The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States

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Introduction

How do tax changes affect GDP?

How do tax changes affect the budget?

How do tax changes affect employment?

How do tax changes affect consumption/investment?

We provide quantitative answers based on

- Reduced form time series models (VARs)
- Dynamic responses to unanticipated changes in average tax rates
- Identification by covariance restrictions obtained from data on federal tax changes
- Focusing on short run

Identification

Strategies to identify unanticipated changes in taxes:

Coefficient Restrictions: Blanchard and Perotti (QJE 2002)

Sign Restrictions: Mountford and Uhlig (JAE 2009)

Narrative Data: Romer and Romer (AER 2010)

Key difficulties we address

1. *Diversity of tax instruments.*
   We distinguish between different tax instruments.
2. *Simultaneous Tax Changes*
   We disentangle causal effects of individual tax instruments.
3. *Fiscal foresight*
   Robustness to news/anticipation effects
4. *Data Quality*
   Robustness to measurement error and reliability estimates

Comparison of 'Peak Tax Multipliers'

Study	Identification	Innovation to	Peak	Period
Blanchard and Perotti (2002)	Coefficients	Total Revenues/GDP	0.78	6-th quarter
Mountford and Uhlig (2009)	Sign	Total Revenues/GDP	3.41	12-th quarter
Romer and Romer (2010)	Narrative	Total Liabilities/GDP	3.08	10-th quarter
Mertens and Ravn (2011)	Narrative	Total Liabilities/GDP	2.00	10-th quarter
Favero and Giavazzi (2011)	Narrative	Total Liabilities/GDP	1.00	10-th quarter
Barro and Redlick (2011)	IV with Narrative	AMTR	1.1	first year
This paper	Narrative	APITR	2.5	3-rd quarter
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AMTR: Average Marginal Tax Rates (Personal Income)
APITR: Average Personal Income Tax Rates
ACITR: Average Corporate Income Tax Rates

Confidence intervals
Two real outliers

Main Results

1. Large and immediate output effects of both PI and CI tax changes.
2. PI tax cuts reduce tax revenues and increase debt.
   CI tax cuts have little budgetary impact.
3. CI and PI tax changes have different macroeconomic effects, e.g.

   PI tax cut: employment $\uparrow$, hours per worker $\uparrow$.
   CI tax cut: employment $=$, hours per worker $=$.

   PI tax cut: consumption $\uparrow$, investment $\uparrow$
   CI tax cut: consumption $=$ or $\downarrow$, investment $\uparrow$
4. Reconciliation with previous multiplier estimates

Outline

- Empirical methodology
- Benchmark results
- Discussion and robustness
- Results for other macro aggregates
  - Interaction with monetary policy
  - Labor market
  - Consumption and investment
- Reconciliation with previous estimates

Structural Vector Autoregression

Stationary vector of n observables Y_t with **VAR representation**

$$Y_t = \delta' X_t + \mathcal{B}\varepsilon_t,$$

where $X_t = [Y'_{t-1}, ..., Y'_{t-p}]'$, δ is $pn \times n$, $\mathcal{B}$ is $n \times n$ nonsingular.

ε_t is an $n \times 1$ vector of **structural shocks** with $E[\varepsilon_t] = 0$, $E[\varepsilon_t \varepsilon'_t] = I$, $E[\varepsilon_t \varepsilon'_s] = 0$ for $s \neq t$.

Reduced form residuals u_t are

$$u_t = \mathcal{B}\varepsilon_t$$

such that $E[u_t u'_t] = \mathcal{B}\mathcal{B}'$. We need additional identification assumptions.

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)

Identification

Partition $\varepsilon_t = \begin{bmatrix} \underset{k\times 1}{\varepsilon_{1t}} \\ \underset{n-k\times 1}{\varepsilon_{2t}} \end{bmatrix}$, ε_{1t} are the shocks of interest.

Suppose we have $k \times 1$ vector of proxy variables m_t, w.l.g $E[m_t] = 0$.

Identification assumptions:

$$E[m_t \varepsilon_{1t}'] = \Phi \quad (1)$$
$$E[m_t \varepsilon_{2t}'] = 0 \quad (2)$$

where Φ is $k \times k$, unknown and nonsingular.

Note: $E[m_t X_t'] = 0$ is not necessary, testable, not rejected.

See also Stock (2008), Stock and Watson (2012).

Partition $\mathcal{B} = \begin{bmatrix} \underset{k\times k}{\beta_{11}} & \underset{k\times n-k}{\beta_{12}} \\ \underset{n-k\times k}{\beta_{21}} & \underset{n-k\times n-k}{\beta_{22}} \end{bmatrix}$, $\beta_1 = \begin{bmatrix} \underset{k\times k}{\beta_{11}} \\ \underset{n-k\times k}{\beta_{21}} \end{bmatrix}$

Identifying assumptions (1)-(2) imply $n \times k$ conditions

$$\Phi\beta_1' = \Sigma_{mu'}$$

from which we extract $(n-k)\times k$ covariance restrictions

$$\beta_{21} = (\Sigma_{mu_1'}^{-1}\Sigma_{mu_2'})'\beta_{11} \ . \tag{3}$$

Three steps:

1. Estimate the reduced form VAR
2. Estimate $\Sigma_{mu_1'}^{-1}\Sigma_{mu_2'}$ from regressions of u_t on m_t.
3. Impose the restrictions in (3), see Hausman and Taylor (1983)

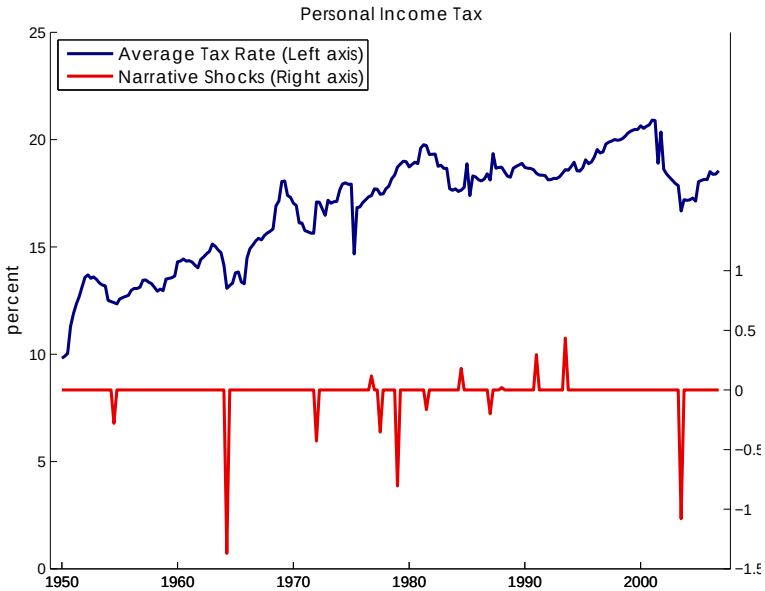
$\Sigma_{mu_1'}^{-1}\Sigma_{mu_2'}$ is also 2SLS estimator in regression of u_{2t} on u_{1t} using m_t as instruments for u_{1t}.

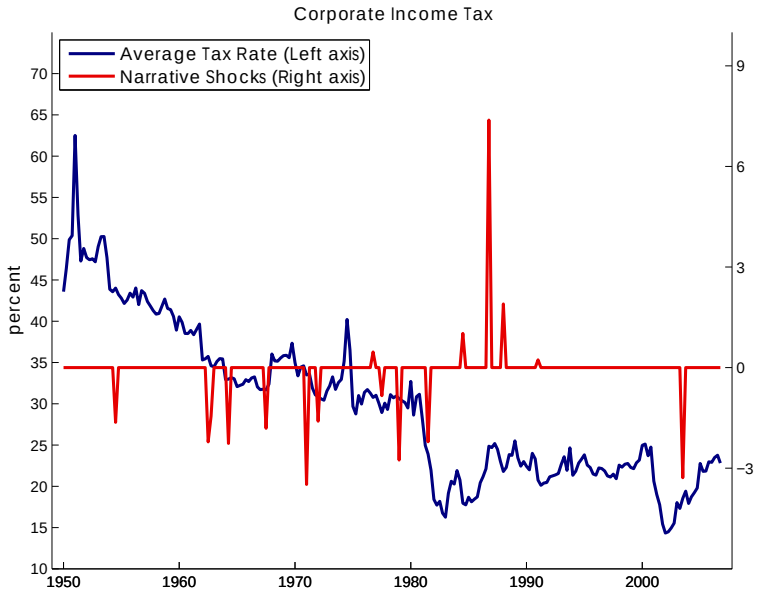
Proxy Variables m_t for Tax Shocks ϵ_{1t}

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, cfr. Romer and Romer (2009), (48 obs)
4. Unanticipated, 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

Robustness to Measurement Error

Add a **measurement error equation**

$$m_t = D_t \left(\Gamma \varepsilon_{1t} + \upsilon_t \right) \ , \tag{4}$$

where υ_t is a $k \times 1$ vector of measurement errors with $E[\upsilon_t] = 0$, $E[\upsilon_t \upsilon_t'] = \Sigma_{\upsilon\upsilon'}$ and $E[\upsilon_t \upsilon_s'] = 0$ for $s \neq t$.

D_t is $k \times k$ censoring process (identical and independently random).

Rewrite $Y_t = \delta' X_t + \mathcal{B}\varepsilon_t$,as

$$Y_t = \theta' X_t^* + w_t \ , \tag{5}$$

where $X_t^* = [Y_{t-1}', ..., Y_{t-p}' \ , \varepsilon_{1t}']'$, $\theta = [\delta', \beta_1]'$ and $w_t = \beta_2 \varepsilon_{2t}$.

Objective is to estimate θ, but X_t^* is unobservable.
Instead we observe $\bar{X}_t = [Y_{t-1}', ..., Y_{t-p}' \ , m_t']'$

The enlarged system is

$$\begin{aligned} Y_t &= \gamma' \bar{X}_t + z_t \ , \\ \bar{X}_t &= \Omega X_t^* + \Upsilon_t \ , \end{aligned}$$

where

$$\theta = \Omega' \gamma \ , \ \ w_t = z_t + \gamma' \Upsilon_t \ , \ \ \Omega = \begin{bmatrix} I & 0 \\ 0 & \Gamma \end{bmatrix} \ , \ \ \Upsilon_t = \begin{bmatrix} 0 \\ D_t \upsilon_t + (D_t - I_k)\Gamma \varepsilon_{1t} \end{bmatrix} .$$

Naive estimator $\Sigma_{\bar{X}\bar{X}'}^{-1} \Sigma_{\bar{X}Y}$ is biased since

$$\theta = \Omega' \ \Lambda_{\bar{X}}^{-1} \ \Sigma_{\bar{X}\bar{X}'}^{-1} \Sigma_{\bar{X}Y} \ ,$$

1. $\Omega' \neq I$: scaling
2. $\Lambda_{\bar{X}}^{-1} \neq I$: additive measurement error
3. (censoring)

Reliability of m_t

The second bias term is $\Lambda_{\bar{X}} = \begin{bmatrix} I & 0 \\ 0 & \Lambda \end{bmatrix}$

where Λ is the **reliability matrix** of (the uncensored realizations of) m_t.

$$\Lambda = \Sigma_{mm'}^{-1} E[D_t]\Gamma\Gamma' \ ,$$

Under the additional measurement equation assumptions, Λ is identified and is a useful diagnostic tool.

Λ quantifies the link between SVAR shocks and narrative events.

One last identification issue

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

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

u_{1t} : reduced form tax rate innovations
u_{2t} : reduced form innovations to other variables

ϵ_{1t}: structural tax shocks
ϵ_{2t}: other structural shocks

Need to identify $\beta_1 = \begin{bmatrix} I + \eta(I - \zeta\eta)^{-1}\zeta \\ (I - \zeta\eta)^{-1}\zeta \end{bmatrix} S_1$

Covariance restrictions identify $\beta_1 S_1^{-1}$ and $S_1 S_1'$, but not S_1.

