# Reconciling VAR-based and Narrative Measures of the Tax Multiplier

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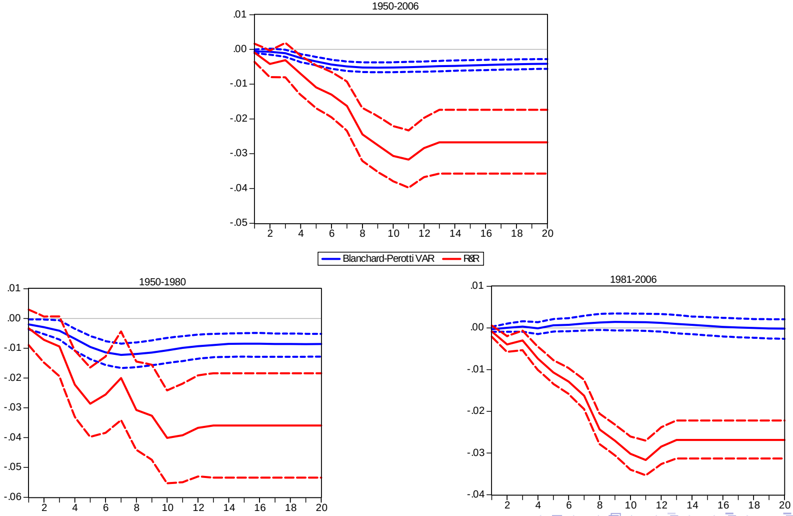
# Motivation

- Surprising and puzzling differences between various estimates of the effects on U.S output of an exogenous shift in Federal tax liabilities
- Romer and Romer, for the post WW II period, find a multiplier significantly greater than one: a tax increase of 1% of U.S. GDP reduces output over the next three years by nearly 3%
- Blanchard and Perotti, over the same time period, estimate a multiplier whose size (1.3) is less than a half
- These differences are not stable across sub-periods
    - in B&P up to 1980 tax cuts have a *positive and significant* effect on output, with a multiplier only slightly smaller compared with R&R. After 1980, the effect turns *negative and significant*
    - R&R find that the tax multiplier is stable over the sample

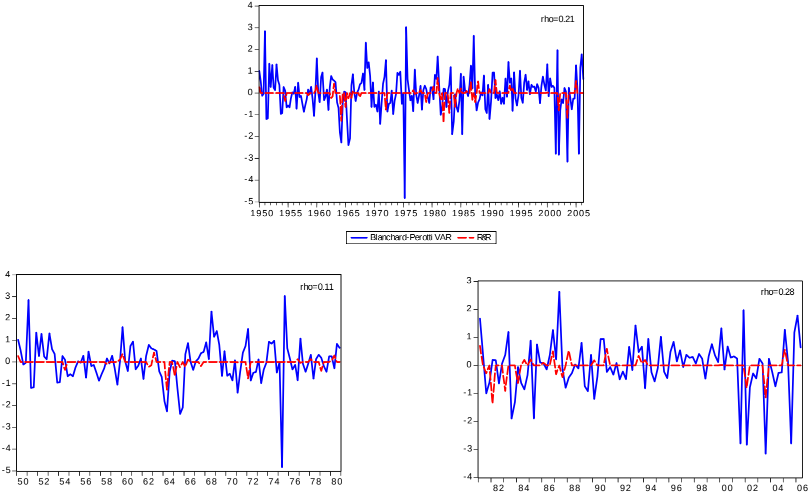
# The effect on U.S. GDP of an exogenous increase in taxes equivalent to 1% of GDP: B&P vs r&R



# Where could these differences come from? Different shocks or different models?

- Different identification of exogenous tax shocks: SVAR vs "narrative"
  - R&R argue that differences in tax multipliers are the result of the failure of structural VAR's to identify truly exogenous shifts in taxes: different impulse responses are the evidence that the shocks identified are very different
  - What matters is that shocks measure truly exogenous shifts in taxes. There is no reason why such shifts should be unique. Different identification approaches could produce different time series of fiscal shocks, each exogenous and thus each legitimate (issue reminescent of the Rudebusch vs Sims debate on the identification of monetary policy shocks)

