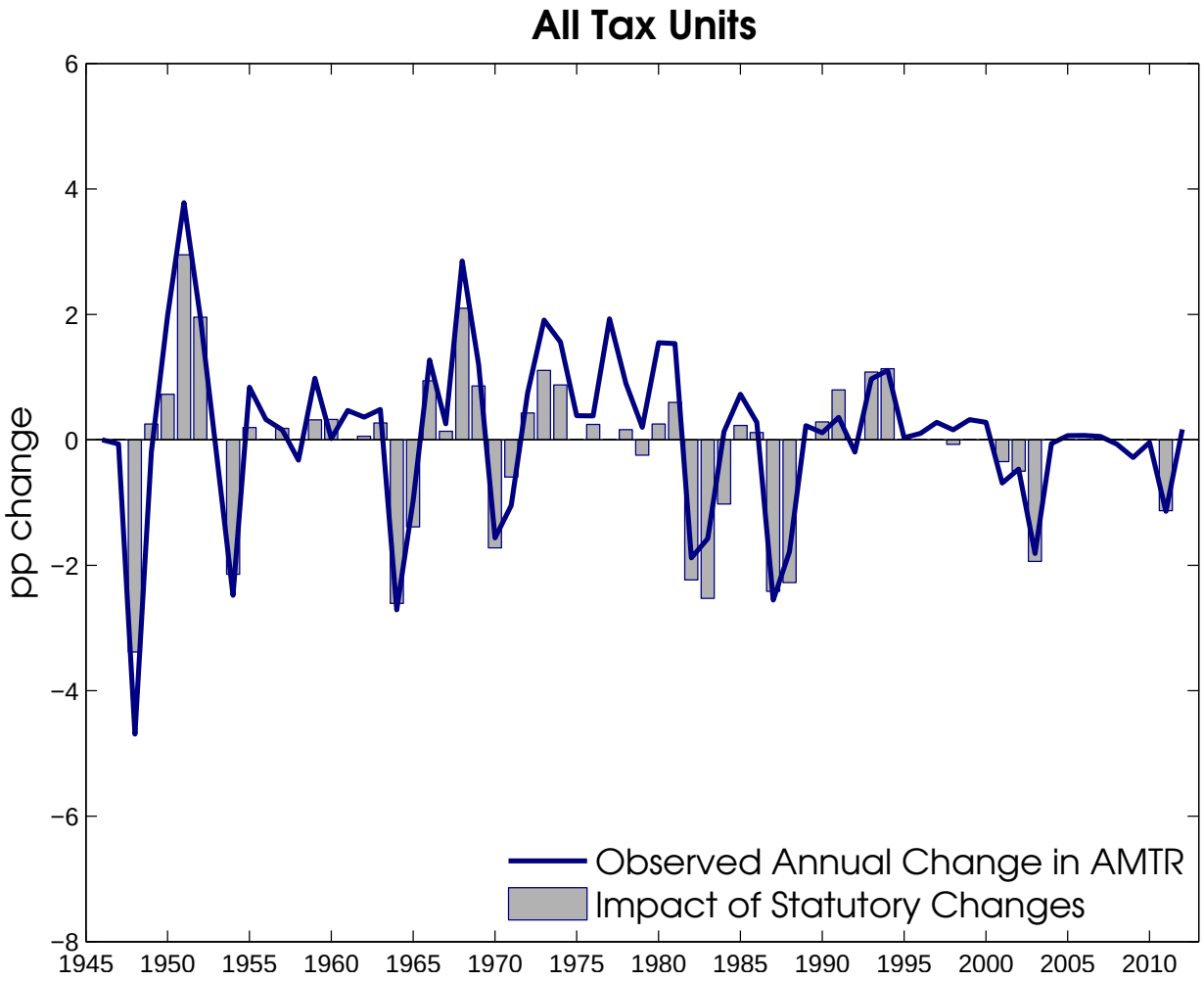


Average Marginal Tax Rates

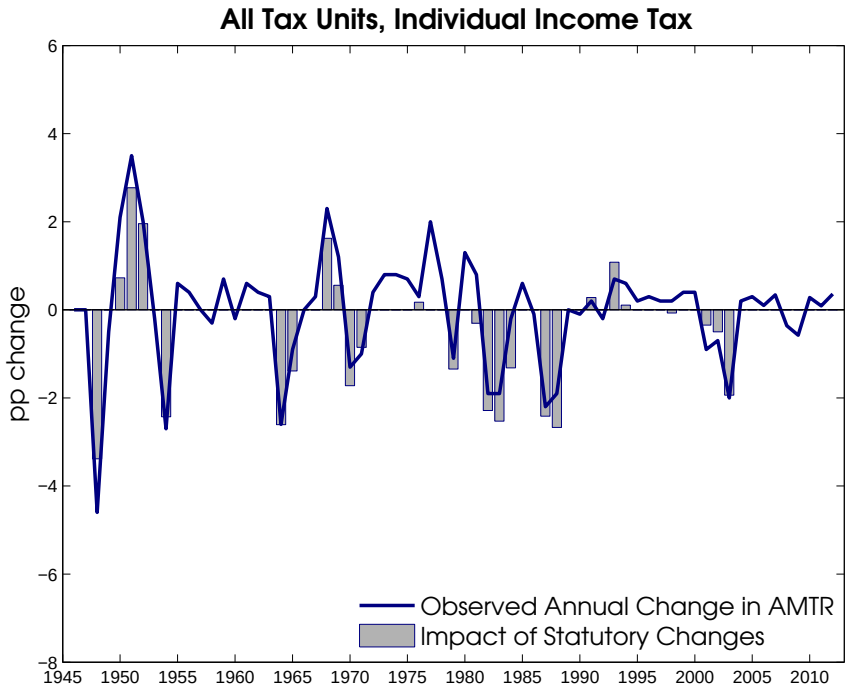




Tax Policy Changes



Tax Policy Changes



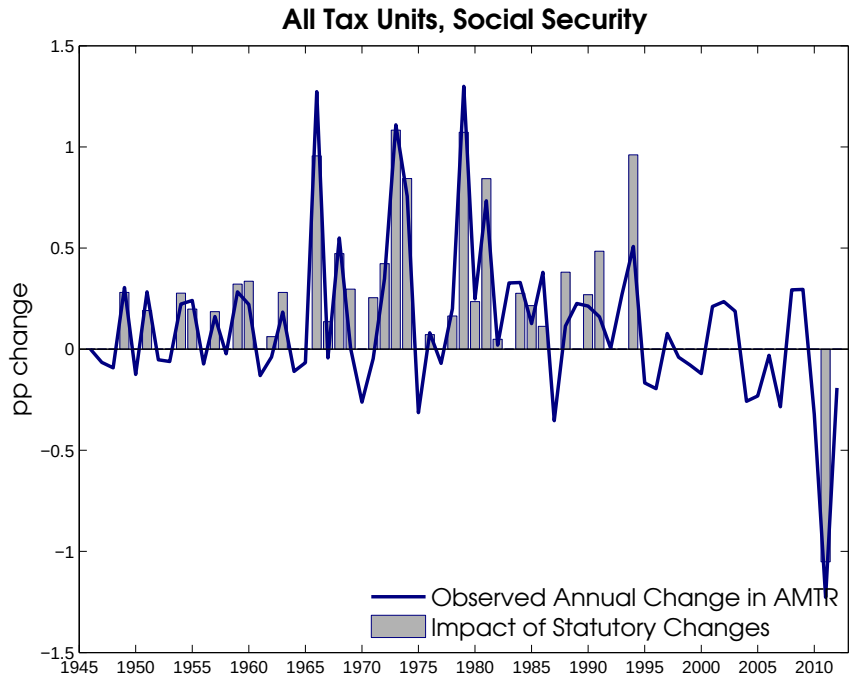


Table I Average Marginal Tax Rates 1946-2012: Descriptive Statistics

		AMTR × 100		Δln(1 − AMTR) × 100								
										% of total variation due to statutory changes in		
		Mean	*St. Dev.*	*St. Dev.*	*Correlation with* [2]	[3]	[5]	[8]	[9]	*Inc Tax*	*SS Tax*	*Both*
[1]	All (BR 2011)	29.11	4.38	1.83	0.97	0.82	0.91	0.96	0.93	0.76	0.14	0.87
[2]	All (PS 2007)	29.50	5.05	1.99	1.00	0.84	0.93	0.99	0.96	0.74	0.17	0.86
[3]	Top 1%	45.20	7.34	4.86	0.84	1.00	0.94	0.77	0.70	0.86	0.01	0.87
[4]	Top 5%	38.38	4.42	3.29	0.90	0.97	0.99	0.83	0.75	0.82	0.02	0.83
[5]	Top 10%	35.89	4.30	2.78	0.93	0.94	1.00	0.88	0.79	0.79	0.03	0.81
[6]	Top 5-1%	33.43	6.29	2.54	0.90	0.85	0.96	0.87	0.78	0.67	0.03	0.70
[7]	Top 10-5%	30.94	6.39	2.12	0.91	0.74	0.90	0.91	0.83	0.55	0.09	0.61
[8]	Bottom 99%	27.80	5.74	1.87	0.99	0.77	0.88	1.00	0.98	0.62	0.20	0.80
[9]	Bottom 90%	26.03	5.46	1.86	0.96	0.70	0.79	0.98	1.00	0.53	0.24	0.77

Descriptive statistics for combined federal income and social security tax rates (see section 2.2). AMTR is the tax rate in percent and $\Delta\ln(1-\text{AMTR})$ is the annual log change in the net-of-tax rate. Rows [1]-[2] are national averages using Barro and Redlick (2011), resp. Piketty and Saez (2007) income concepts. Rows [3] to [9] are averages within the specified brackets using the income measures of Piketty and Saez (2007). The last three columns report the R^2 coefficient of regressions of $\Delta\ln(1-\text{AMTR})$ on the estimated impact of statutory changes to income taxes, social security taxes, or both, on the overall tax rates of the specified income bracket. These numbers indicate explanatory power of legislated tax changes for average marginal tax rates only in a purely accounting sense.

Some Regressions

Same year tax elasticity:

$$\Delta \log(income_t) = \beta \Delta \log(1 - AMTR_t) + u_t$$

Following year tax elasticity:

$$\log(income_{t+1}) - \log(income_{t-1}) = \beta \Delta \log(1 - AMTR_t) + u_t$$

See Saez (2004), Slemrod (1995), Saez, Slemrod & Giertz (2012)

Table II Preliminary Univariate Regressions

	All Tax Units		Top 1%	Top 5%	Top 10%	Top 5-1%	Top 10-5%	Btm. 99%	Btm. 90%
	BR 2011	PS 2007							
A. Ordinary Least Squares, Sample: 1947-2012									
Same year	−0.23	−0.21	0.55**	0.37	0.28	0.02	−0.00	−0.35**	−0.49***
	(−0.62, 0.16)	(−0.51, 0.09)	(0.02, 1.07)	(−0.12, 0.86)	(−0.13, 0.70)	(−0.23, 0.26)	(−0.21, 0.20)	(−0.65, −0.06)	(−0.82, −0.16)
Following year	−0.09	−0.09	0.84***	0.62**	0.49**	0.21	0.09	−0.31	−0.52
	(−0.77, 0.58)	(−0.68, 0.50)	(0.24, 1.44)	(0.13, 1.11)	(0.05, 0.92)	(−0.06, 0.48)	(−0.30, 0.49)	(−0.96, 0.33)	(−1.24, 0.20)
B. Ordinary Least Squares with Controls, Sample: 1948-2012									
Same year	−0.05	−0.07	0.61***	0.48***	0.40***	0.01	−0.03	−0.19	−0.28
	(−0.43, 0.33)	(−0.36, 0.22)	(0.31, 0.91)	(0.25, 0.70)	(0.20, 0.60)	(−0.16, 0.18)	(−0.15, 0.10)	(−0.52, 0.13)	(−0.69, 0.14)
Following year	0.09	0.19	1.02***	0.80***	0.64***	0.19**	0.15	0.07	0.00
	(−0.44, 0.63)	(−0.29, 0.67)	(0.70, 1.33)	(0.50, 1.10)	(0.38, 0.90)	(0.04, 0.34)	(−0.11, 0.41)	(−0.38, 0.52)	(−0.56, 0.57)
C. 2SLS with Controls and Statutory Tax Changes as Instrument, Sample: 1948-2012									
Same year	0.04	0.08	0.64***	0.48***	0.39**	0.13	−0.09	−0.10	−0.09
	(−0.33, 0.42)	(−0.26, 0.43)	(0.22, 1.05)	(0.16, 0.80)	(0.10, 0.68)	(−0.11, 0.37)	(−0.37, 0.20)	(−0.52, 0.33)	(−0.63, 0.44)
Following year	0.33	0.40*	1.07***	0.75***	0.57***	0.22*	0.03	0.20	0.36
	(−0.11, 0.77)	(−0.05, 0.86)	(0.59, 1.54)	(0.43, 1.07)	(0.30, 0.83)	(−0.03, 0.47)	(−0.34, 0.40)	(−0.36, 0.76)	(−0.27, 0.99)
1st Stage F	307.68	149.49	124.82	232.03	150.80	72.87	50.84	190.72	160.56