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

We can obtain response to any linear combination of shocks ϵ_{1t}.
Choleski shocks are shocks to 'cyclically adjusted' changes in tax rates, $u_{1t} - \eta u_{2t}$.

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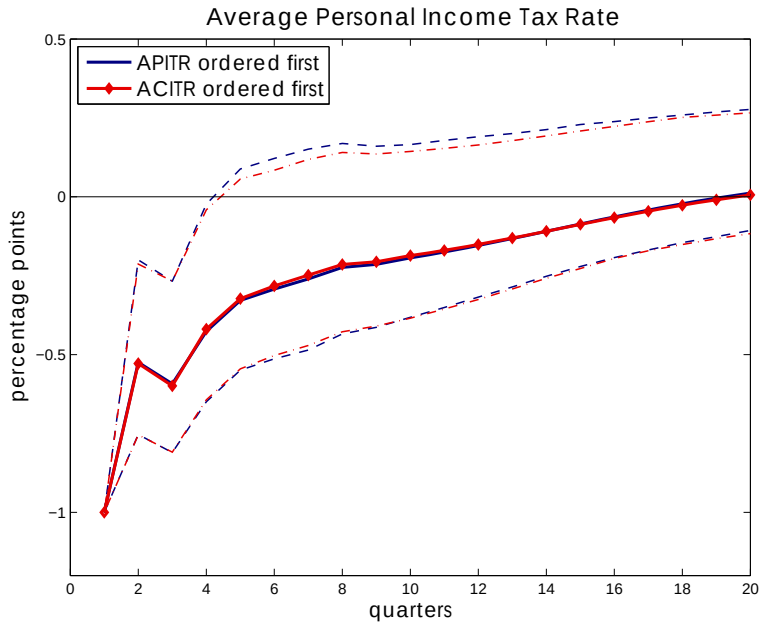
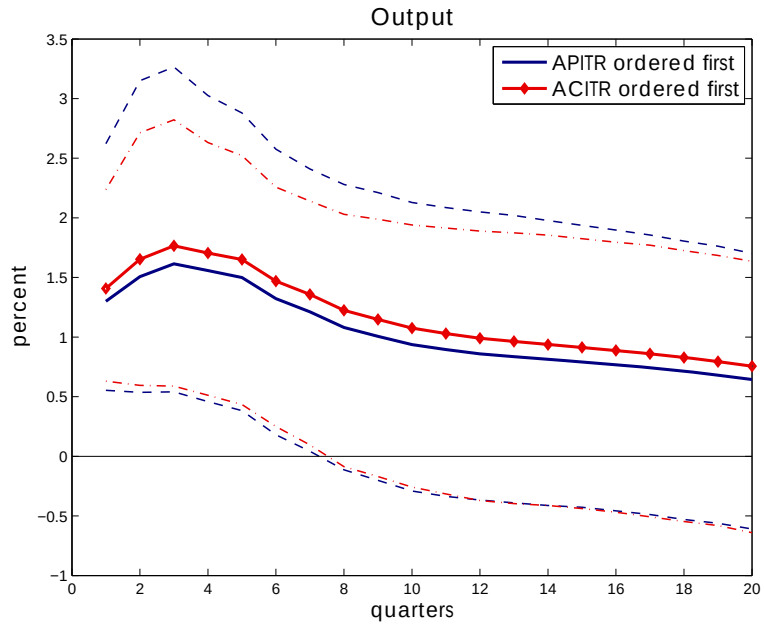
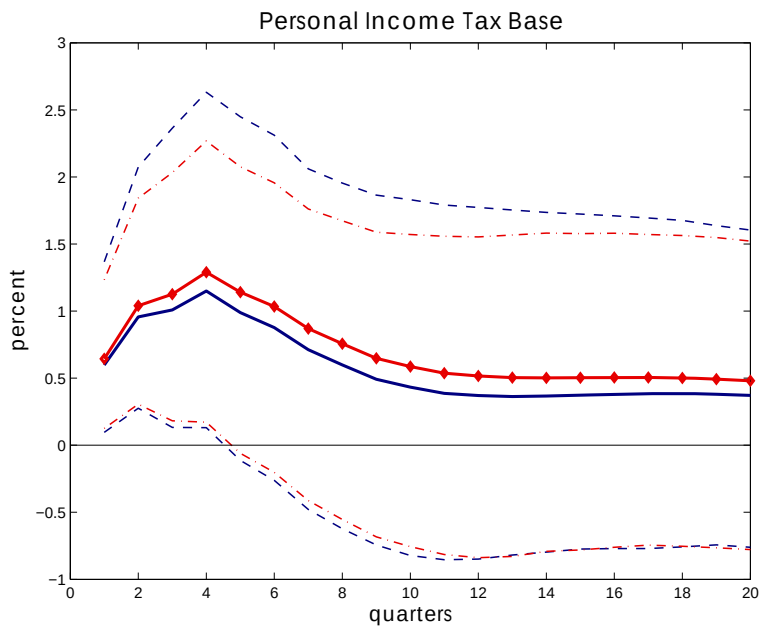
Log levels

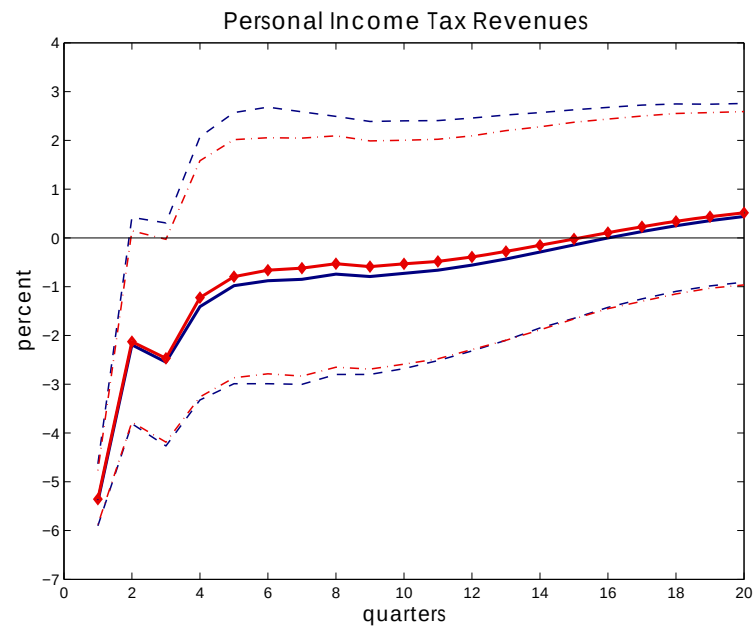
Four lags (Akaike)

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

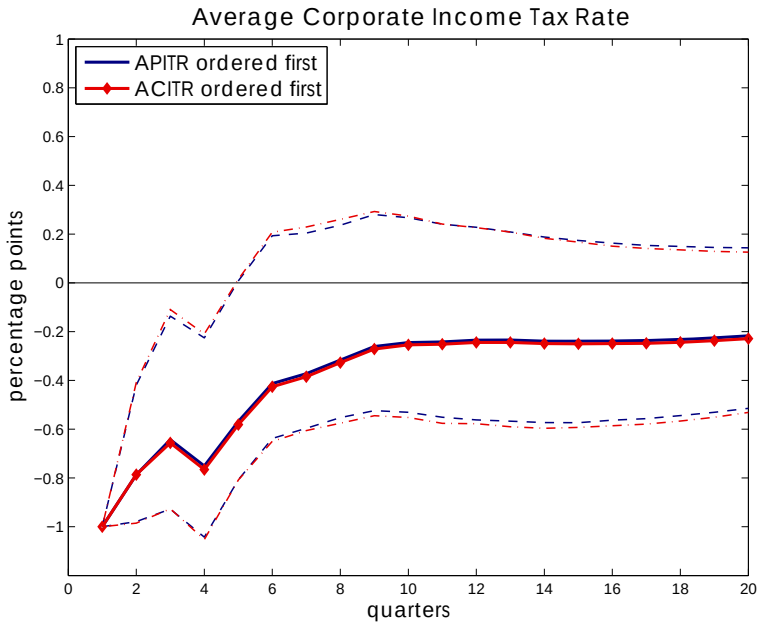


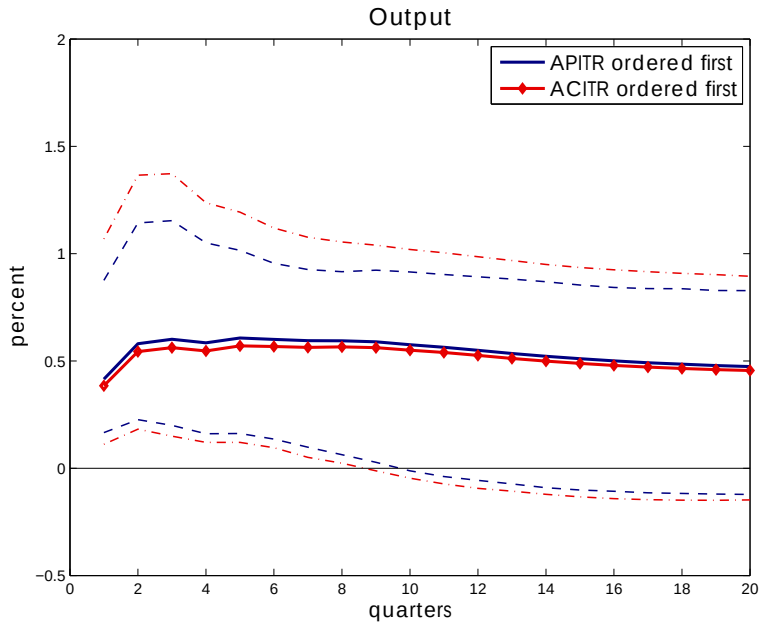


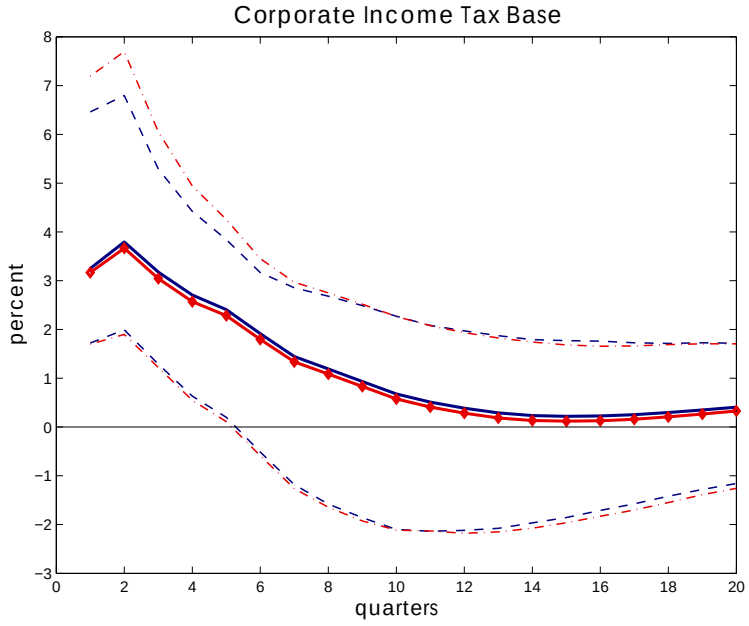


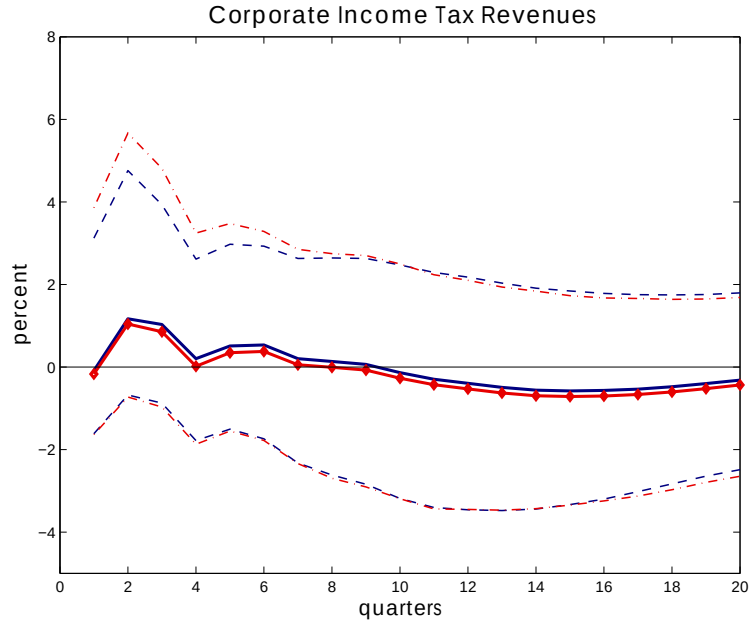


One PP Cut in **Average Corporate Income Tax** Rate (95% Confidence Intervals)