# B&P and R&R identify different exogenous tax shocks



# Where could these differences come from? Different shocks or different models?

- Differences in the empirical models used to derive impulse responses to tax shocks
  - R&R estimate tax multipliers using a univariate regression of GDP growth on the identified exogenous tax shocks
  - B&P compute impulse responses within a SVAR that contains equations for output growth, inflation, interest rates, taxes and spending

# The Blanchard-Perotti SVAR Approach

To study of the dynamic response of macro variables to shifts in fiscal policy they estimate a VAR of the form

$$\begin{aligned}\mathbf{Z}_t &= \mathbf{C}_1\mathbf{Z}_{t-1} + \mathbf{u}_t \\ \mathbf{Z}_t^{\prime} &= \left[\begin{array}{ccccc} g_t & \tau_t & \Delta y_t & \Delta p_t & i_t \end{array}\right]\end{aligned}$$

# Identifying exogenous shifts in taxes and spending

- Innovations in the reduced form equations for taxes and government spending, $u_t^g$ and $u_t^\tau$, contain three terms
  1. the *automatic* response of $\tau$ and $g$ to fluctuations in macroeconomic variables
  2. the *discretionary* response of $\tau$ and $g$ to news in macro variables
  3. truly exogenous shifts in taxes and spending
- Identification strategy
  - identify (3) assuming (2) to be zero within a quarter
  - identify (1) using institutional information on the elasticities of tax revenues and government spending to macro variables

# Identifying exogenous shifts in taxes and spending

Exogenous shifts in $g$ and $\tau$ are identified by imposing on the $\mathbf{A}$ and $\mathbf{B}$ matrices in $\mathbf{Au} = \mathbf{B}\varepsilon$ the following structure

$$\begin{bmatrix} 1 & 0 & a_{gy} & a_{g\Delta p} & a_{gi} \\ 0 & 1 & a_{ty} & a_{t\Delta p} & a_{ti} \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \mathbf{u}_t = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^g \\ \varepsilon^\tau \\ \varepsilon_t^1 \\ \varepsilon_t^2 \\ \varepsilon_t^3 \end{bmatrix}$$

# Impulse responses

Having identified exogenous shifts in $g$ and $\tau$ and having estimated the parameters in the SVAR

$$\mathbf{Z}_t = \mathbf{C}_1 \mathbf{Z}_{t-1} + \mathbf{A}^{-1} \mathbf{B} \varepsilon_t$$

the effect of tax changes on output are computed via the impulse responses to $\varepsilon_t^{\tau}$, in the infinite order MA representation of the SVAR

$$\begin{aligned} \mathbf{Z}_t &= \Gamma(L)\varepsilon_t \\ \Gamma(L) &\equiv \frac{A^{-1}B}{1 - A^{-1}CL} \end{aligned}$$

# The R&R "narrative" approach

- A time-seires of exogenous shifts in taxes shocks is constructed using Congressional reports, etc.to identify the size, timing, and principal motivation for all major postwar tax policy actions
  - legislated tax changes are classified into endogenous (induced by short-run countercyclical concerns or taken as a response to chages in $g$) and exogenous, responses to the state of government debt, to concerns about long-run economic growth or politically motivayed: $\varepsilon_{t-i}^{RR}$
- $\varepsilon_{t-i}^{RR}$ measure the impact of a tax change at the time it was implemented $(t-i)$ on tax liabilities at time $t$.
- the effect of $\varepsilon_{t-i}^{RR}$ on output is estimated using quarterly data and OLS in a single equation, a truncated $(M=12)$ MA

$$\Delta y_t = a + \sum_{i=0}^{M} b_i \varepsilon_{t-i}^{RR} + \varepsilon_t$$

For $M=12$. Note that this equation is a truncated MA. Impulse resposnes are read directly off the $b_i$ coefficients.