(Newey West 95% confidence intervals in parentheses)

At least two key endogeneity problems remain:

1. Tax policy changes are responses to changes in spending, public debt, unemployment, past tax rates,...

2. Many tax changes are legislated well before they are go into effect

A Proxy/External Instrument Approach

Estimate instead

$$\upsilon_t^{income} = \beta \upsilon_t^{AMTR} + u_t$$

using AMTR impact of Romer tax reforms (A2) as instrument, where

$$\begin{aligned} \upsilon_t^{income} &\equiv \log(income_t) - E\left[\log(income_t) \mid \mathcal{I}_{t-1}\right] \\ \upsilon_t^{AMTR} &\equiv \log(1 - AMTR_t) - E\left[\log(1 - AMTR_t) \mid \mathcal{I}_{t-1}\right] \end{aligned}$$

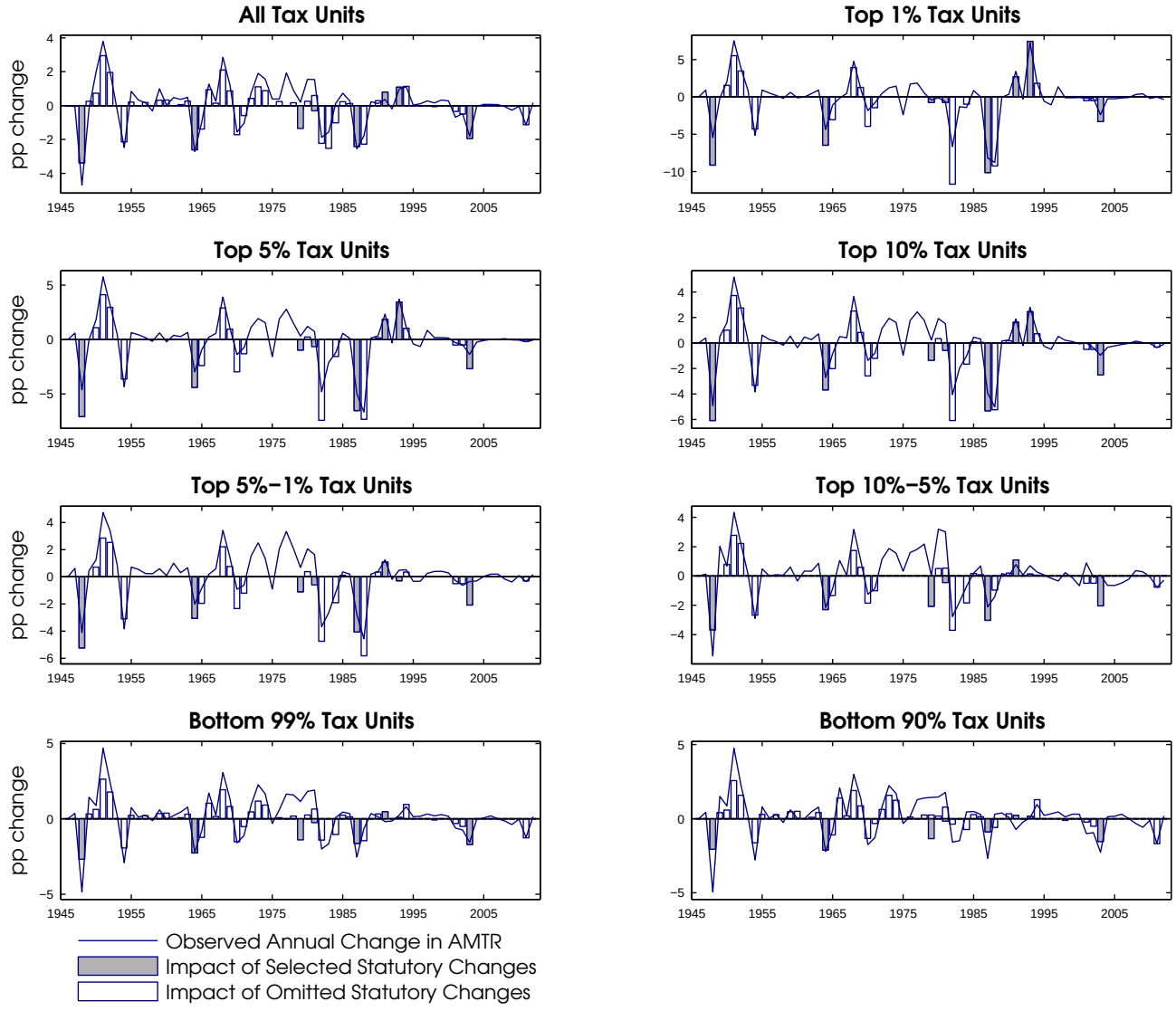
Model $E[\cdot \mid \mathcal{I}_{t-1}]$ by a VAR.

New instruments for marginal tax rate changes to increase relevance (A1):

Counterfactual change in AMTR from $t-1$ to t of changes to the tax code made by the new law relative to tax code for period t under prior law, fixing all incomes to levels in period $t-1$ and adjusting for automatic indexation provisions.

Table III Estimated AMTR Impact of Selected Tax Reforms

	In year	**All Tax Units**	**Top 1%**	**Top 5%**	**Top 10%**	**Top 5-1%**	**Top 10-5%**	**Btm. 99%**	**Btm. 90%**
Revenue Act of 1948	1948	−3.38	−9.14	−7.07	−6.07	−5.24	−3.68	−2.67	−2.06
Revenue Act of 1964	1964	−2.61	−6.47	−4.39	−3.66	−3.05	−2.30	−2.26	−2.11
Revenue Act of 1978	1979	−1.35	−0.76	−0.96	−1.36	−1.09	−2.06	−1.40	−1.34
Economic Recovery Tax Act 1981	1981	−0.31	−0.77	−0.66	−0.58	−0.58	−0.46	−0.26	−0.17
Tax Reform Act of 1986	1987	−2.41	−10.15	−6.52	−5.31	−4.05	−3.03	−1.64	−0.89
Omnibus Budget Reconciliation Act of 1990	1991	0.79	2.70	1.86	1.63	1.09	1.09	0.48	0.22
Omnibus Budget Reconciliation Act of 1993	1993	1.08	7.43	3.45	2.45	−0.28	0.13	0.09	0.17
Jobs and Growth Tax Relief Reconciliation Act of 2003	2003	−1.95	−3.30	−2.68	−2.50	−2.07	−2.03	−1.71	−1.54


All Tax Units
Top 1% Tax Units
Top 5% Tax Units
Top 10% Tax Units
Top 5%−1% Tax Units
Top 10%−5% Tax Units
Bottom 99% Tax Units
Bottom 90% Tax Units
pp change
1945
1955
1965
1975
1985
1995
2005
Observed Annual Change in AMTR
Impact of Selected Statutory Changes
Impact of Omitted Statutory Changes

Benchmark Specification

$$\begin{bmatrix} \ln(1 - AMTR_t) \\ \ln(income_t) \\ X_t \end{bmatrix} = d_t + B(L) \begin{bmatrix} \ln(1 - AMTR_{t-1}) \\ \ln(income_{t-1}) \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \upsilon_t^{AMTR} \\ \upsilon_t^{income} \\ \upsilon_t^{x} \end{bmatrix},$$

Sample: 1946-2012, two lags, so effectively 1948-2012

d_t: constant term and 1949 and 2008 dummies

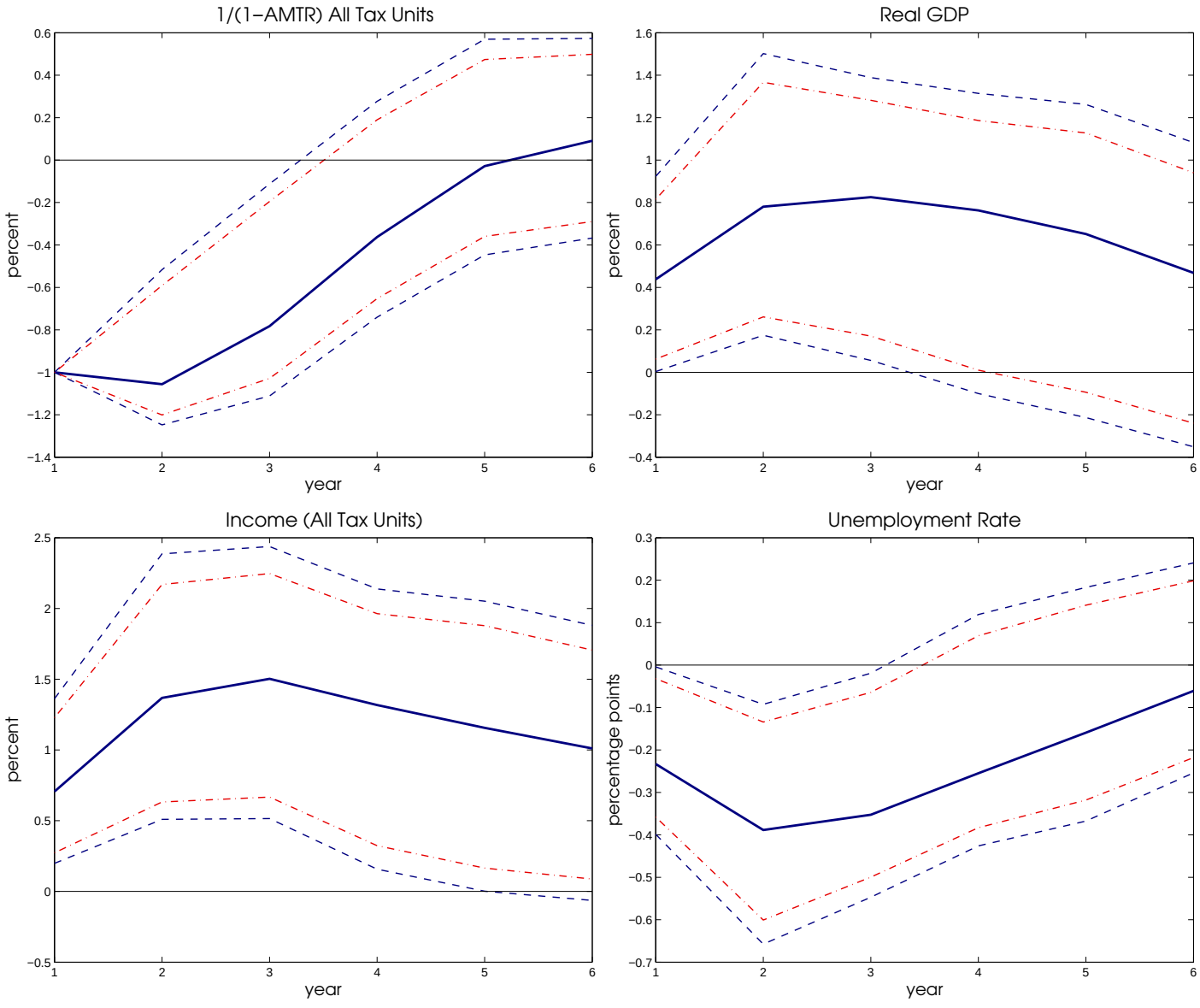
$\log(1 - AMTR_t^j)$: AMTR for income group j