Response of other variables, ▸ graphs

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

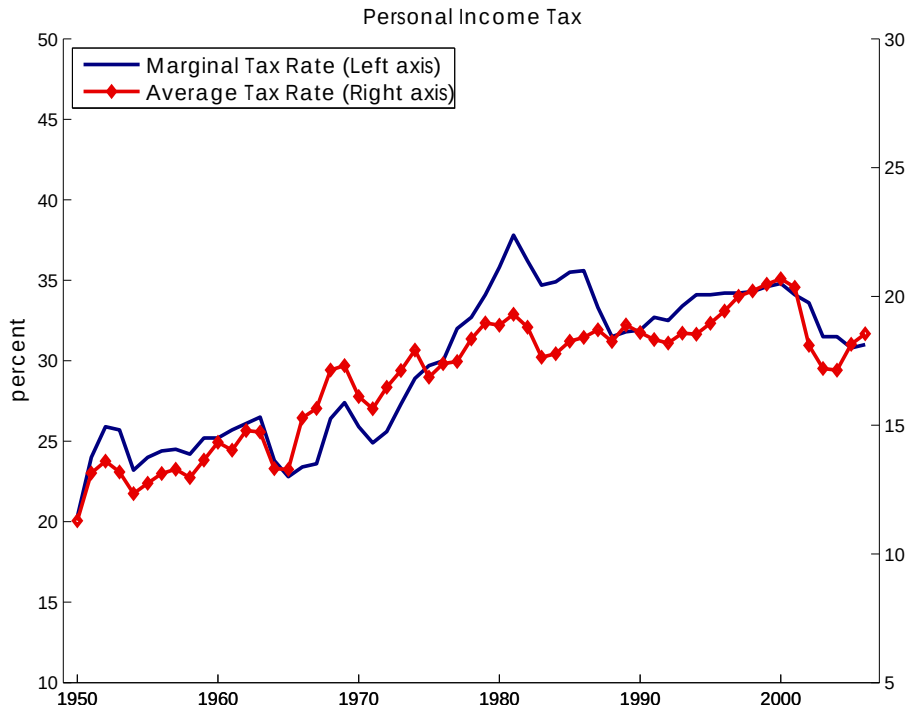
Principal components of m_t have correlation with ϵ_{1t} of 0.55 and 0.83.

What if we ignore correlation between m_t? ▸ graphs

What if we use traditional specifications? ▸ graphs

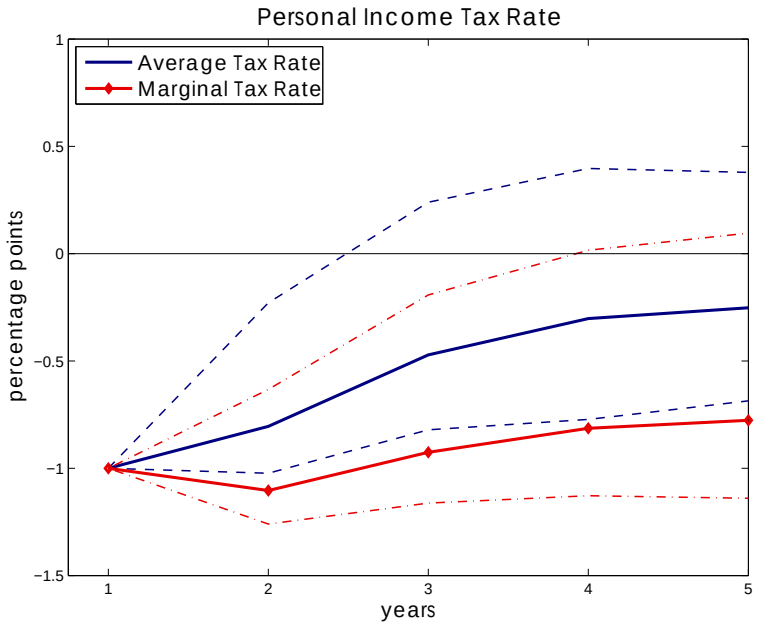
Comparison with Barro and Redlick (2011).

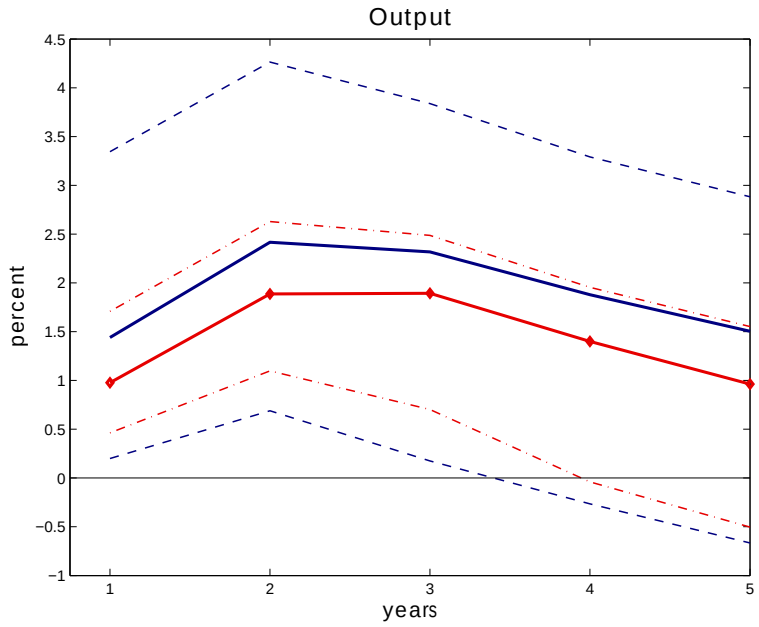
Average vs. Marginal Tax Rate Changes



Correlation: 0.90 (levels), 0.62 (first differences)

Average vs. Marginal Tax Rate Changes





Robustness

- First differences-deterministic trend ▸ graphs
- Fiscal foresight ▸ graphs
  - municipal bond spreads, Leeper, Walker & Yang (2011)
  - defense stock prices, Fisher and Peters (2010)
  - defense news, Ramey (2011)
- Alternative proxies ▸ graphs
- Timing Error ▸ graphs

Effects of Tax Changes on Other Macro Variables

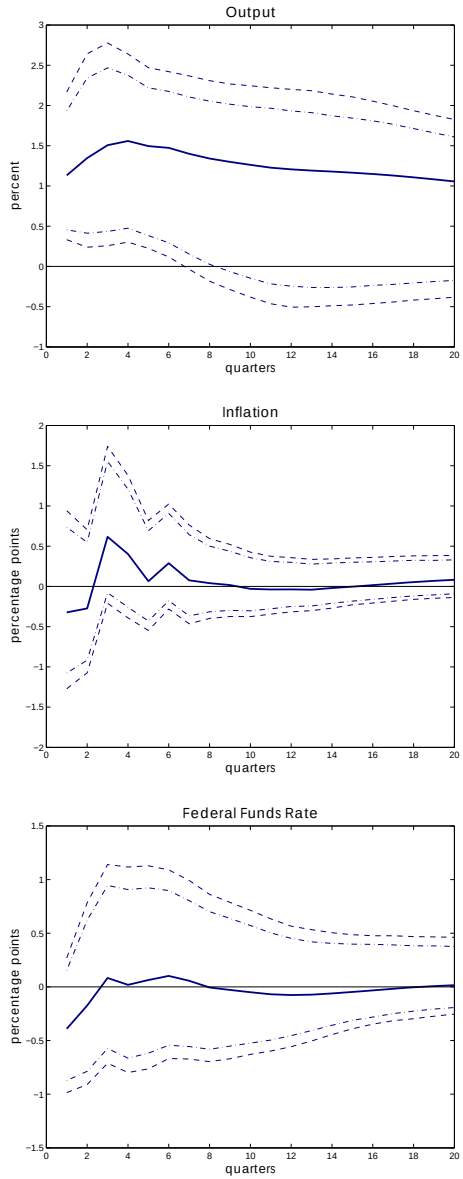
Alternative VAR systems:

- 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

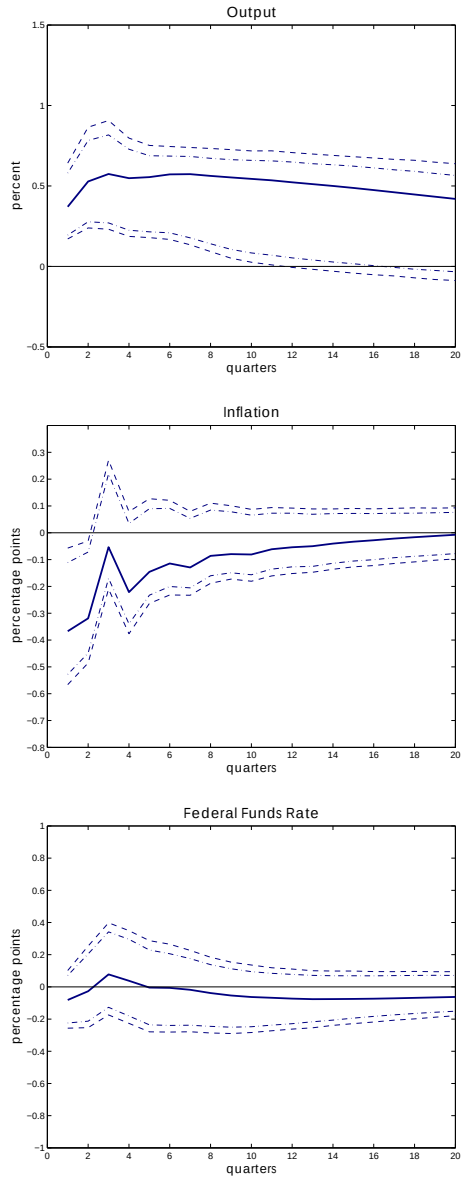
We consider:

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

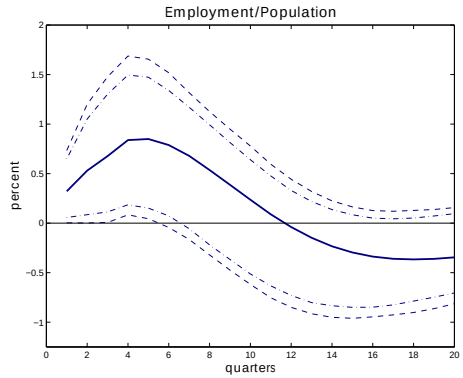


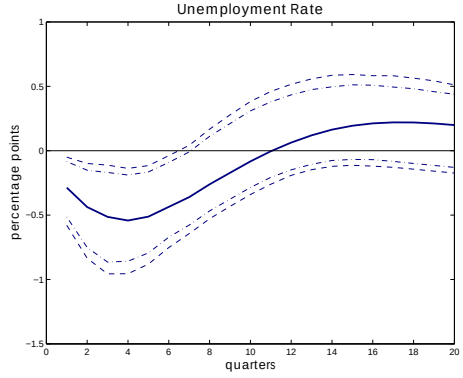
(B) Corporate Income Tax Cut



▸ Government Debt ▸ Other Inflation Measures

(A) Personal Income Tax Cut





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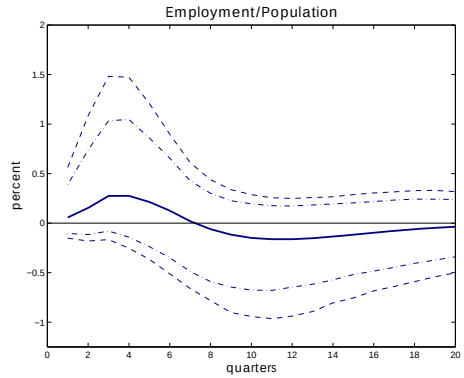
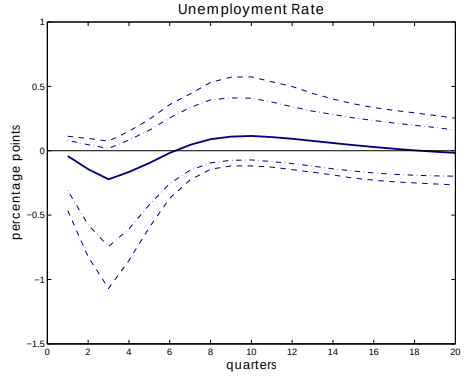
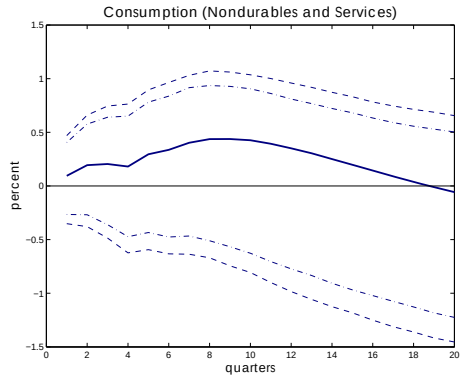
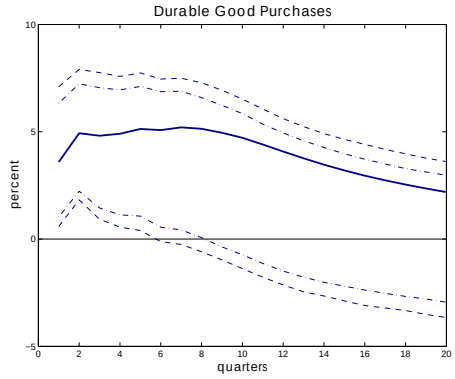


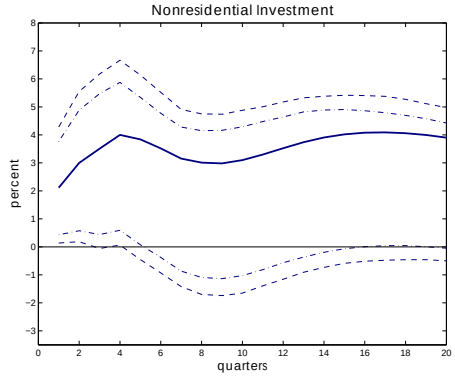


▸ Labor Force Participation ▸ Private vs. Public Sector Employment

(A) Personal Income Tax Cut







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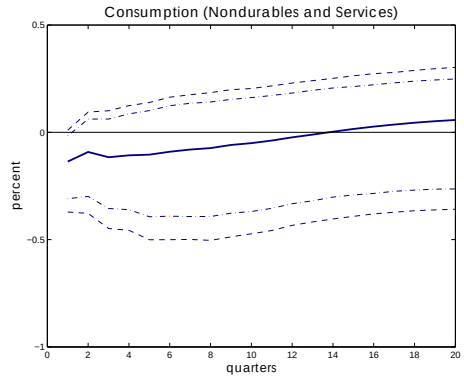

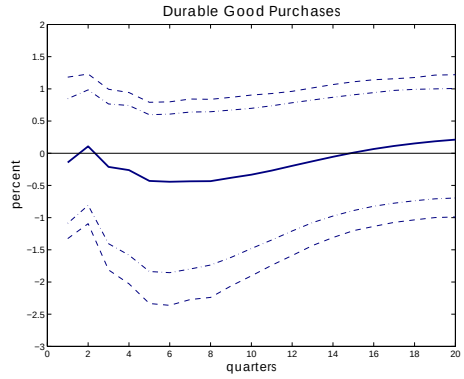

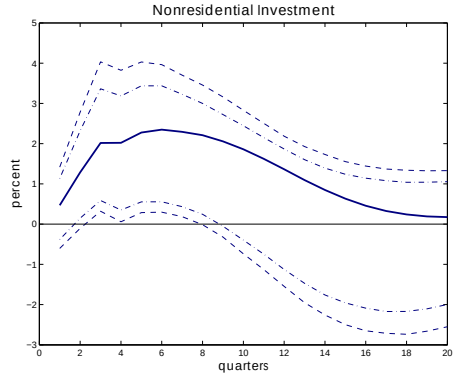

▸ Residential Investment

Implications

- No systematic interaction with monetary policy.
  CI tax cuts are disinflationary.
- *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.

▸ Skip to conclusion

Reconciling with Previous Results

Study	Identification	Innovation to	Peak	Period
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Confidence intervals
Two real outliers

Blanchard and Perotti (2002) SVAR

Variables: total tax revenues T_t, govt spending G_t and output Y_t.

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

Blanchard and Perotti (2002):

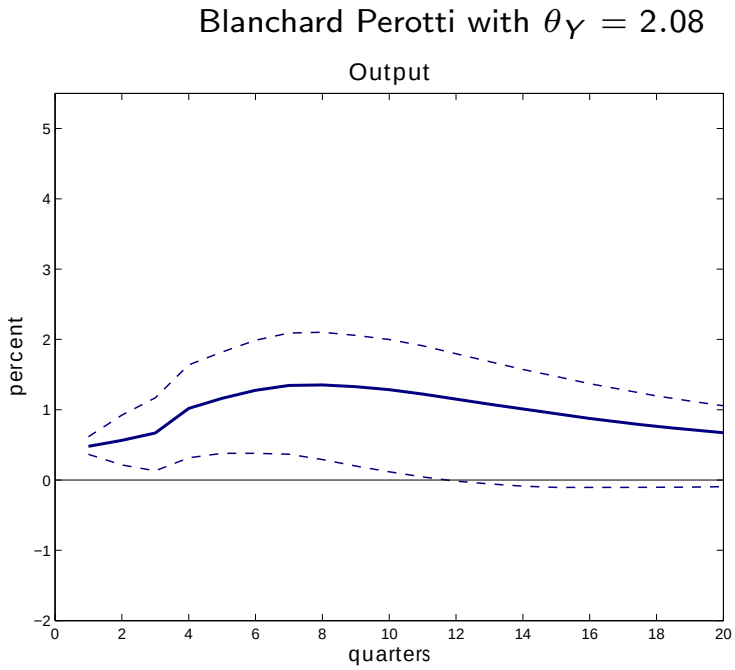
Output elasticity of tax revenues : $\theta_Y = 2.08$ (OECD, CBO)

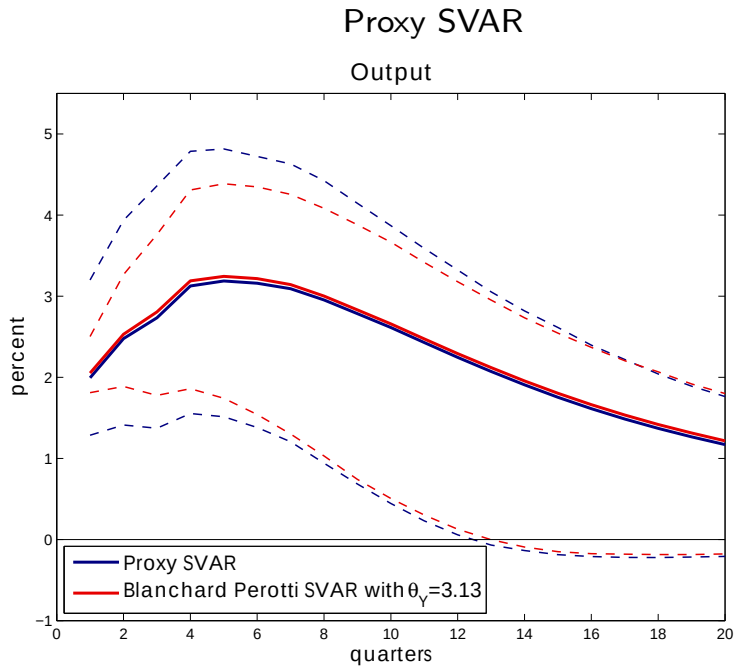
Decision lags, quarterly data: $\gamma_T = 0$, $\gamma_Y = 0$.

Equation		Proxy SVAR	Blanchard-Perotti SVAR	
			$\theta_Y = 2.08$	$\theta_Y = 3.13$
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 of 10, 000 bootstrap replications.

Tax multipliers





Caldara (2010) shows Mountford Uhlig (JAE 2009) implies $\theta_Y = 3.3$

Response of revenues to tech shock in Mertens Ravn (2010): $\theta_Y = 3.7$

Brueckner (2011), Cloyne (2011)

◂ Favero and Giavazzi (2011) is measurement error.

Conclusion

Identifying the effects of federal tax changes is difficult.

Romer and Romer (2010) narrative/event study approach is very useful.

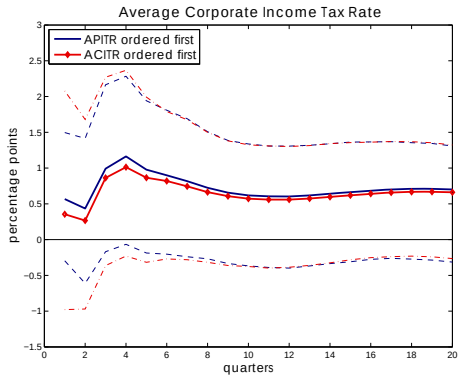
Our methodology deals with three issues that matter a lot quantitatively:

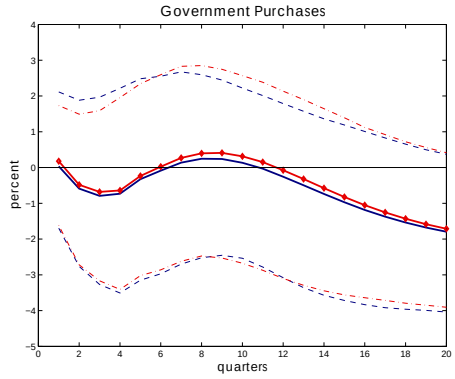
1. distinguishing between two main tax categories and controlling for interactions
2. avoiding tax foresight problems
3. robustness to many types of measurement error.