# Three potential sources of the observed differences

1. Limited Information versus Full Information
2. Econometric implications of fiscal foresight
3. Intertemporal government budget constraint

*Rb*: differences in the identified tax shocks (provided they are exogenous) cannot account for differences the estimated tax mulipliers

# 1. Limited Information versus Full Information

To undertand the narrative approach in terms of the SVAR rewrite the infinite MA representation of the VAR as follows:

$$\begin{aligned} \mathbf{Z}_t &= \sum_{i=0}^{M} \Gamma_0 \Gamma_1^i \boldsymbol{\varepsilon}_{t-i} + \Gamma_1^{M+1} \mathbf{Z}_{t-M+1} \\ \Gamma_0 &\equiv A^{-1}B, \ \Gamma_1 \equiv A^{-1}C. \end{aligned}$$

# Limited Information versus Full Information

Within this infinite MA representation, the equation for output growth is

$$
\begin{aligned}
\Delta y_t &= \sum_{i=0}^{M} e^t \Gamma_0 \Gamma_1^i \varepsilon_{t-i} + \sum_{i=0}^{M} \left(\iota - e^t\right) \Gamma_0 \Gamma_1^i \varepsilon_{t-i} + \Gamma_1^{M+1} \mathbf{Z}_{t-M+1} \\
e^t &= \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \end{bmatrix} \\
\iota &= \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \end{bmatrix}.
\end{aligned}
$$

which compares with the truncated MA representation estimated by R&R

$$\Delta y_t = a + \sum_{i=0}^{M} b_i \varepsilon_{t-i}^{RR} + \varepsilon_t$$

# Limited Information versus Full Information

Comparing

$$\Delta y_t = \sum_{i=0}^{M} e^t \Gamma_0 \Gamma_1^i \boldsymbol{\varepsilon}_{t-i} + \sum_{i=0}^{M} \left(\iota - e^t\right) \Gamma_0 \Gamma_1^i \boldsymbol{\varepsilon}_{t-i} + \Gamma_1^{M+1} \mathbf{Z}_{t-M+1}$$

and

$$\Delta y_t = a + \sum_{i=0}^{M} b_i \varepsilon_{t-i}^{RR} + \varepsilon_t$$

it is clear that B&P use a Full information approach, while R&R use a limited information one.

Under which conditions do they deliver the same estimate of the tax multiplier?

# Limited Information versus Full Information

Under which conditions do

$$\Delta y_t = \sum_{i=0}^{M} e^t \Gamma_0 \Gamma_1^i \boldsymbol{\varepsilon}_{t-i} + \sum_{i=0}^{M} \left( \iota - e^t \right) \Gamma_0 \Gamma_1^i \boldsymbol{\varepsilon}_{t-i} + \Gamma_1^{M+1} \mathbf{Z}_{t-M+1}$$

and

$$\Delta y_t = a + \sum_{i=0}^{M} b_i \varepsilon_{t-i}^{RR} + \varepsilon_t$$

deliver the same estimate of the tax multiplier?

1. $\varepsilon_t^{RR}$ are orthogonal to any other shock in $\varepsilon_t$ that might influence output growth. This is R&R's identifying assumption
2. $\varepsilon_t^{RR}$ are orthogonal to $\mathbf{Z}_{t-M+1}$. This is unlikely to be satisfied: $\varepsilon_t^{RR}$ include tax changes in response to the state of the debt, and $\mathbf{Z}$ includes all the variables that determine the dynamics of debt.