$\log(income_t^j)$: average total income (or wage) income reported to IRS for income group j

X_t: macro controls

- Log real GDP per capita
- Unemployment Rate
- Inflation (CPI-U-RS)
- Federal Funds Rate
- Log real government spending per capita (Purchases + Net Transfers)
- Log change of real federal government debt per capita (held by the public)
- Log real stock price index

Aggregate Results



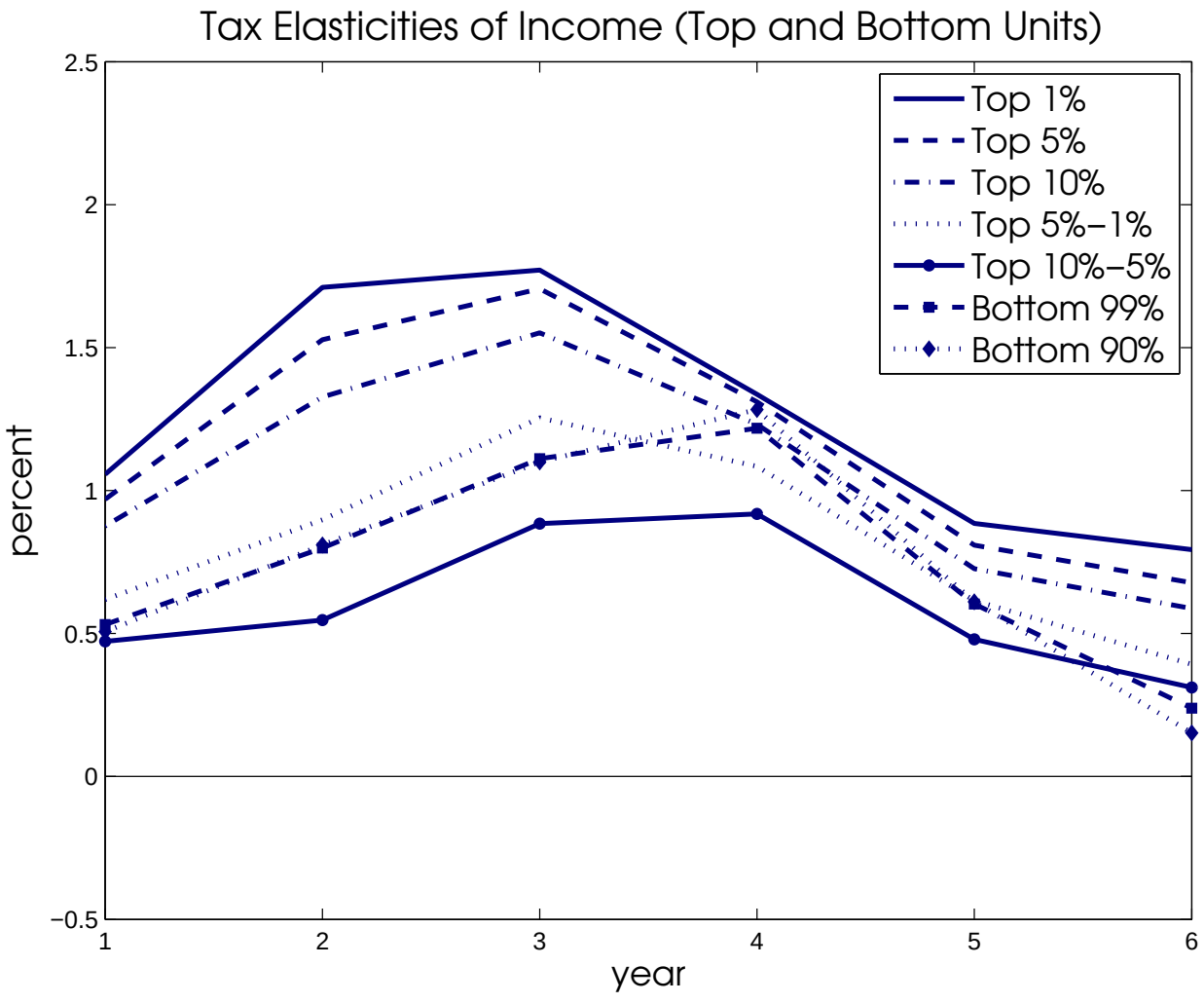
95% and 90% bootstrapped confidence bands

Table IV Structural Estimates of Short Run Tax Elasticities of Income

	All Tax Units		Top 1%	Top 5%	Top 10%	Top 5-1%	Top 10-5%	Btm. 99%	Btm. 90%
	BR 2011	PS 2007							
A. 2SLS with Controls and Selected Statutory Tax Changes as Instrument, Sample: 1948-2012									
Same year	0.71***	0.75***	0.71***	0.66***	0.65***	0.56*	0.47***	0.44*	0.51
	(0.29, 1.13)	(0.30, 1.19)	(0.26, 1.16)	(0.23, 1.08)	(0.25, 1.06)	(−0.06, 1.17)	(0.12, 0.82)	(−0.07, 0.95)	(−0.24, 1.26)
Following year	1.19***	1.24***	1.37***	1.24***	1.03***	0.85**	0.50	0.73	0.79
	(0.45, 1.93)	(0.57, 1.91)	(0.44, 2.30)	(0.57, 1.92)	(0.45, 1.61)	(0.12, 1.58)	(−0.12, 1.12)	(−0.19, 1.66)	(−0.35, 1.94)
1st Stage F	229.25	62.24	51.30	33.38	34.43	17.88	14.07	29.91	16.90
B. 2SLS with Controls and Aggregate SVAR Tax Shock as Instrument, Sample: 1948-2012									
Same year	0.71***	0.71**	0.69***	0.64***	0.60***	0.61***	0.47***	0.51*	0.49
	(0.20, 1.21)	(0.17, 1.24)	(0.19, 1.19)	(0.22, 1.07)	(0.20, 0.99)	(0.21, 1.02)	(0.15, 0.78)	(−0.08, 1.09)	(−0.24, 1.21)
Following year	1.07***	1.08***	1.31***	1.13***	0.93***	0.85***	0.53**	0.80**	0.83*
	(0.41, 1.74)	(0.42, 1.74)	(0.60, 2.02)	(0.66, 1.60)	(0.55, 1.32)	(0.24, 1.46)	(0.07, 0.99)	(0.03, 1.57)	(−0.10, 1.77)
1st Stage F	100.56	53.68	60.97	74.01	72.77	18.80	54.39	53.00	45.99
C. Structural VAR using Selected Statutory Tax Changes as Proxy, Sample: 1948-2012									
Same year	0.71***	0.75***	0.71***	0.66**	0.65**	0.56*	0.47**	0.44	0.51*
	(0.19, 1.33)	(0.25, 1.46)	(0.29, 1.04)	(0.13, 1.12)	(0.18, 1.25)	(−0.05, 2.25)	(0.01, 1.25)	(−0.08, 1.10)	(−0.04, 1.34)
Following year	1.37***	1.45***	1.35***	1.21**	1.06**	0.91*	0.79**	1.01**	0.98**
	(0.50, 2.33)	(0.61, 2.53)	(0.53, 1.89)	(0.30, 1.97)	(0.10, 1.86)	(−0.01, 2.73)	(0.09, 1.76)	(0.16, 2.02)	(0.03, 2.12)

2SLS: Newey West 95% confidence intervals in parentheses
SVAR: 95% bootstrapped confidence bands

Dynamic Elasticities Across the Income Distribution



Average Tax Rates or Marginal Tax Rates?

Extend the VAR by including average tax rate.

Use the Romer tax liability narrative as an additional instrument.

Table VI Estimated Tax Liability Impact of Selected Tax Reforms

		Federal Individual Income Tax		Social Security Tax	
	Due to	Changes in rate schedule (1)	Other changes (2)	OASDI-HI changes (3)	Other changes (4)
	In year				
[1] Revenue Act of 1948	1948	−2.4	−2.2	0	0
[2] Internal Revenue Code of 1954	1954	0	-0.8	0	0
[3] Revenue Act of 1964	1964	−6.3	0.2	0	0
[4] Revenue Act of 1971	1971	0	−2.0	0	0
[5] Tax Reform Act of 1976	1976	1.65	0	0	0
[6] Tax Reduction and Simplification Act of 1977	1977	0	−5.4	0	0
[7] Revenue Act of 1978	1979	−10.4	−4.8	0	0
[8] Economic Recovery Tax Act 1981	1981	−3.6	0.5	0	0
[9] Tax Equity and Fiscal	1982	0	0.7	0	0
Responsibility Act of 1982	1983	0.7	3.1	0.8	2.2
[10] Deficit Reduction Act of 1984	1984	0	2.1	0	0
[11] Tax Reform Act of 1986	1987	−21.1	3.7	0	−0.1
[12] Omnibus Budget Reconciliation Act of 1987	1988	0	−0.2	0.5	1.2
[13] Omnibus Budget Reconciliation Act of 1990	1991	1.3	1.5	4.2	1.1
[14] Omnibus Budget Reconciliation Act of 1993	1993	15.4	0	0	0
[15] Jobs and Growth Tax Relief Reconciliation Act of 2003	2003	−43.0	−20.5	0	0

Billions of current dollars.

What is Identified by the Proxies

Correlation between average and marginal tax instrument is of course very high, hence neither is measure of independent exogenous variation.

$$\begin{aligned} \upsilon_{1t} &= \eta\upsilon_{2t} + S_1 e_{1t} \\ \upsilon_{2t} &= \zeta\upsilon_{1t} + S_2 e_{2t} \end{aligned}$$

υ_{1t} : reduced form marginal and average tax rate innovations (in this order)
υ_{2t} : reduced form innovations to other variables
e_{1t}: structural tax shocks
e_{2t}: other structural shocks

Need to identify $\mathcal{D}_1 = \begin{bmatrix} \mathcal{D}_{11} \\ \mathcal{D}_{21} \end{bmatrix} = \begin{bmatrix} I + \eta(I - \zeta\eta)^{-1}\zeta \\ (I - \zeta\eta)^{-1}\zeta \end{bmatrix} S_1$

Covariance restrictions identify $\mathcal{D}_{21}{\mathcal{D}_{11}}^{-1}$ and $S_1 S_1'$, but not S_1.

Additional Restriction

$$\begin{aligned} v_{1t} &= \eta v_{2t} + S_1 e_{1t} \\ v_{2t} &= \zeta v_{1t} + S_2 e_{2t} \end{aligned}$$

We can obtain response to any linear combination of shocks e_{1t}.