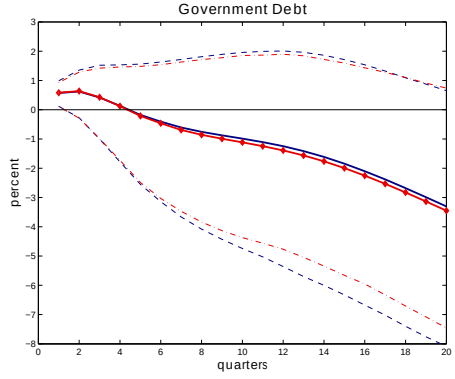
Main results:

1. Large and immediate output effects of both PI and CI tax changes.
2. PI tax cuts reduce tax revenues and increase debt.
   CI tax cuts have little budgetary impact.
3. CI and PI tax changes have different macroeconomic effects

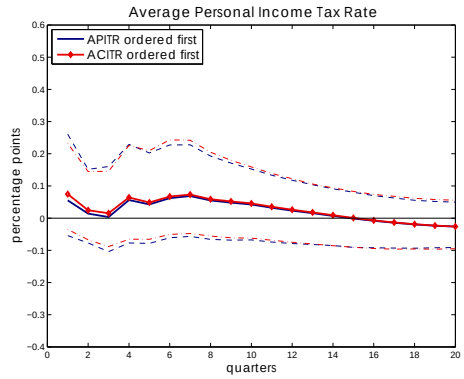
(A) Personal Income Tax Cut

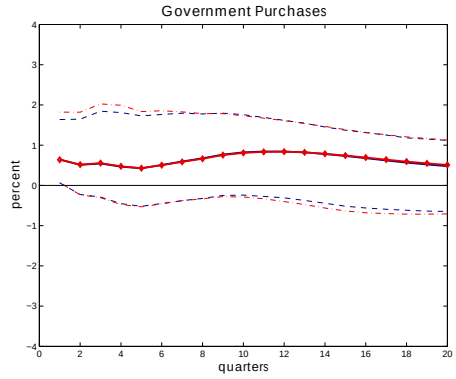


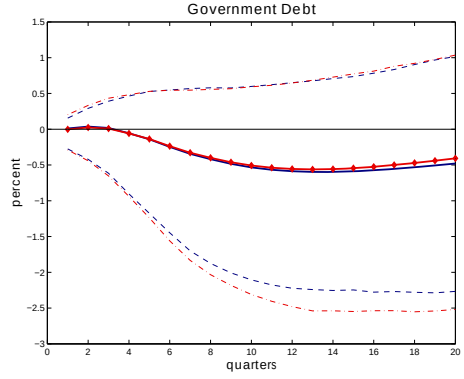




(B) Corporate Income Tax Cut







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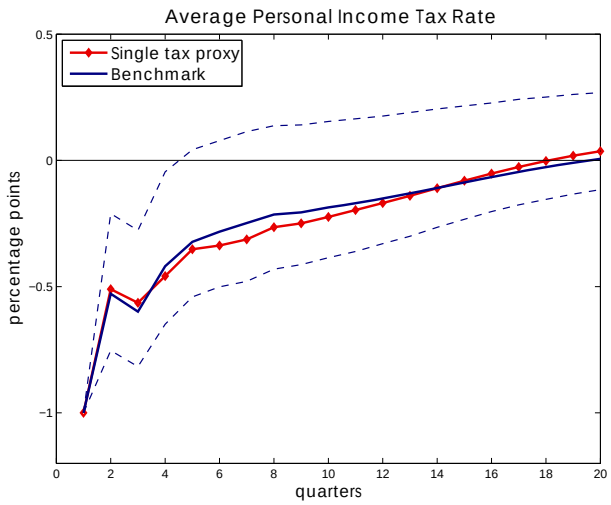
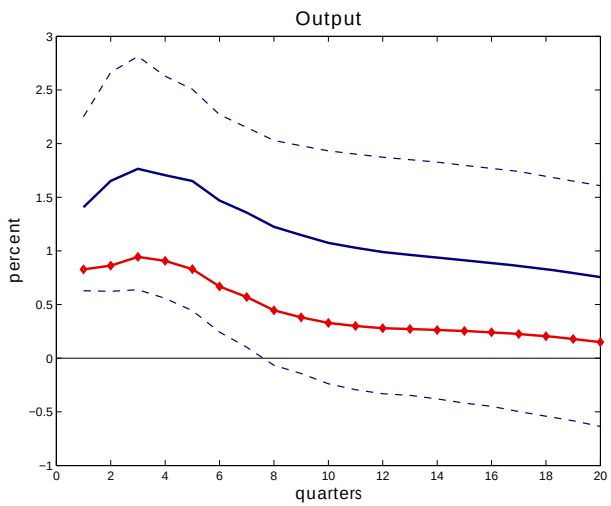
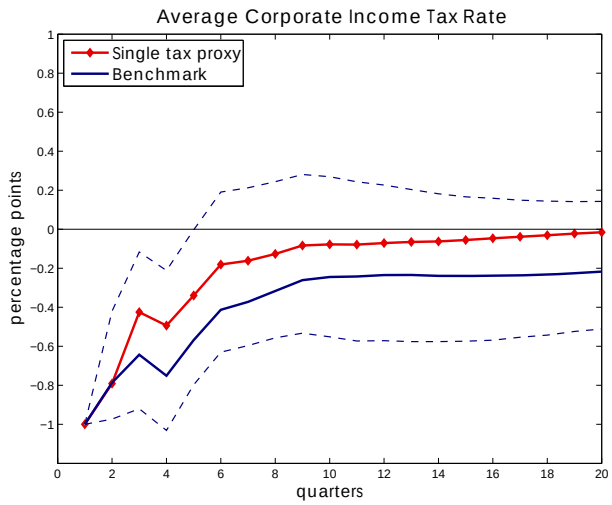
Ignoring Correlation m_t

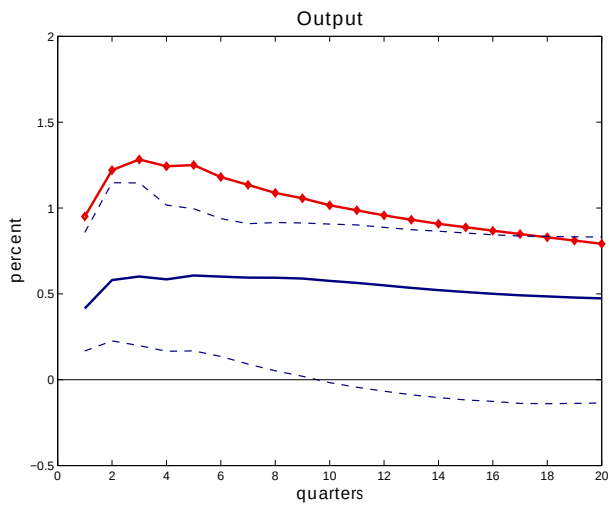
(A) Personal Income Tax Cut





(B) Corporate Income Tax Cut





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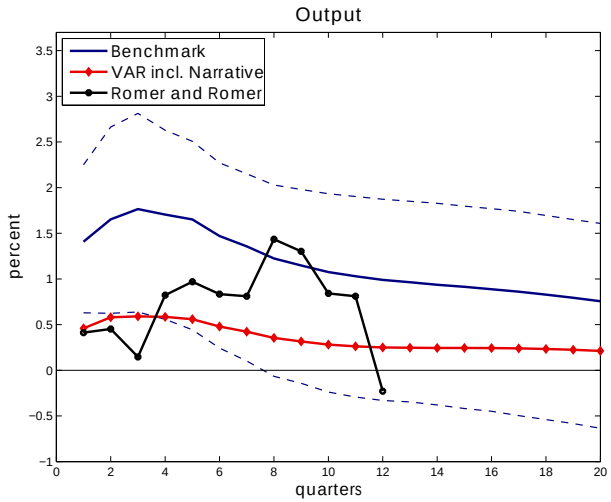
Traditional specifications

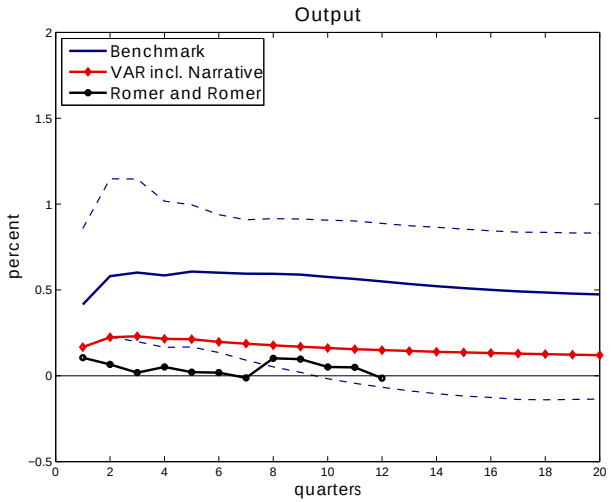
For $i = PI, CI$

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

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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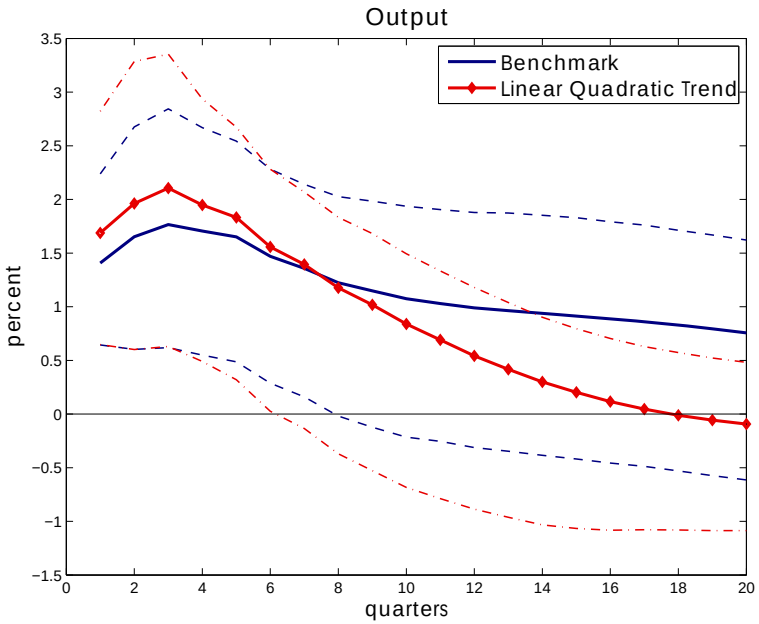
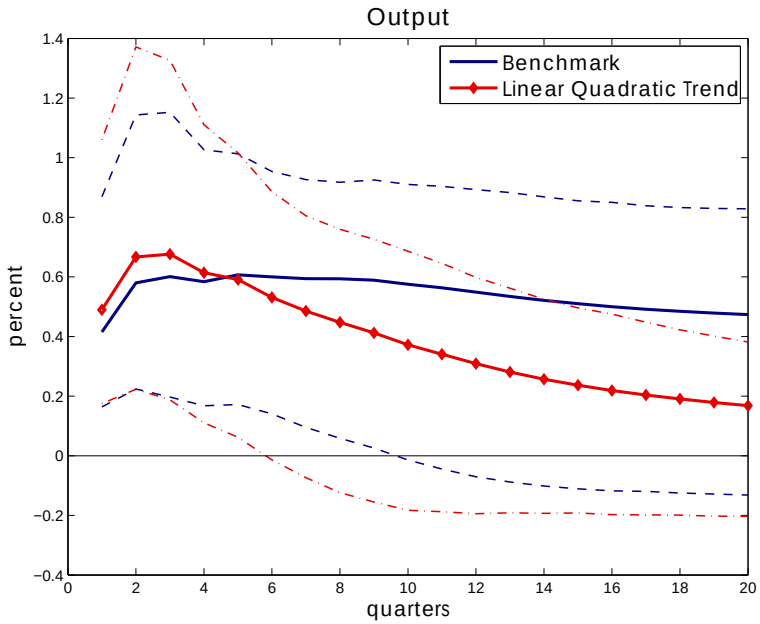
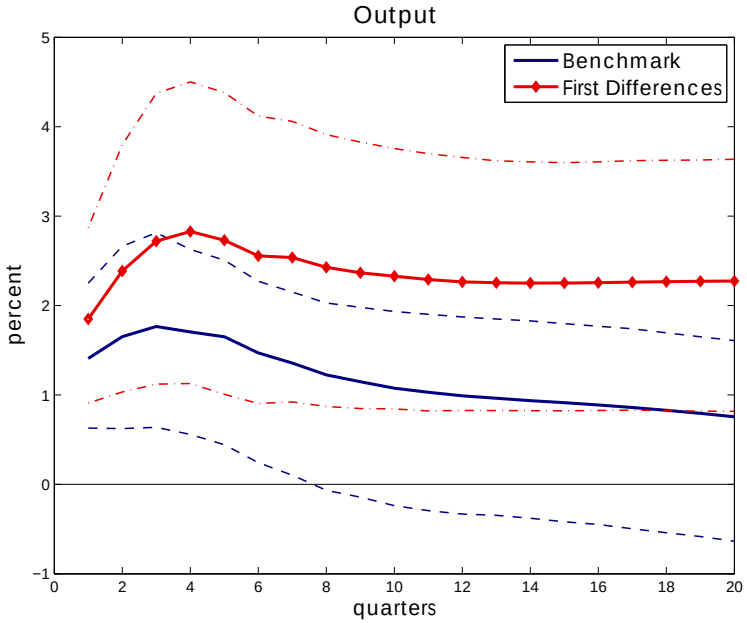
First Differences or Deterministic Trend