# 2. Econometric Implications of fiscal foresight

"... *fiscal foresight (private agents receive signals in the present on the taxes they will face in the future) produces equilibrium time-series with a non-invertible moving average component. So there is a misalignment between the true agents information set and the econometrician's information set in the estimated VAR. Economic meaningful shocks to taxes cannot be extracted from statistical innovations in VARs in conventional ways.*"

[E. Leeper, T. Walker and Sun Chun Yang, 2008]

# Implications of fiscal foresight: a simple illustration

- Log linearized standard growth model with log preferences, inelastic labour supply and complete depreciation of capital.
- A proportional tax is levied on income, and rebated (period-by-period) through lump-sum transfers.. There is no government spending.
- The economy is subject to two shocks
  - exogenous technological shocks $\epsilon_{A,t}$
  - tax shocks, $\epsilon_{\tau,t-q}$, where news about future tax rates arrives $q$ periods before the new rates are implemented

# Implications of fiscal foresight: a simple illustration

Equilibrium conditions

$$
\begin{aligned}
\frac{1}{C_t} &= \alpha\beta E_t \left(1-\tau_{t+1}\right) \frac{1}{C_{t+1}} \frac{Y_{t+1}}{K_t} \\
C_t + K_t &= Y_t = A_t K_{t-1}^{\alpha} \\
\tau_t &= \bar{\tau} \exp\left(\epsilon_{\tau,t-q}\right) \\
A_t &= \exp\left(\epsilon_{A,t}\right)
\end{aligned}
$$

Solution

$$
k_t = a k_{t-1} + \epsilon_{A,t} - \rho \sum_{i=0}^{\infty} \theta^i E_t \epsilon_{\tau,t-q+1+i}
$$

# Implications of fiscal foresight: a simple illustration

The solution is different for different degrees of fiscal foresight

- $q = 0$

$$k_t = \alpha k_{t-1} + \epsilon_{A,t}$$

- $q = 1$

$$k_t = \alpha k_{t-1} + \epsilon_{A,t} - \rho \epsilon_{\tau,t}$$

- $q = 2$

$$k_t = \alpha k_{t-1} + \epsilon_{A,t} - \rho \left( \epsilon_{\tau,t-1} + \theta \epsilon_{\tau,t} \right)$$

- for q $\geqq$ 2 we have non-invertibility: it is impossible to identify structural shocks from the VAR residuals.

# 3. The government's intertemporal budget constraint

The models considered so far are linear. However, there is a natural source of non-linearity among the variables included in a fiscal VAR which arises from the government intertemporal budget constraint

$$d_t = \frac{1+i_t}{(1+x_t)} d_{t-1} + \frac{\exp(g_t) - \exp(\tau_t)}{\exp(y_t)}$$

$$x_t \equiv \Delta p_t + \Delta y_t + \Delta p_t \Delta y_t$$

# A VAR with the Government Intertemporal budget constraint

$$\mathbf{Z}_t = \mathbf{C}\mathbf{Z}_{t-1} + \gamma_i \left( d_{t-1} - d^* \right) + \mathbf{u}_t$$

$$d_t = \frac{1 + i_t}{\left(1 + \Delta p_t\right)\left(1 + \Delta y_t\right)} d_{t-1} + \frac{\exp\left(g_t\right) - \exp\left(\tau_t\right)}{\exp\left(y_t\right)}$$

# Different shocks, same models, same impulse responses

To understand the relative effect of all potential sources of discrepancies between R&R and traditiona, SVAR-based tax multipliers,we adopt this specification

$$\begin{aligned} \mathbf{Z}_t &= \sum_{i=1}^{k} \mathbf{C}_i \mathbf{Z}_{t-i} + \delta_i u_t^t + \gamma_i \left( d_{t-1} - d^* \right) + \mathbf{e}_t \\ d_t &= \frac{1 + i_t}{\left(1 + \Delta p_t\right)\left(1 + \Delta y_t\right)} d_{t-1} + \frac{\exp\left(g_t\right) - \exp\left(t_t\right)}{\exp\left(y_t\right)} \end{aligned}$$

where $\mathbf{Z}_t$ includes the five variables that enter the government budget constraint