Meaningful IR's using a harmless zero restriction in S_1:

- S_1 lower triangular,

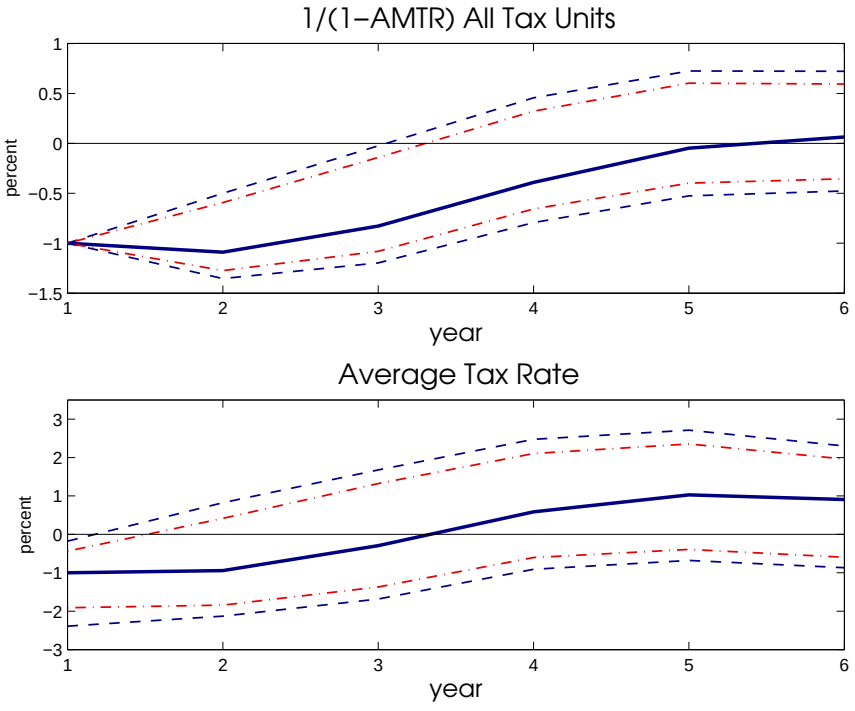
  first column is shock to marginal tax rates allowing for statutory change in average tax ratess

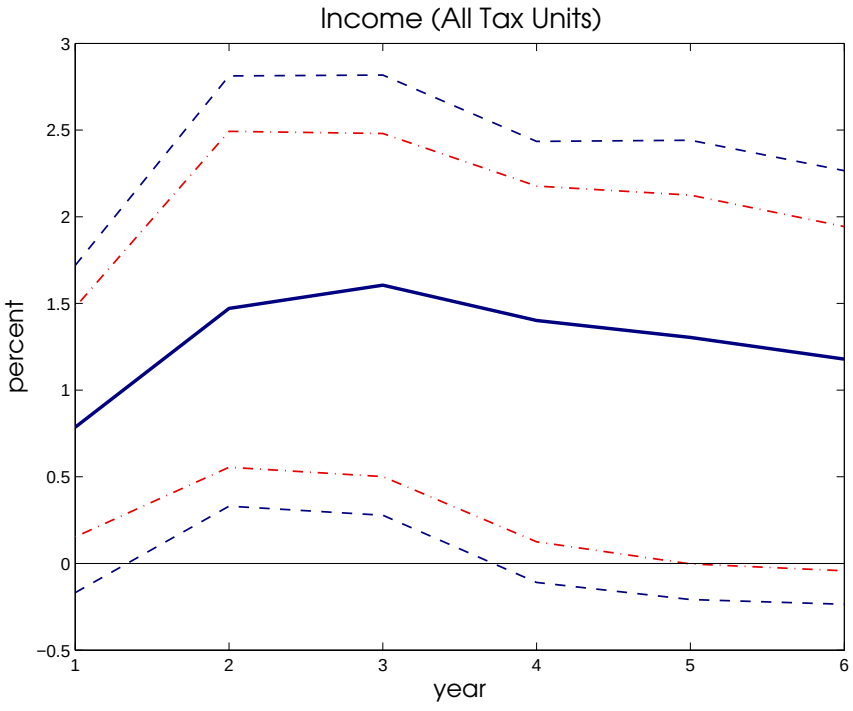
  second column is shock to average tax rates with no statutory change in marginal tax rates

- S_1 upper triangular,

  first column is shock to marginal tax with no statutory change in average tax rates

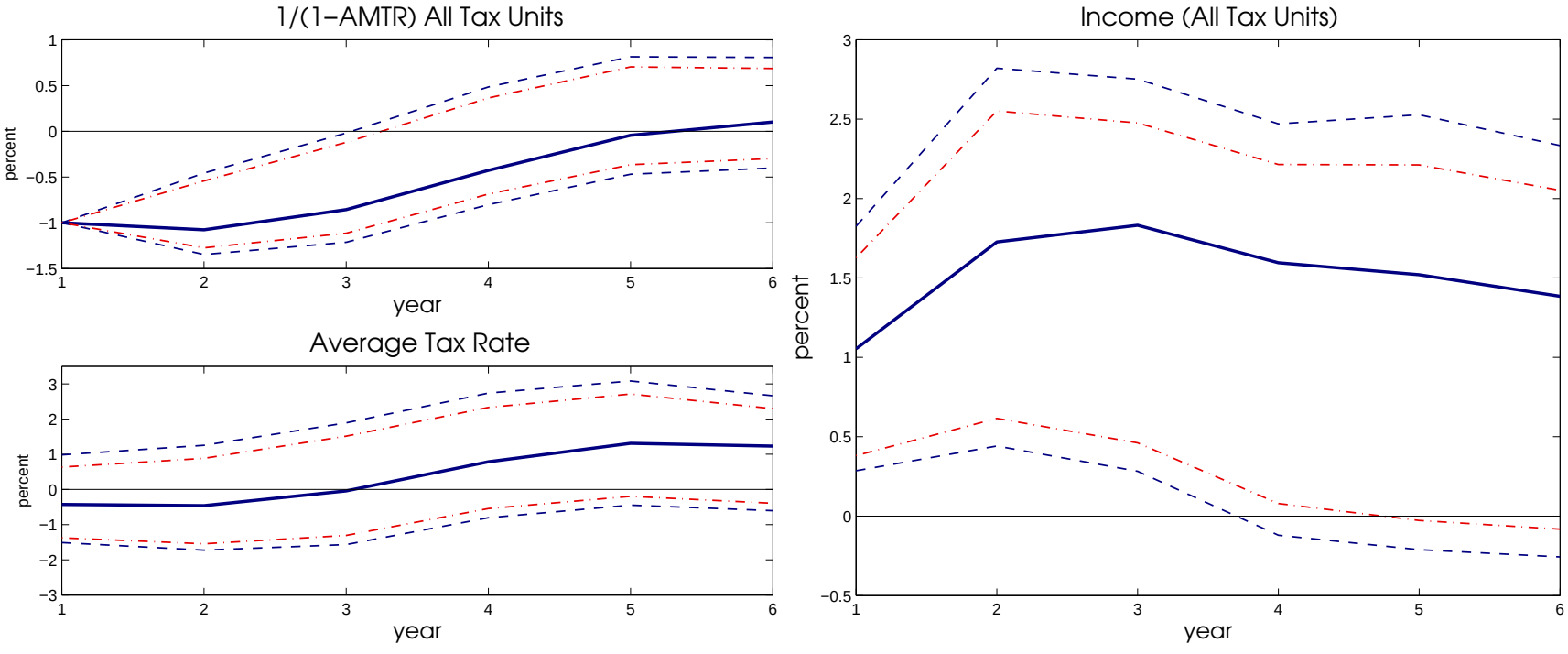
A. Cut in Marginal Tax Rate Allowing Statutory Impact on Average Tax Rate





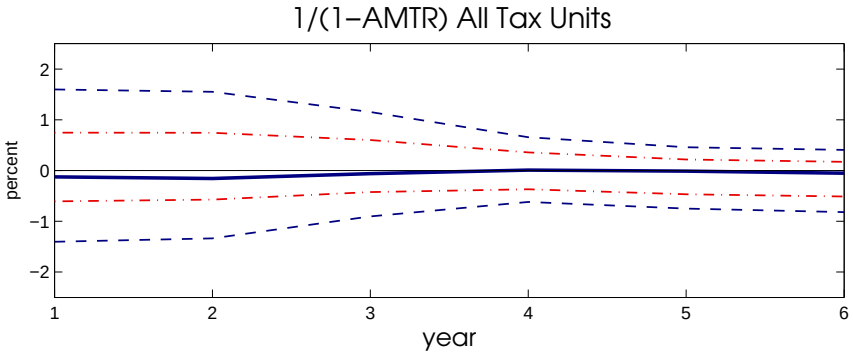
95% and 90% bootstrapped confidence bands

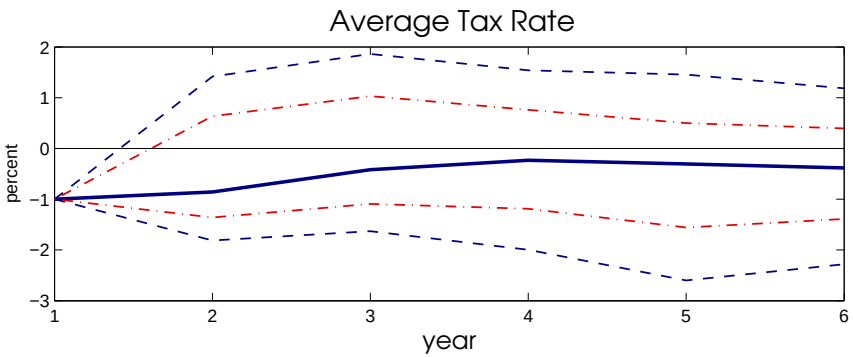
B. Cut in Marginal Tax Rate Without Statutory Impact on Average Tax Rate