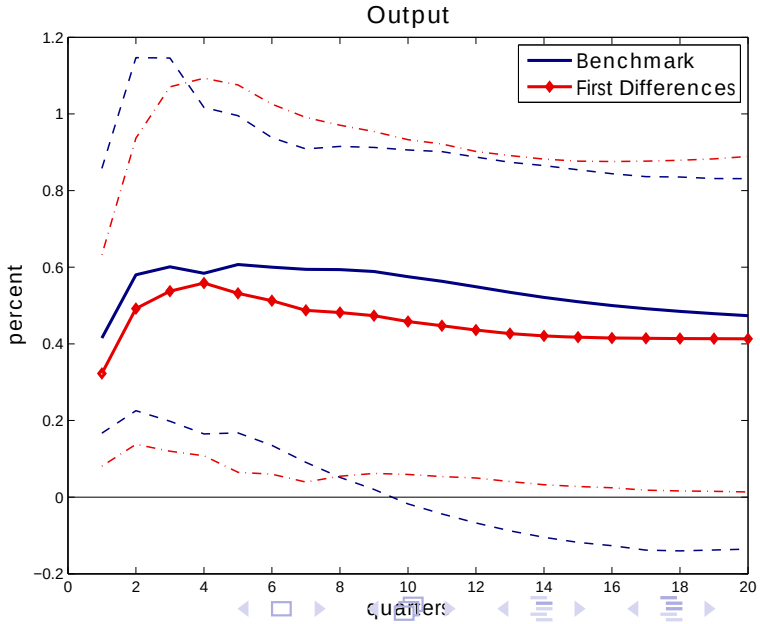
(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut

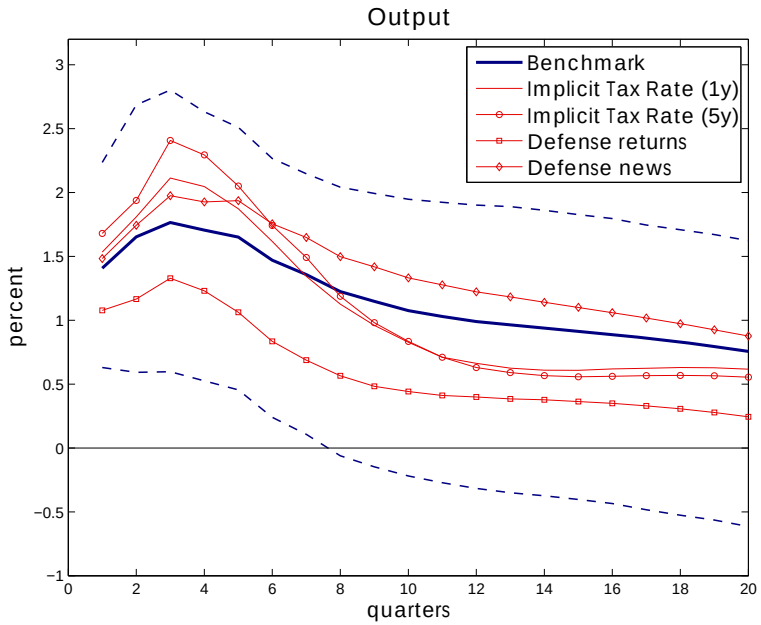




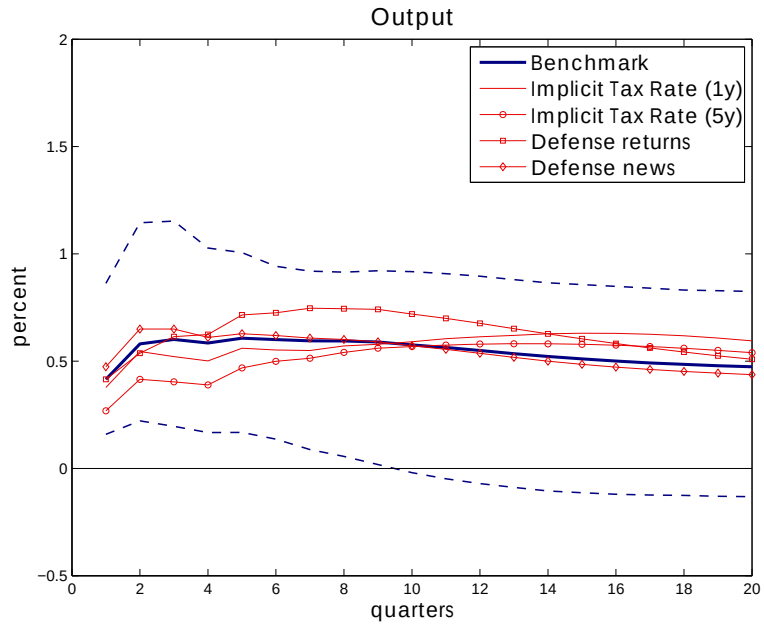


Expanding the Information Set

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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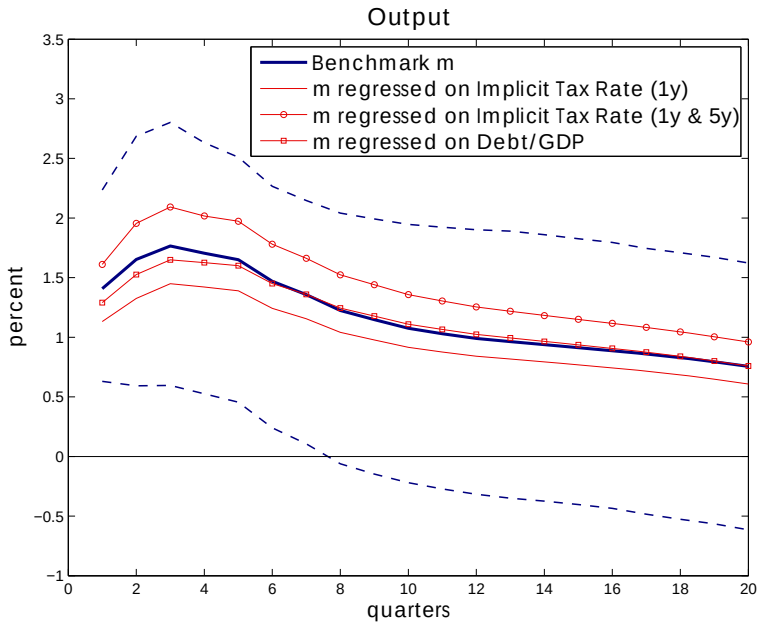
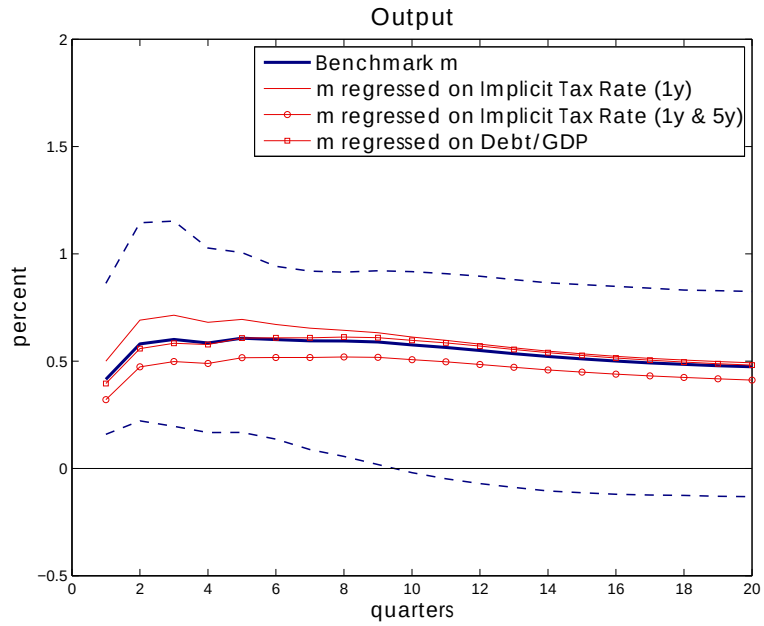
Alternative Proxies

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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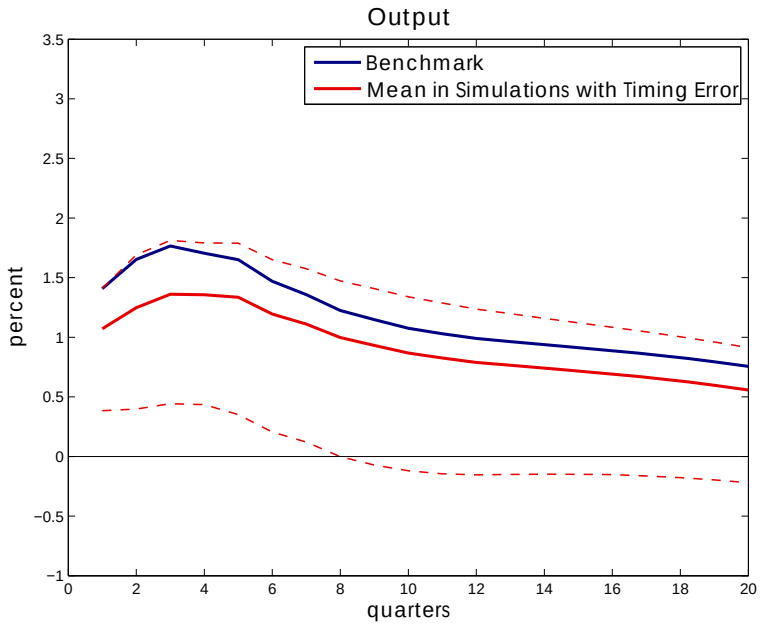
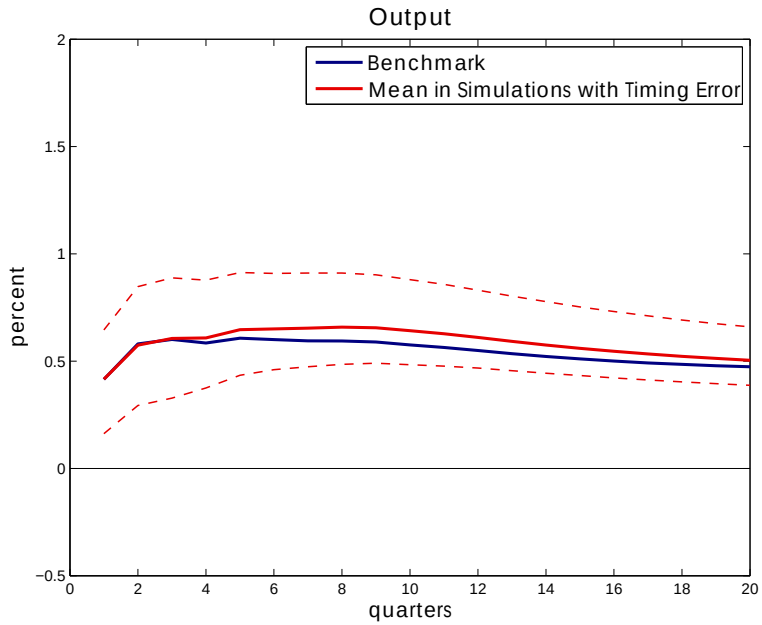
Timing Error