# Computing impulse responses in a VAR with a debt dynamics equation

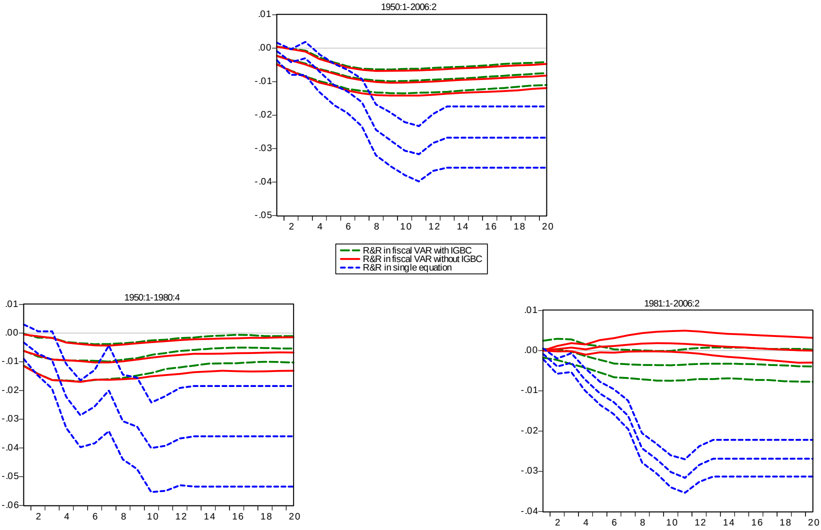
- generate a baseline simulation for all variables by solving the equation for $\mathbf{Z}_t$ dynamically forward (this requires setting to zero all shocks for a number of periods equal to the horizon up to which impulse responses are needed),
- generate an alternative simulation for all variables by setting to one–just for the first period of the simulation–the structural shock of interest, and then solve dynamically forward the model up to the same horizon used in the baseline simulation,
- compute impulse responses to the structural shocks as the difference between the simulated values in the two steps above.
- compute confidence intervals via bootstrap methods.

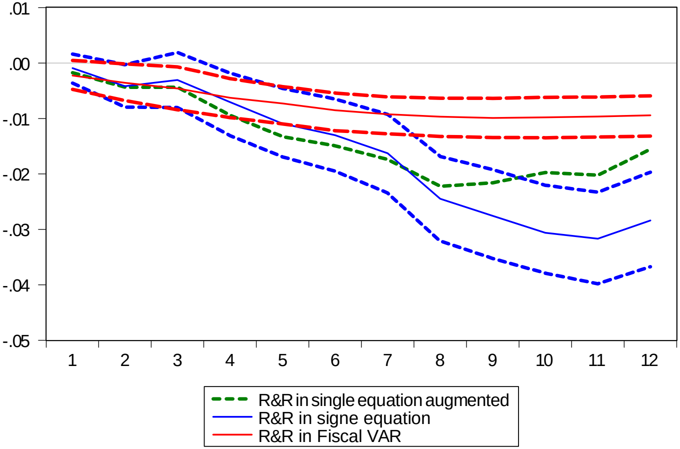
# Empirical results

- R&R shocks when used in the SVAR have the same multiplier as B&P shocks
- Augmenting the R&R equation with lags of the VAR variables explains the difference between R&R and VAR

$$\Delta Y_t = a + \sum_{i=0}^{M} b_i e_{t-i}^{RR} + \mathbf{C}_i^{M+1} \mathbf{Z}_{t-M+1} + e_t$$

- The effect of the non-linearities generated by IGBC is small


1950:1-2006:2
R&R in fiscal VAR with IGBC
R&R in fiscal VAR without IGBC
R&R in single equation
1950:1-1980:4
1981:1-2006:2



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12
R&R in single equation augmented
R&R in signe equation
R&R in Fiscal VAR

# Conclusions

Use narrative shocks in Fiscal VARs