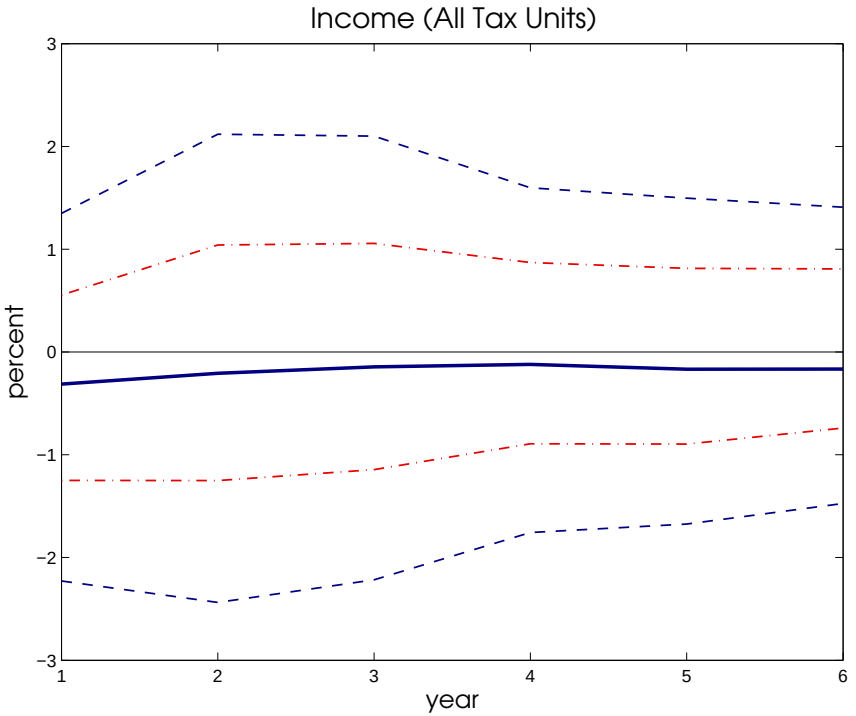


95% and 90% bootstrapped confidence bands

C. Cut in Average Tax Rate Without Statutory Impact on Marginal Tax Rate







95% and 90% bootstrapped confidence bands

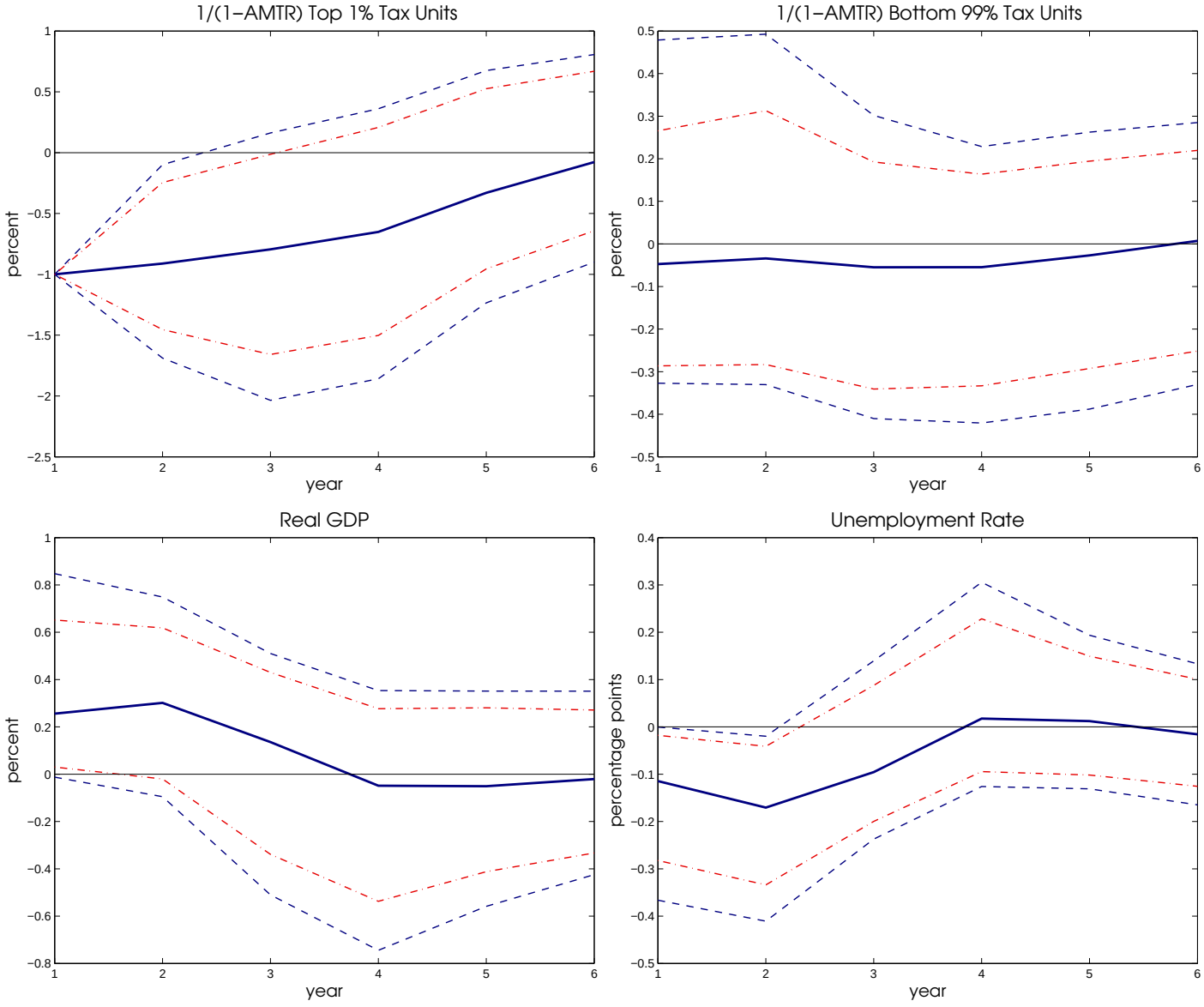
Changes in Top Marginal Rates

Why look at changes in top rates only?

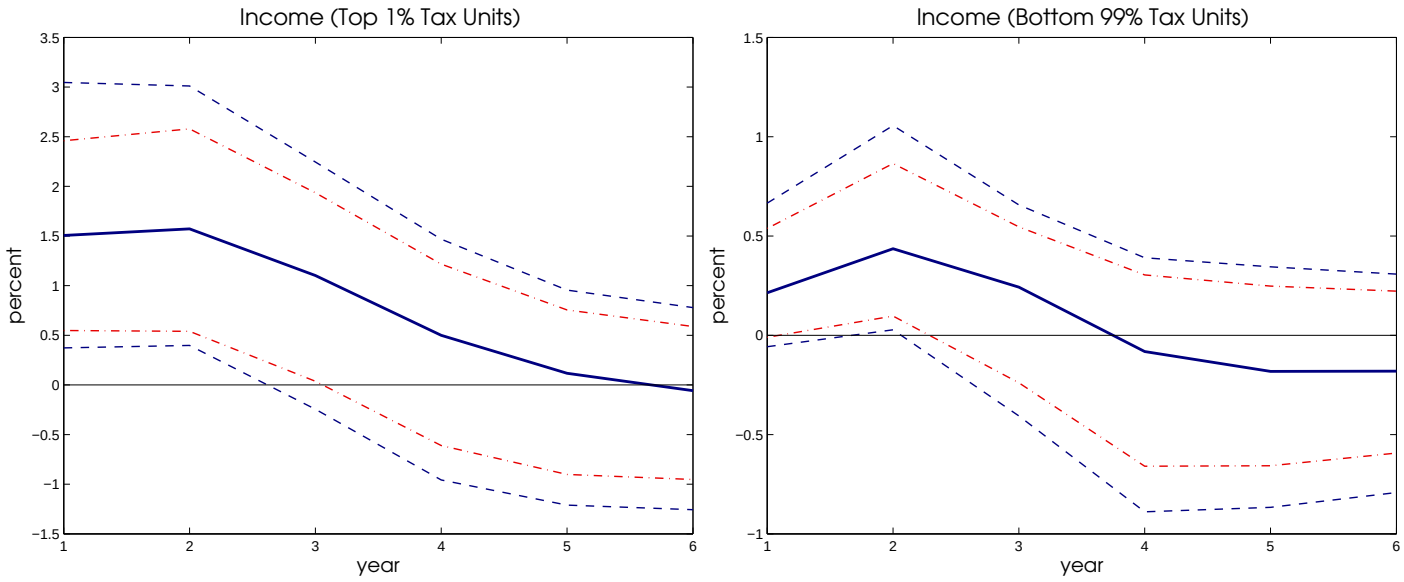
- Many postwar reforms have made large changes to top marginal tax rates.
- Top rates correlate with income inequality (Saez, Piketty & Stantcheva 2014).
- 'Smaller' general equilibrium effects (cfr. Romer and Romer 2012)

Methodology:

Include Top 1% and Bottom 99% AMTR and incomes jointly in the VAR and use corresponding instruments.



95% and 90% bootstrapped confidence bands

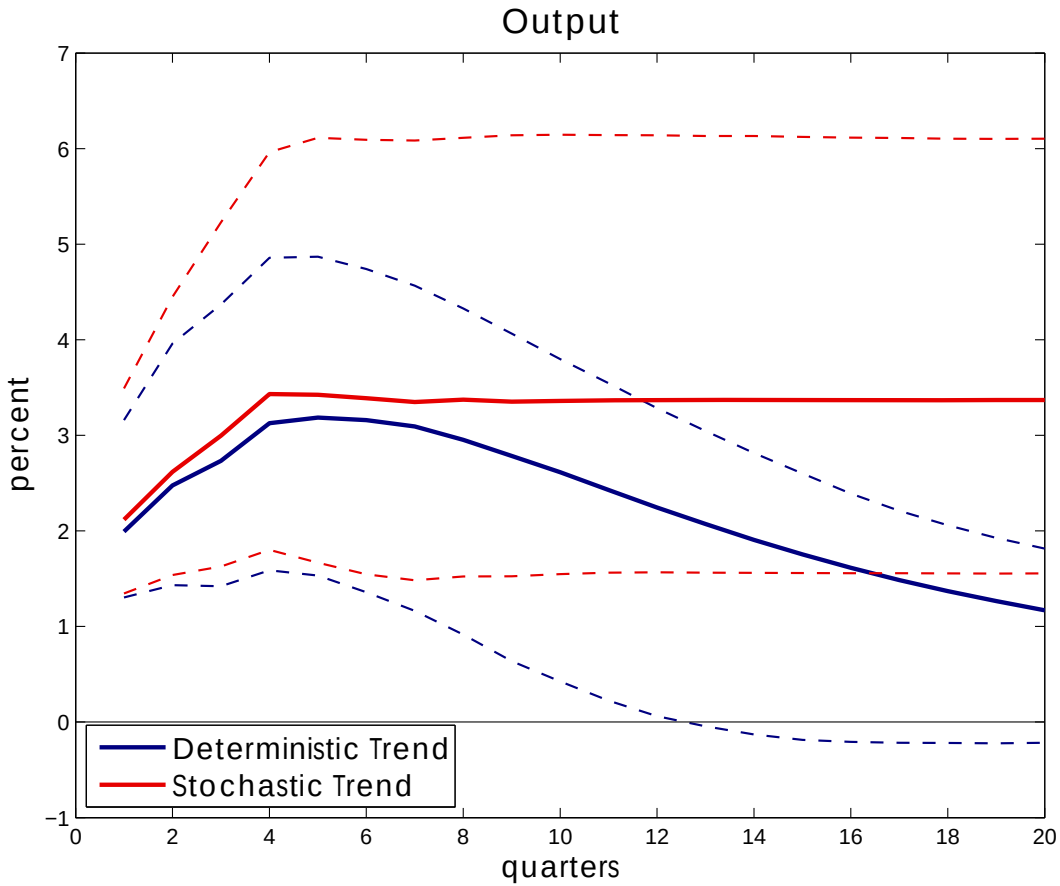


95% and 90% bootstrapped confidence bands

Main Takeaway

SVAR approach using proxies/external instruments has a strong effect on estimates of the tax elasticity of income!

Different Trend Assumptions



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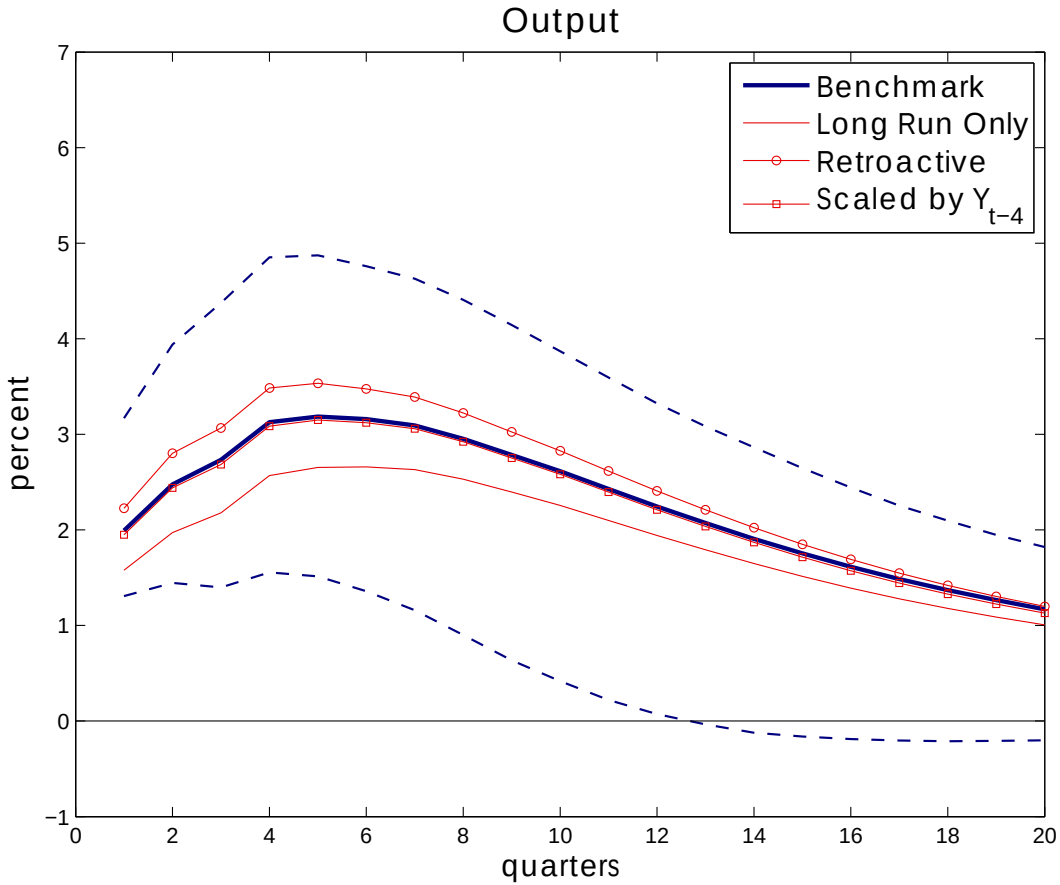
Alternative Narrative Measures