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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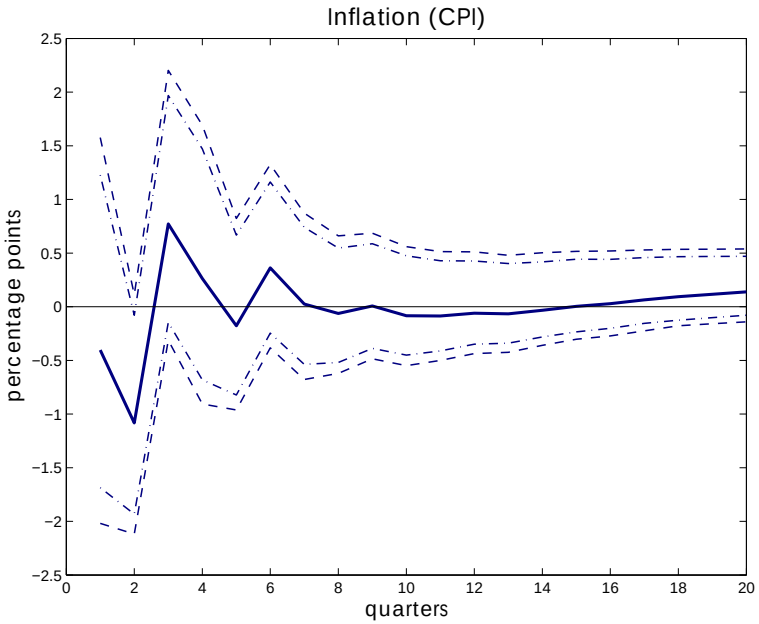
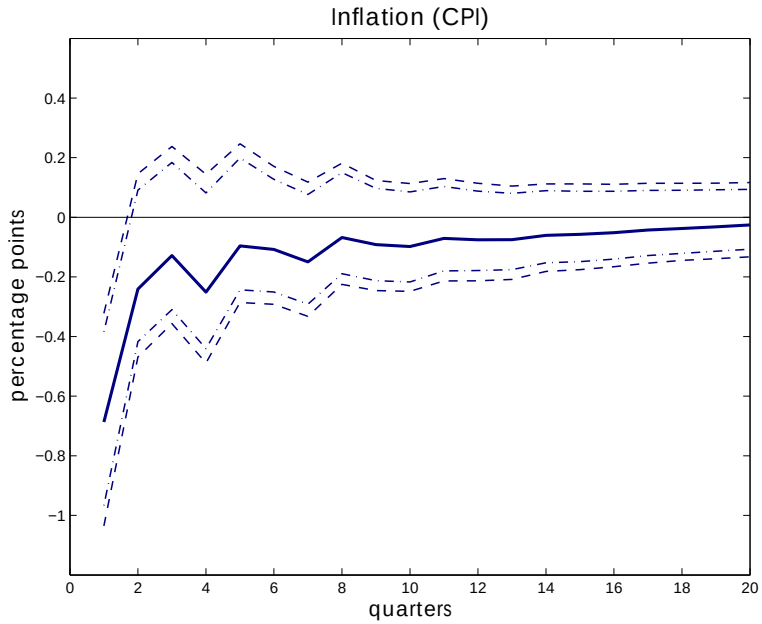
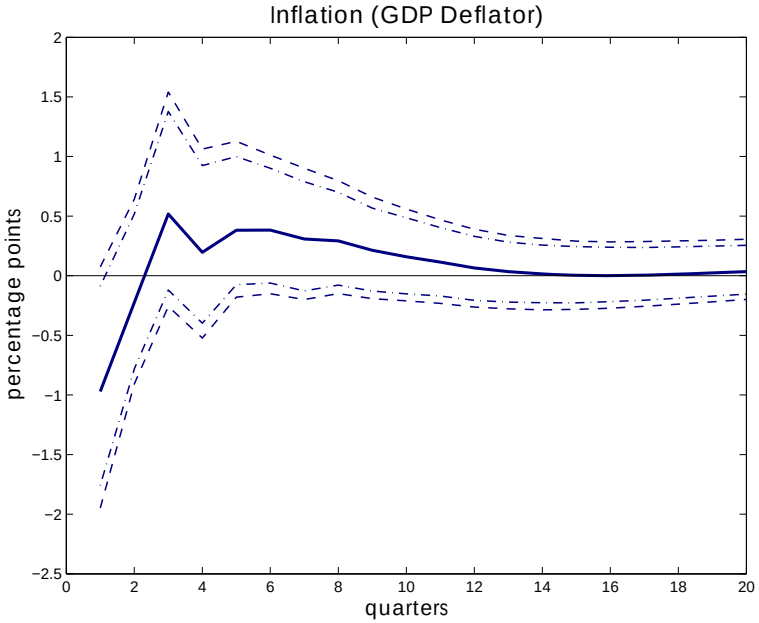
Alternative Inflation Measures

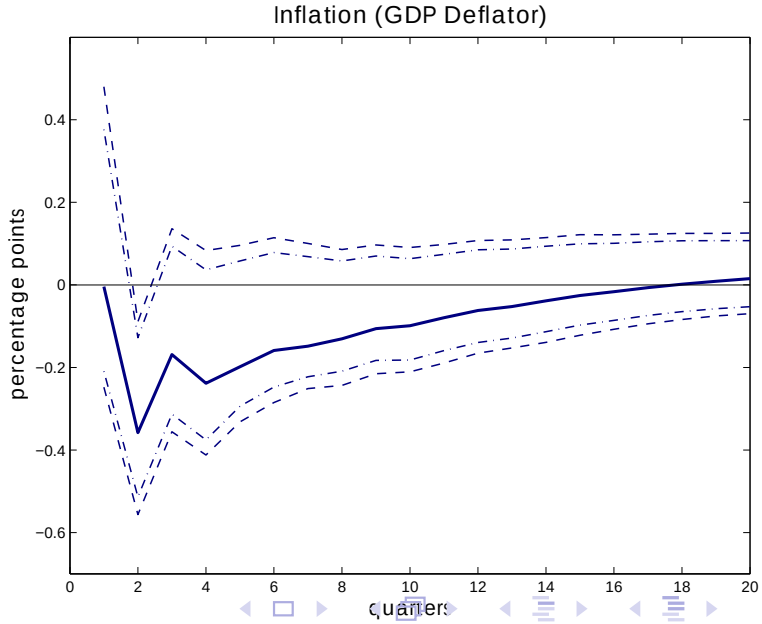
(A) Personal Income Tax Cut



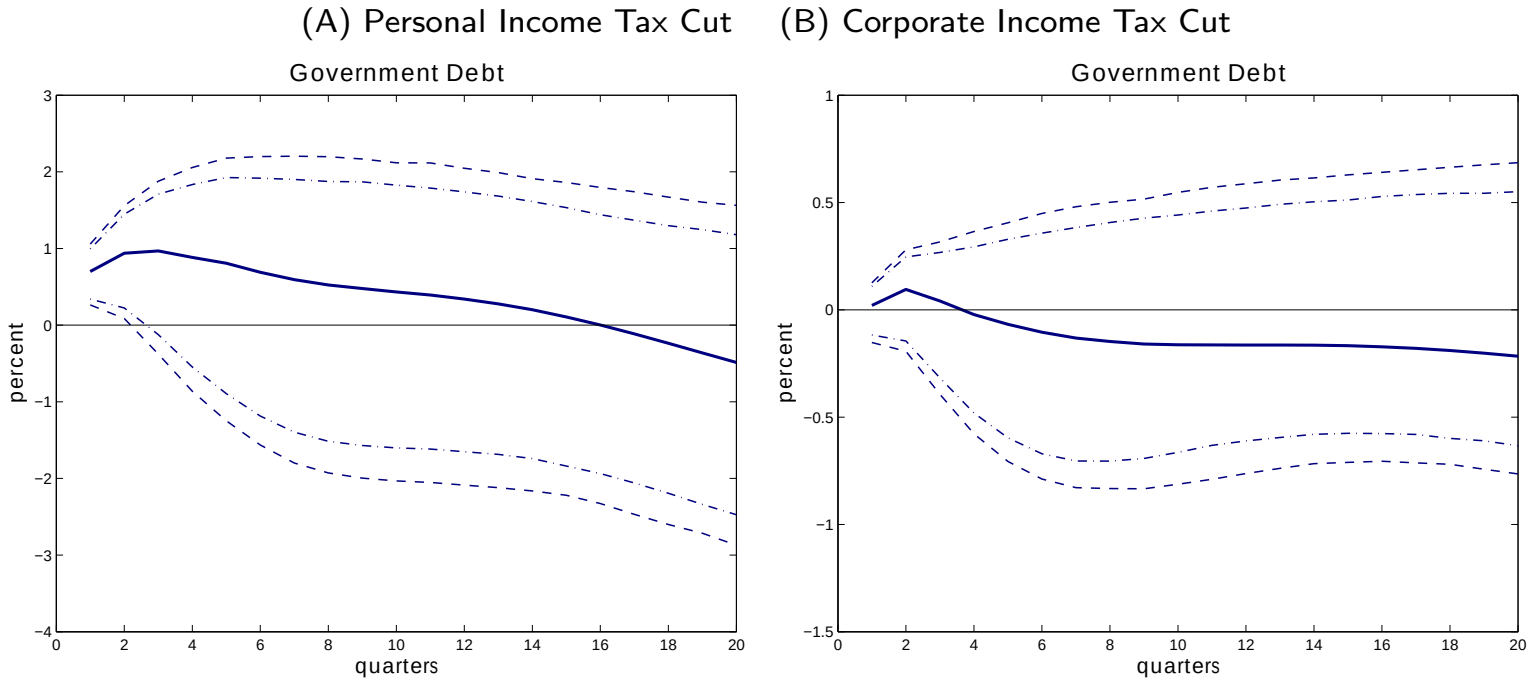
(B) Corporate Income Tax Cut







Response of Government Debt



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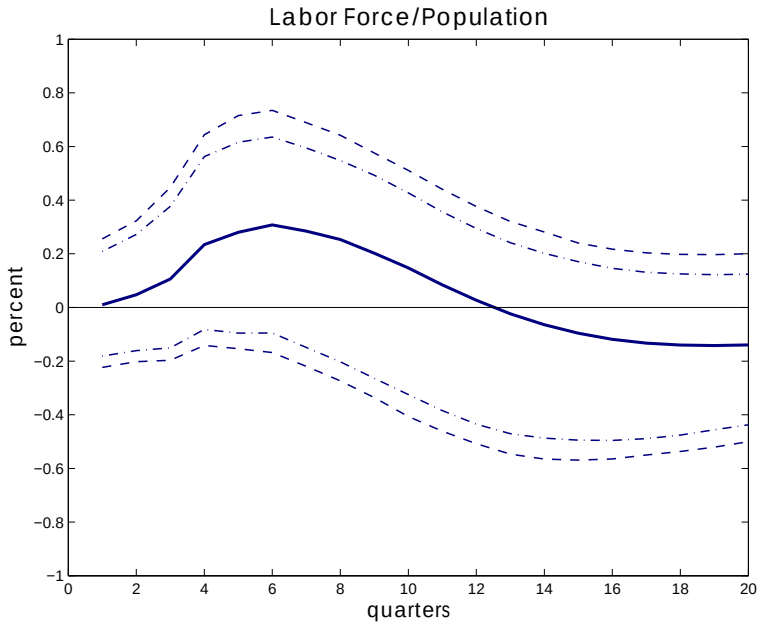
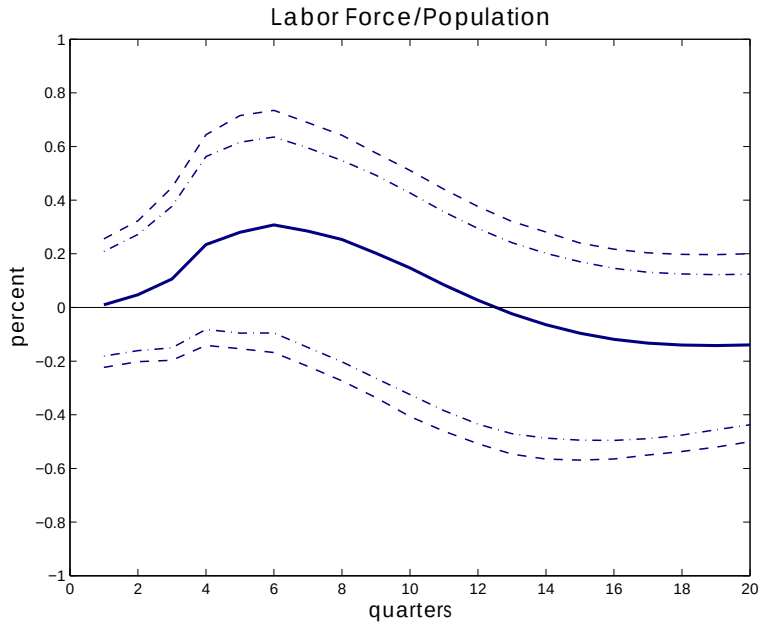
Labor Force Participation

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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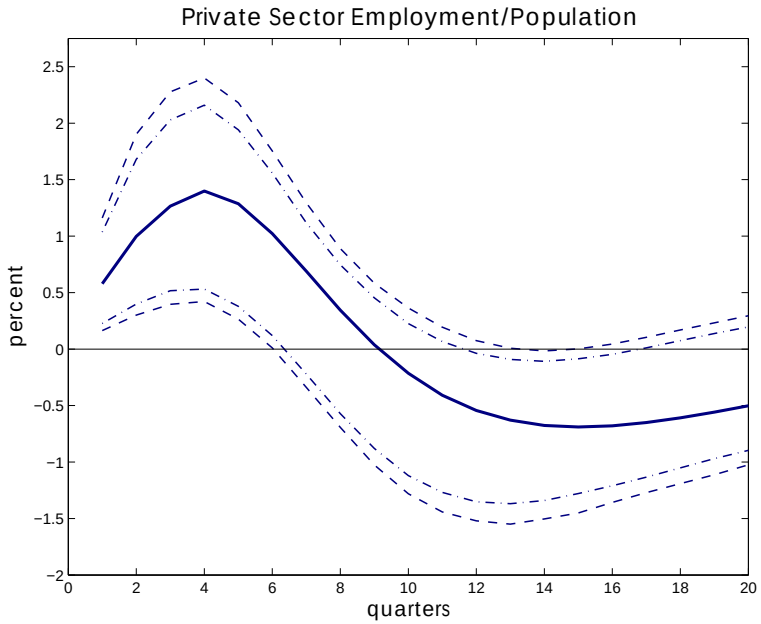
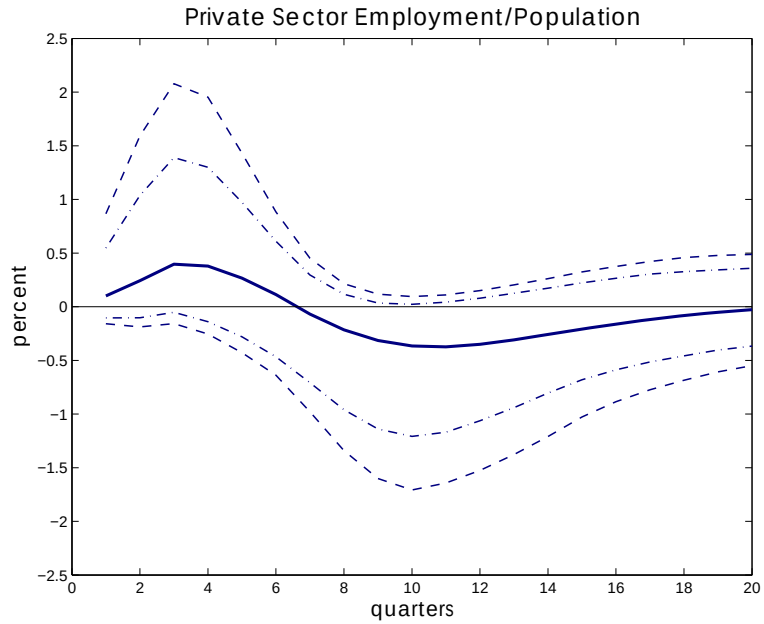
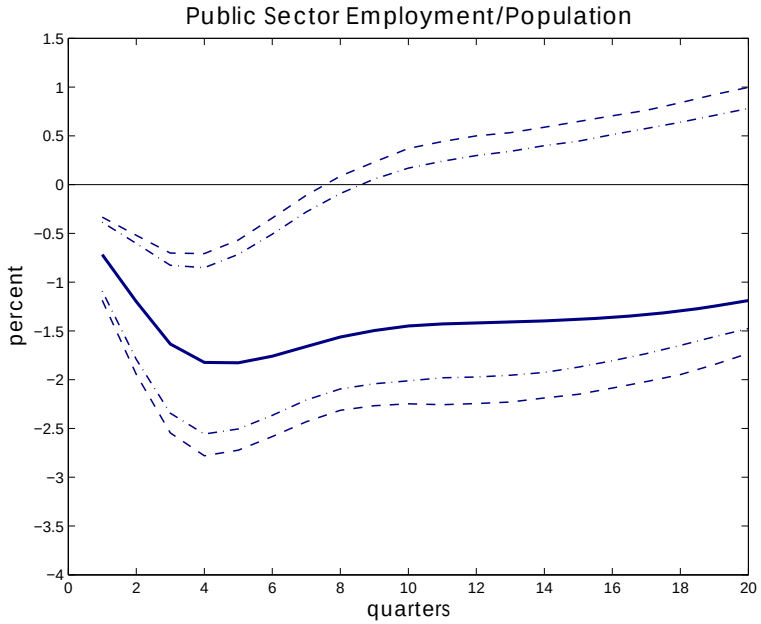
Private vs. Public Sector Employment

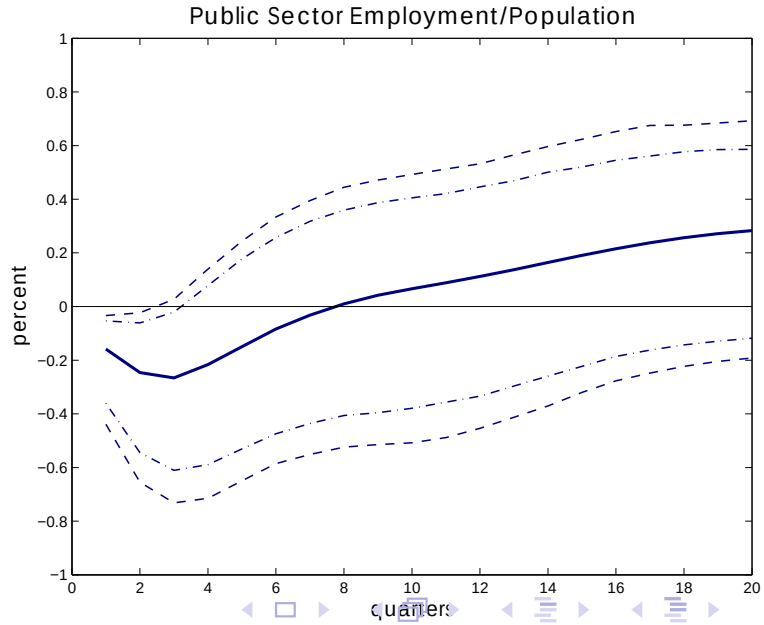
(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut

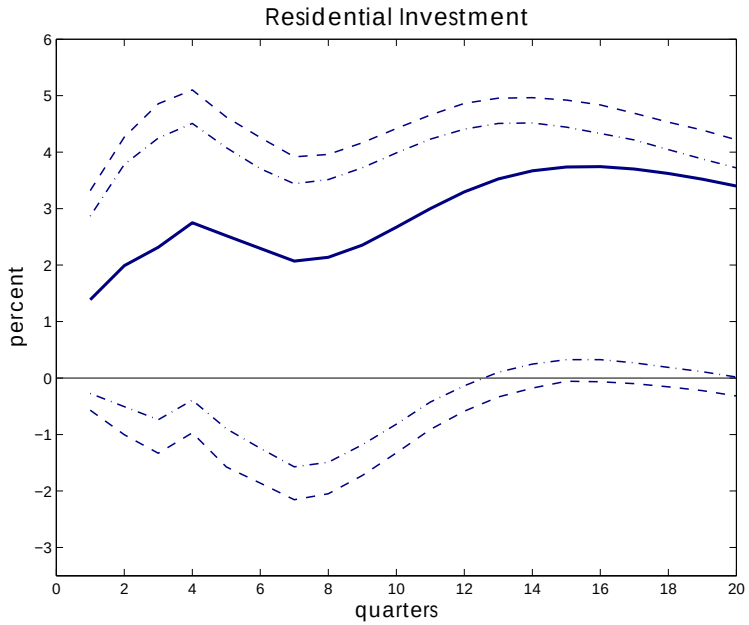




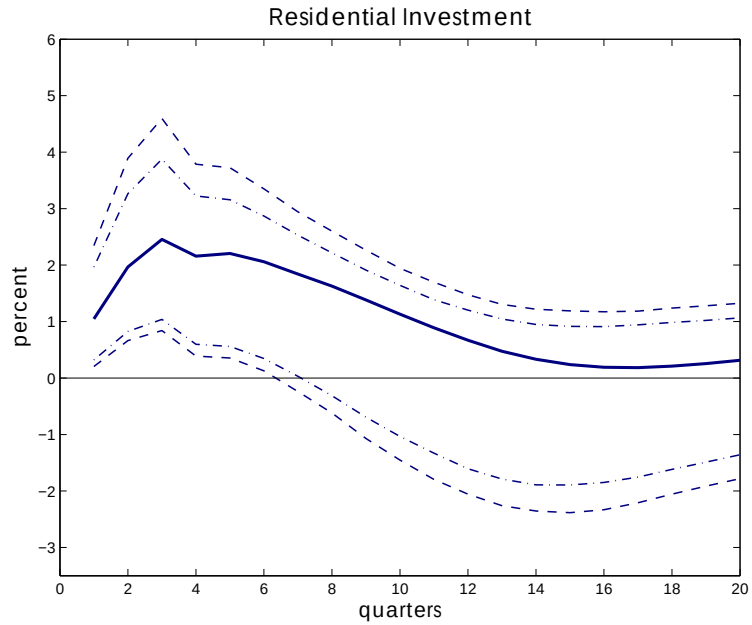


Residential Investment

(A) Personal Income Tax Cut



(B) Corporate Income Tax Cut



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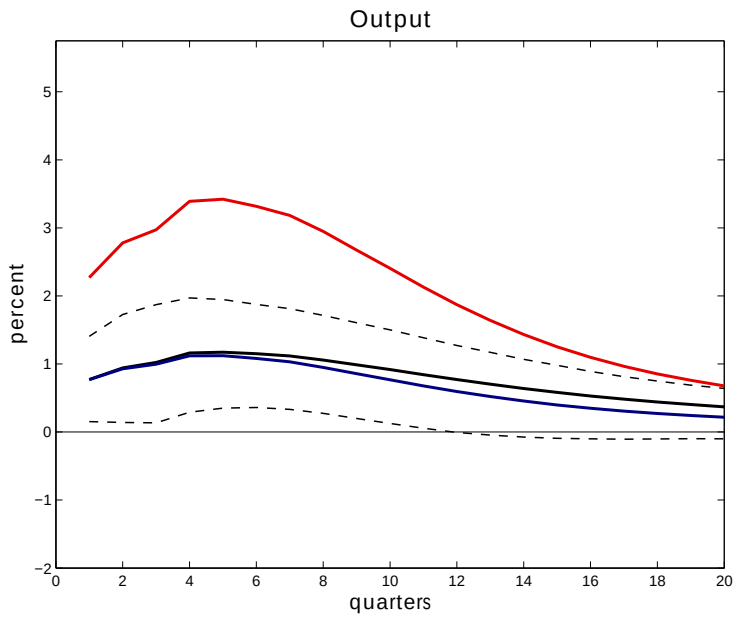
Favero and Giavazzi (2011)

$$Y_t = \delta' X_t + \gamma \Delta T_t^{narr} + u_t$$



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