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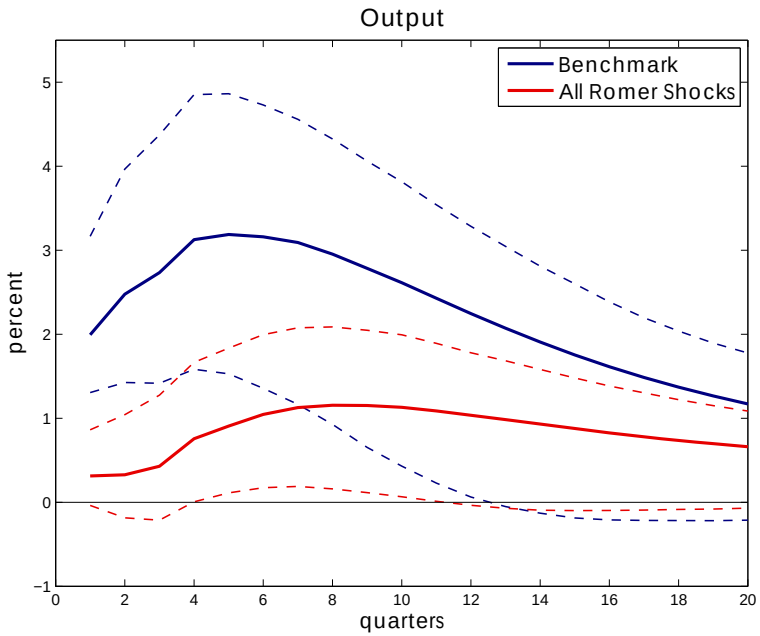
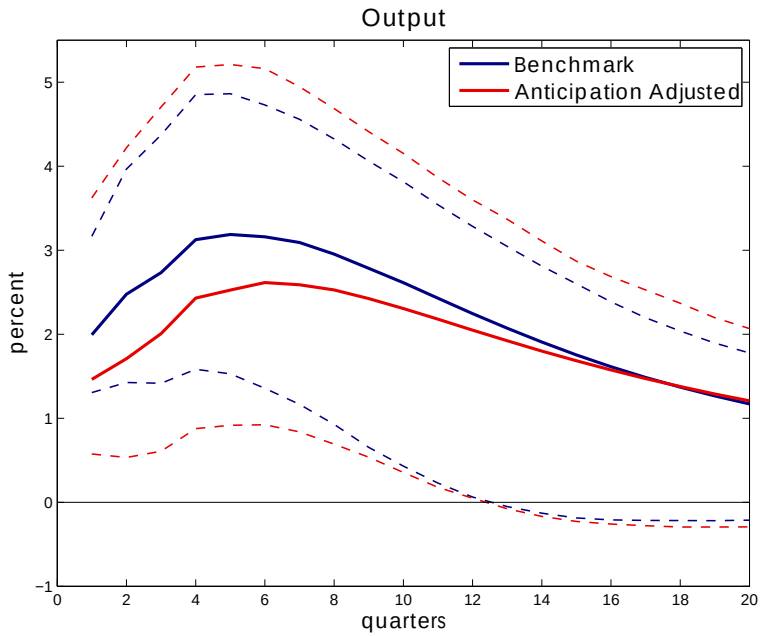
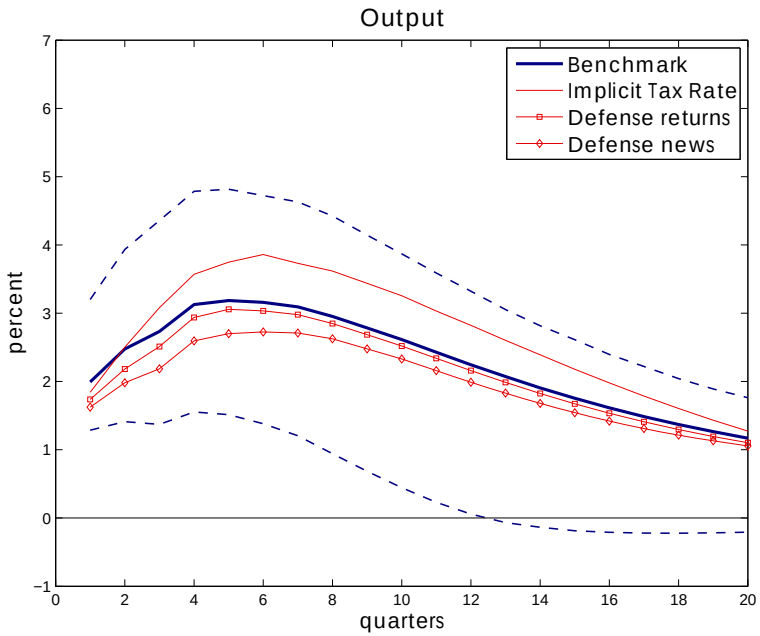
Using All Romer Shocks

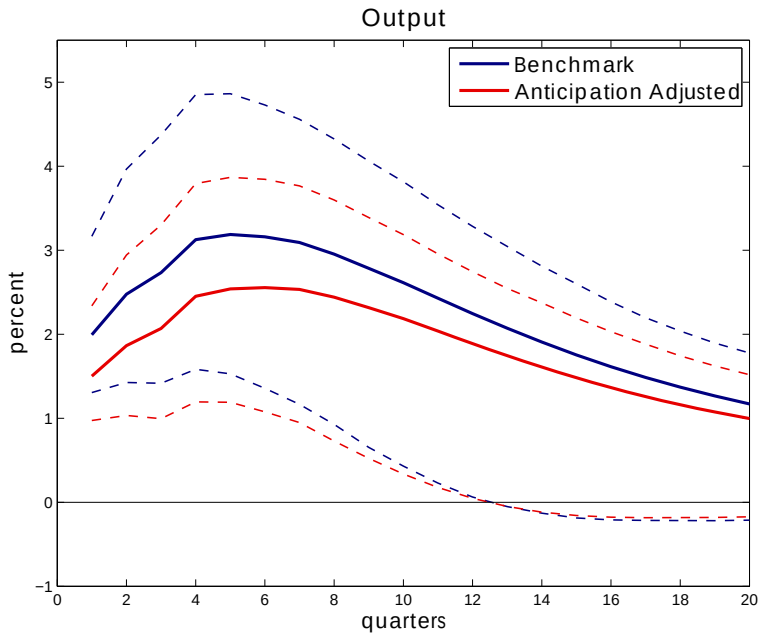




◂ back EXT ◂ back CF

Including 'Fiscal Foresight' Variables





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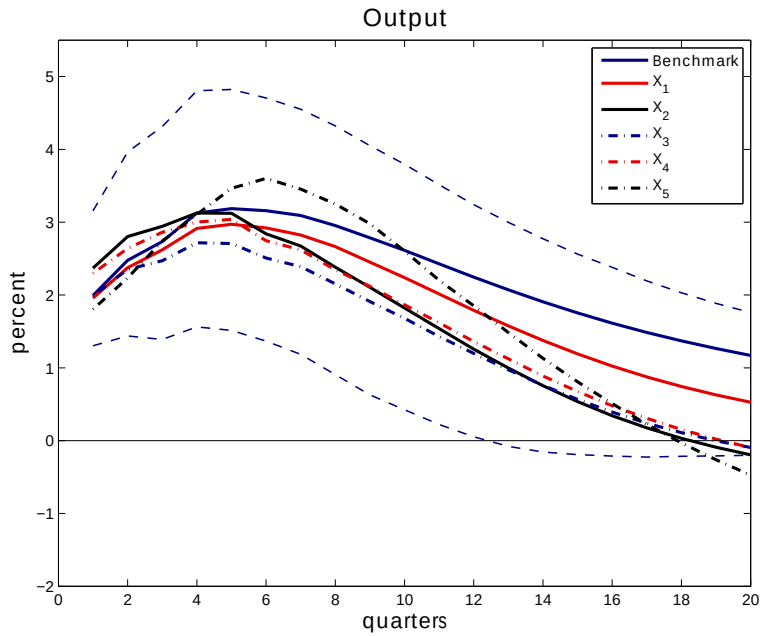
Alternative Proxies

Proxy Used	**Output Elasticity of Tax Revenues, θ_y**	**Reliability**
Benchmark	3.13	0.57
	[2.73, 3.55]	[0.50, 0.61]
Long Run Shocks Only	2.94	0.60
	[2.56, 3.33]	[0.56, 0.63]
Including Retroactive Provisions	3.30	0.48
	[2.78 3.87]	[0.35, 0.54]
Scaled by Y_{t-4}	3.14	0.57
	[2.73 3.57]	[0.45 0.61]
Benchmark, Anticipation Adjusted	2.88	0.59
	[2.53, 3.25]	[0.53, 0.63]
All Romer Tax Shocks	1.84	0.34
	[1.47, 2.29]	[0.25, 0.42]
All Romer Tax Shocks, Anticipation Adjusted	2.70	0.22
	[2.07, 3.53]	[0.13, 0.30]

Values in parenthesis are 95% percentiles computed using 10, 000 bootstrap replications.

◂ back ELA ◂ back REL

Larger VAR Systems



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Larger VAR Systems

Table A-1 Elasticities in Larger VAR Systems

Additional Variables X	$\tilde{\theta}_Y$	$\tilde{\theta}_G$	$\tilde{\theta}_{DEBT}$	$\tilde{\theta}_{FF}$	$\tilde{\theta}_P$	$\tilde{\theta}_{MBS}$	Reliability
$[GDP, G]$ (**Benchmark**)	3.13	-0.20					0.57
	[2.73, 3.55]	[−0.35, −0.07]					[0.50, 0.61]
$[GDP, G, DEBT]$	2.71	-0.15	0.52				0.58
	[2.37, 3.10]	[−0.29, −0.04]	[0.27, 0.69]				[0.52, 0.62]
$[GDP, G, DEBT, FF, P, NBR]$	2.55	-0.16	0.57	0.73	-0.04		0.55
	[1.51, 3.72]	[−0.69, 0.42]	[0.23, 0.85]	[−0.01, 1.60]	[−0.19, 0.08]		[0.44, 0.60]
$[GDP, G, DEBT, FF, P, NBR, DEFD]$	2.63	-0.14	0.49	0.48	-0.04		0.48
	[1.33, 4.08]	[−0.77, 0.56]	[0.05, 0.80]	[−0.45, 1.59]	[−0.22, 0.13]		[0.33, 0.56]
$[GDP, G, DEBT, FF, P, NBR, EXCR]$	2.74	-0.06	0.52	0.27	-0.02		0.53
	[1.62, 4.21]	[−0.69, 0.61]	[0.13, 0.82]	[−0.71, 1.24]	[−0.19, 0.11]		[0.38, 0.60]
$[GDP, G, DEBT, FF, P, NBR, MBS]$	2.77	0.26	0.55	0.42	-0.09	0.15	0.57
	[1.79, 4.28]	[−0.34, 1.05]	[0.16, 0.92]	[−0.55, 1.47]	[−0.28, 0.06]	[0.02, 0.30]	[0.42, 0.63]

Values in parenthesis are 95% percentiles computed using 10,000 bootstrap replications.

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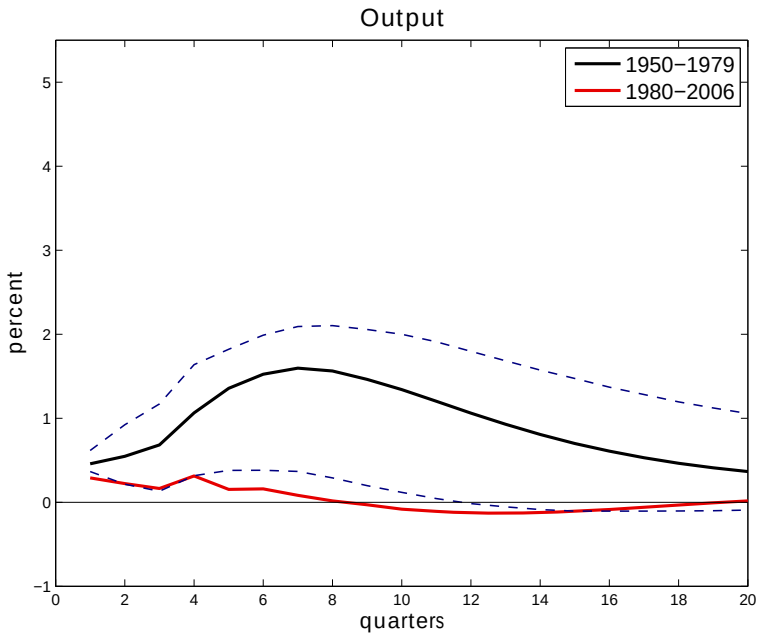
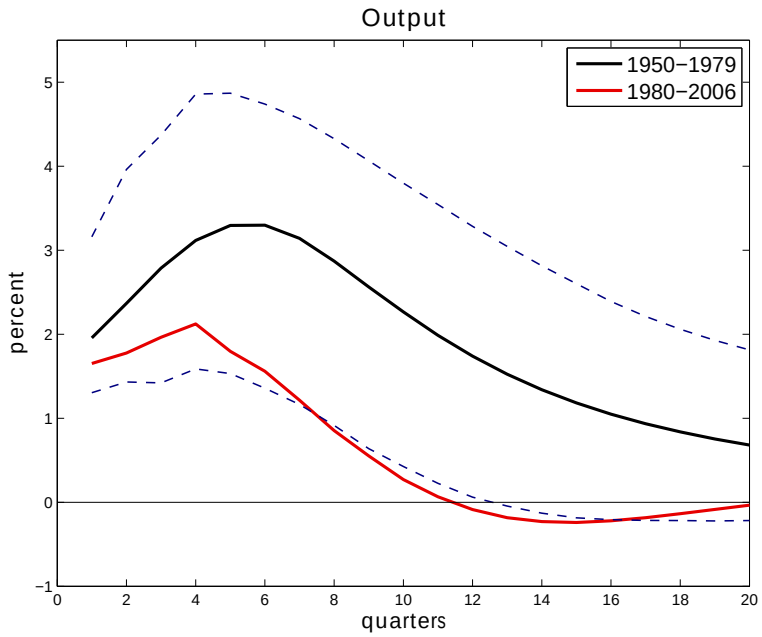
Subsample Stability





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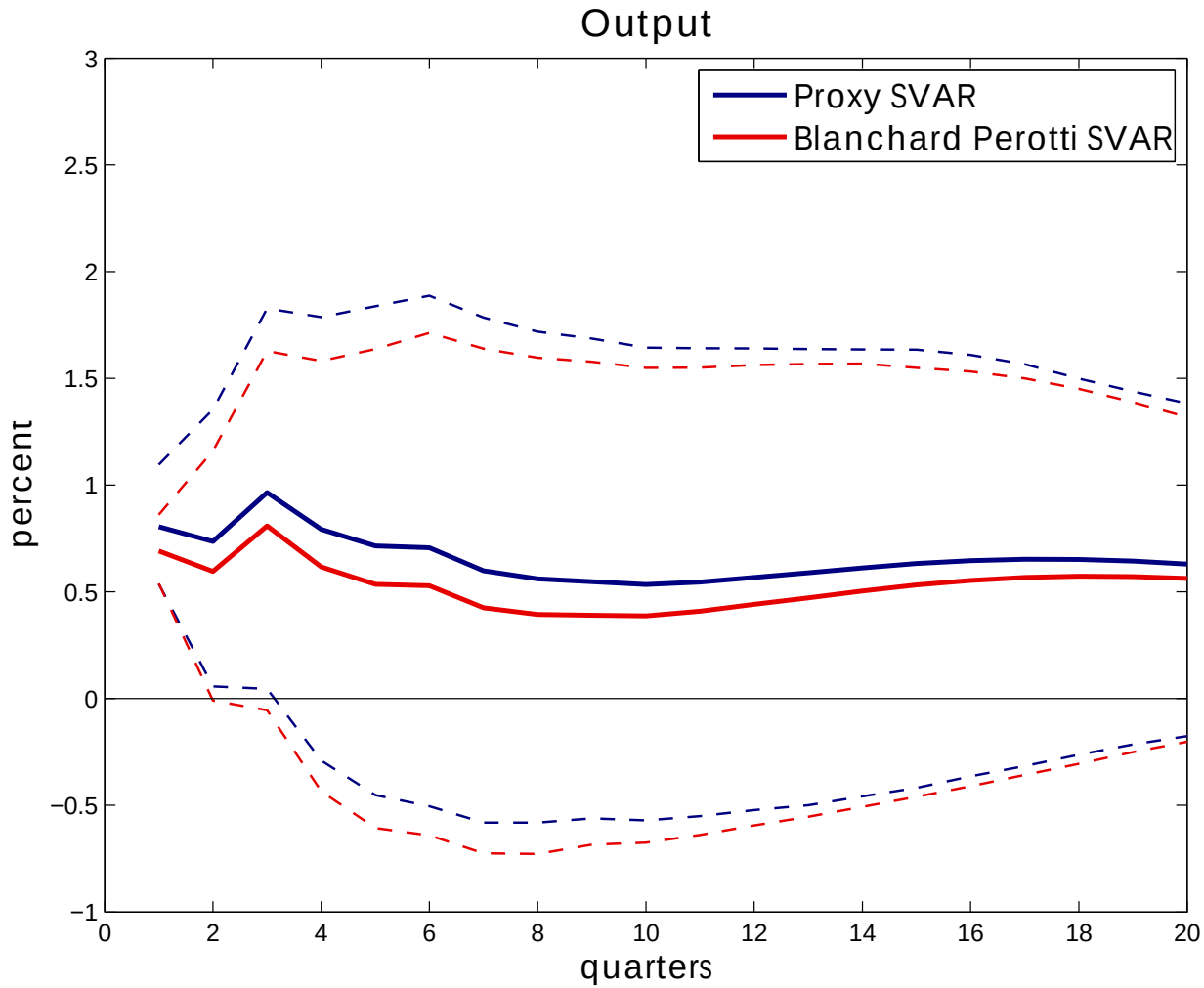
Government Spending Shocks



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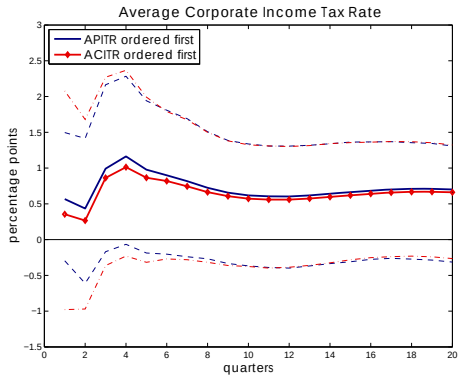
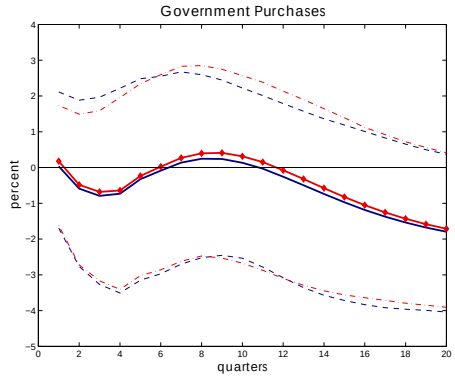
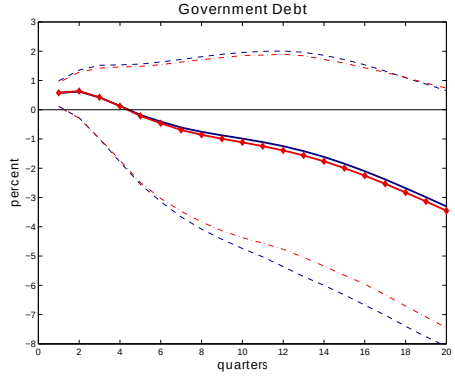
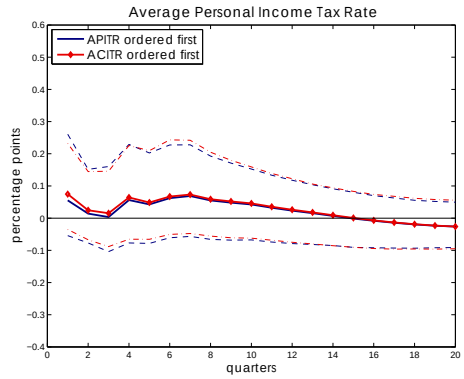
(A) Personal Income Tax Cut

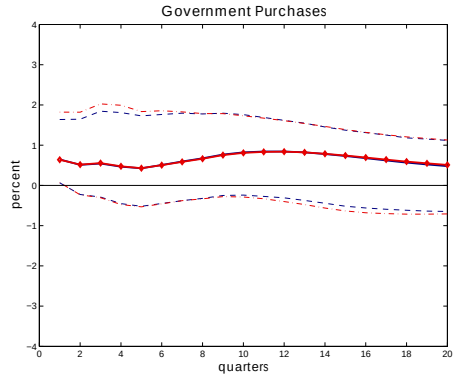


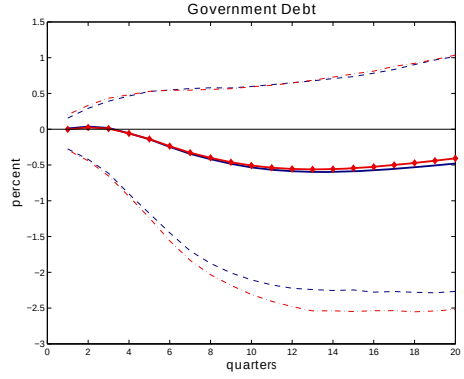




(B) Corporate Income Tax Cut







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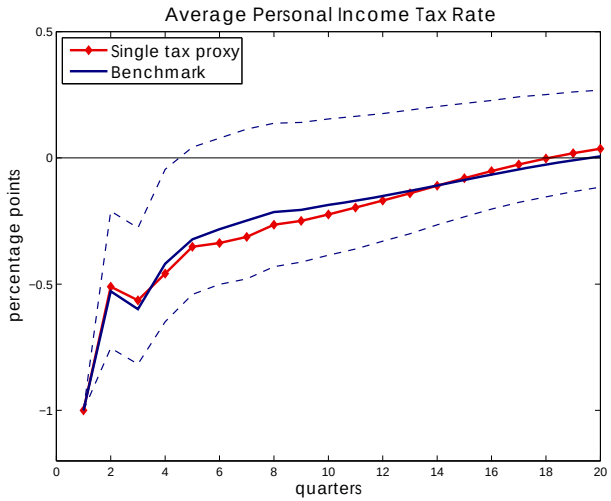
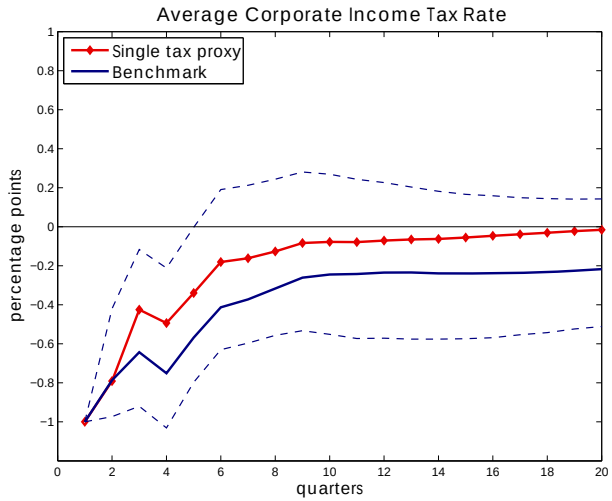
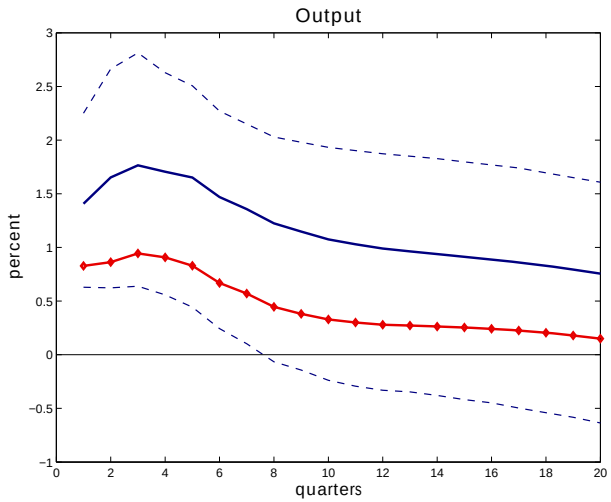
Ignoring Correlation m_t

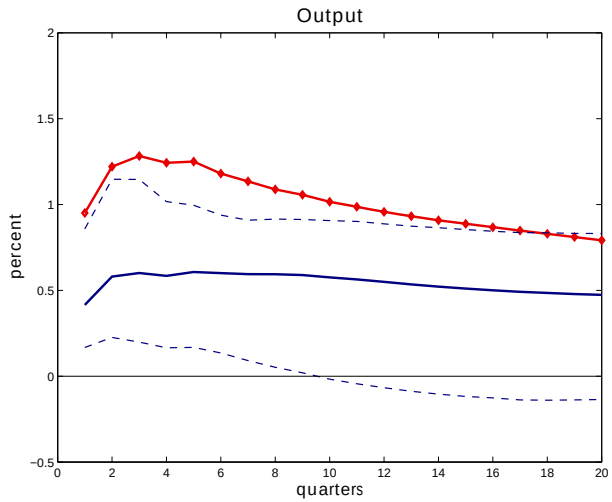
(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut







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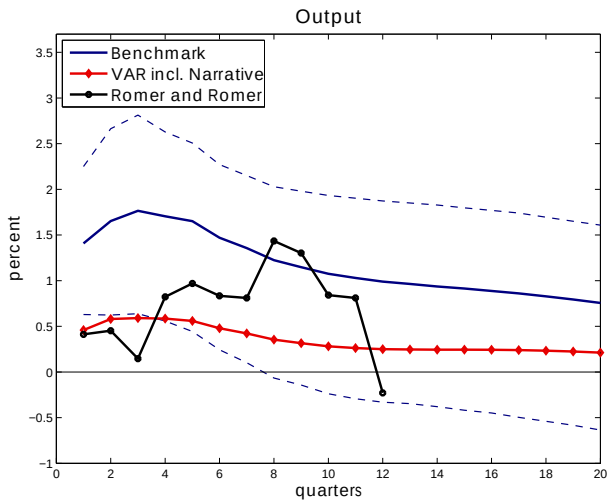
Traditional specifications

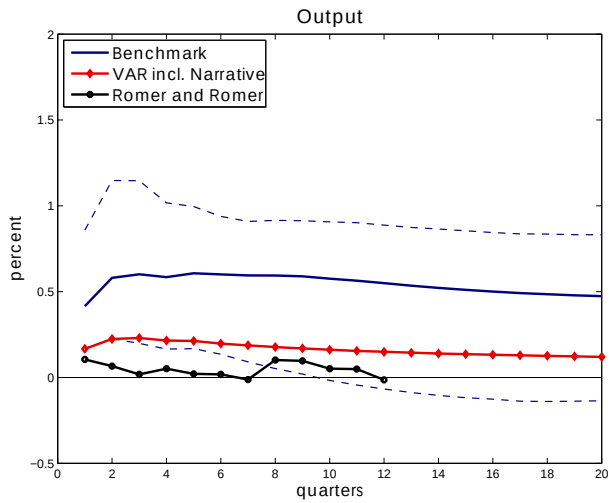
For $i = PI, CI$

$$\begin{aligned} \Delta \ln(GDP_t) &= \sum_{s=1}^{K} \beta_s \Delta T^{i,narr}_{t-s+1} + u_t \\ Y_t &= \delta' X_t + \beta \Delta T^{i,narr}_t + u_t \end{aligned}$$

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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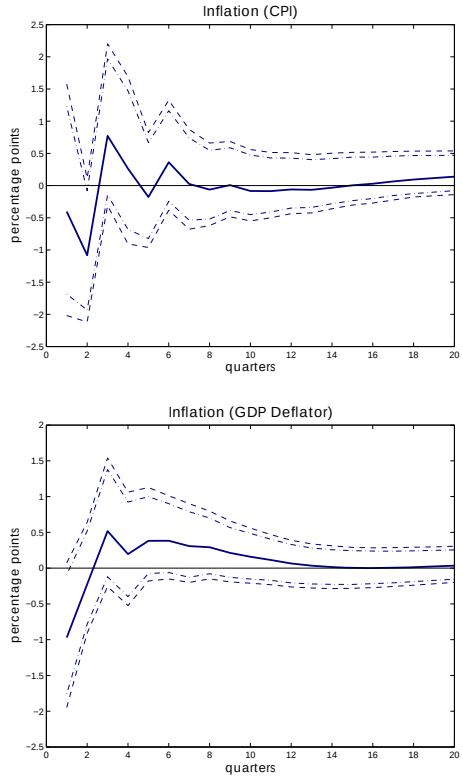
Alternative Inflation Measures

(A) Personal Income Tax Cut



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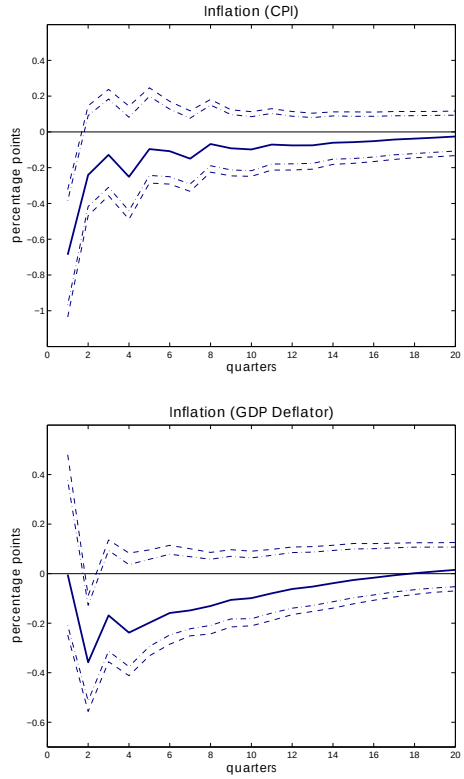

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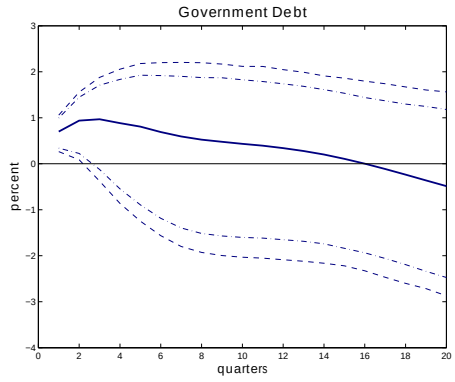
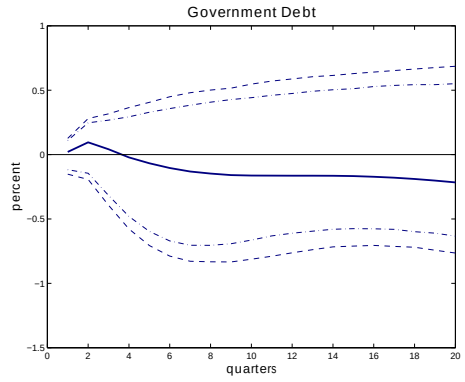
Response of Government Debt

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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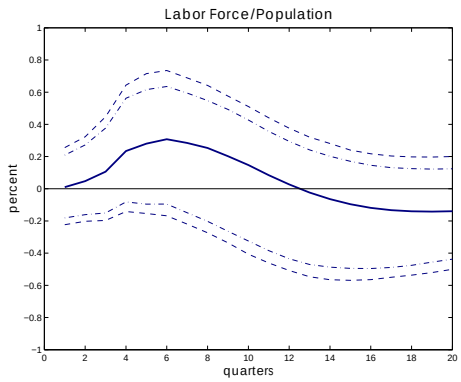
Labor Force Participation

(A) Personal Income Tax Cut



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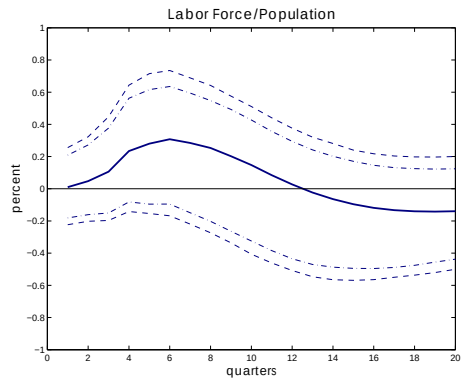

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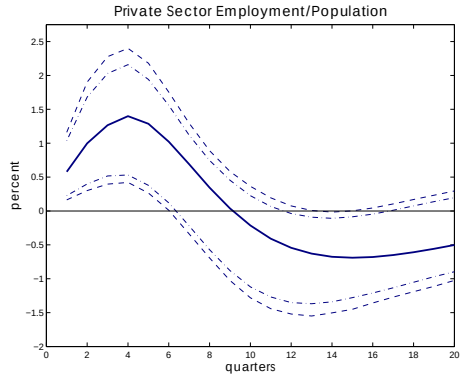
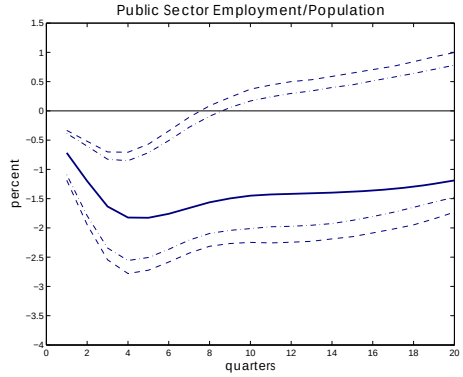
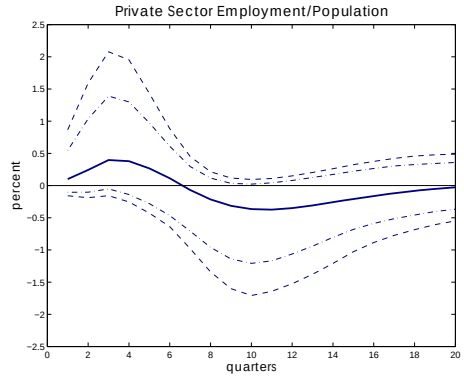
Private vs. Public Sector Employment

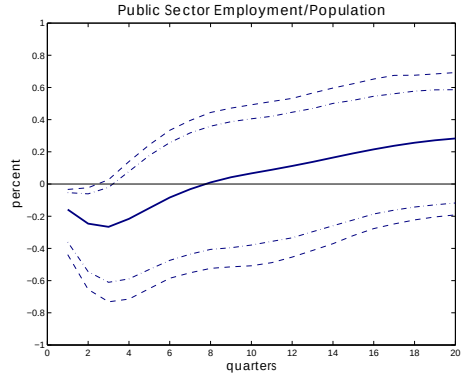
(A) Personal Income Tax Cut





(B) Corporate Income Tax Cut





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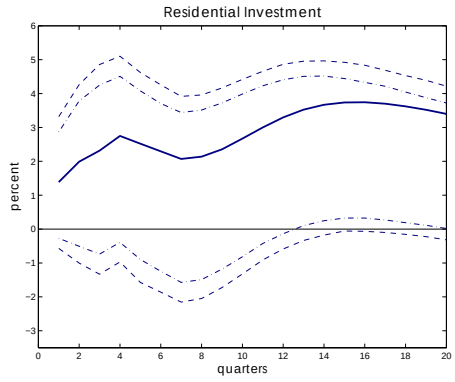
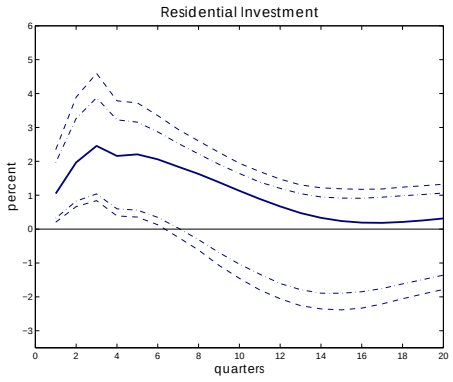
Residential Investment

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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