Can tax cuts restore economic growth in bad times?

Alex Ziegenbein
Universitat Pompeu Fabra & Barcelona GSE

SAEe — December 14, 2017
Background

– Tax cuts often implemented to bring output back to potential

– Recent evidence: large effects of tax cuts on GDP on average

– No evidence how these effects vary over the business cycle

– This paper: can tax cuts restore growth during bad times?
Background
When are tax multipliers large?

1. Wealth effect: tax cut stimulates aggregate demand
   - Effect large when crowding-out small

2. Substitution effect: tax cut stimulates labor supply
   - Effect large when labor market tightness / hiring cost high
This paper

- Study state-dependent effects of tax shocks using US data

Main findings:

- **Good times**: tax shocks have large effects on output

- **Bad times**: tax shocks have small and insignificant effects

  - Holds for two leading identification strategies
  - Holds for variety of alternative specifications
  - Holds for both personal and corporate income tax shocks
Contributions

1. New empirical finding
   - **Good times**: tax shocks have large effects on output
   - **Bad times**: tax shocks have small and insignificant effects

2. Search & matching model with endogenous search effort
   - **Unemployment low**: tax shocks have large effects on output
   - **Unemployment high**: tax shocks have small effects on output
Empirical framework

Two components

1. Local projections (Jordá, 2005)
   - Estimates more robust to model misspecification than in VAR
   - No assumption needed on how the shock affects the state

2. Key identification assumption
   - Narrative measure correlates with latent tax shock
   - Narrative measure is uncorrelated with other structural shocks
Narrative measure of tax "shocks": 1947Q1-2006Q4

Romer & Romer, 2010

\[ RR_t: \text{45 \"shocks\", } \bar{RR} = 0, SD(\bar{RR}) = 0.5, \text{25 positive, 20 negative} \]
Linear specification
Two-stage least squares

\[ ATR_t = a + bRR_t + c'_h z_{t-1} + e_t \]
\[ x_{t+h} = \alpha_h + \beta_h \hat{ATR}_t + \gamma'_h z_{t-1} + u_{t+h} \]

- \( x_t = \{ Y_t, G_t, ATR_t \} \)
- I add four lags of \( G, Y, ATR_t \) for efficiency
- \( G \) and \( Y \) in logs (allow for quadratic trend)
Linear specification

Impulse responses

![Graph showing impulse responses for Y, G, and ATR variables over 12 quarters. Y initially decreases by 2 ppt, then stabilizes. G increases gradually, peaking at 0.5 ppt. ATR shows a fluctuating pattern, with a peak of 0.2 ppt.](image-url)
State-dependent specification

\[ x_{t+h} = l_{t-1} \left[ \alpha^B_h + \beta^B_h \widehat{ATR}_t + \gamma^B_h z_t \right] + (1 - l_{t-1}) \left[ \alpha^G_h + \beta^G_h \widehat{ATR}_t + \gamma^G_h z_t \right] + u_{t+h} \]

- Now \( l_{t-1} \times RR_t \) is an instrument for \( l_{t-1} \times \epsilon^T_t \)

- Baseline slack measure from Ramey & Zubairy (2016)

\[ l_{t-1} = \begin{cases} 
1 & \text{if } U_{t-1} \geq 6.5\% \\
0 & \text{if } U_{t-1} < 6.5\% 
\end{cases} \]
Good times: 26 tax changes, sd(RR) = 0.5, pos. 12, neg. 14
Bad times: 19 tax changes: sd(RR) = 0.5, pos. 13, neg. 6
State-dependent specification

Impulse responses

![Graphs showing impulse responses in Bad Times and Good Times for Y, G, and ATR.](Image)
Effects on other macro variables
Understanding the state-dependent effects of tax shocks

Intuition

Focus on household reaction to income taxation

- $\sim 74\%$ of federal tax revenue from income taxes
- Main effect is a substitution effect (Barro & Redlick, 2011)

- **Good times**: labor market is tight, difficult to fill vacancies
  $\rightarrow$ Tax cut can reduce tightness and increase hiring

- **Bad times**: labor demand depressed, easy to fill vacancies
  $\rightarrow$ Tax cut incentivizing labor supply is ineffective
Search & matching with endogenous job-search effort
Mechanism & empirical evidence

– **Good times**: labor demand high / unemployment low
  $\rightarrow$ **Good times**: hiring cost is high / search frictions matter
  Landais, Michaillat & Saez (2016)

– Income tax cut $\rightarrow$ jobseekers’ job-search effort $\uparrow$
  Gentry & Hubbard (2004)

– Search effort $\uparrow$ $\rightarrow$ tightness & hiring cost $\downarrow$ $\rightarrow$ employment $\uparrow$

– Search effort $\uparrow$ has large effect when search frictions matter
  $\rightarrow$ **Small effect in bad times & large effect in good times**
  Toohey (2017)
Search & matching with endogenous job-search effort

Steady-state equilibrium

\[ L^d = L(\theta, w, A) \]

\[ L^s = L(\theta, s^s) \]

\[ s^s = s(\theta, \Delta U) \]
Good times and bad
Comparative steady-states analysis

- **Good times**: high $A$ steady-state, labor demand is high
- **Bad times**: low $A$ steady-state, labor demand is low
- As in Hall (2005) the wage is fixed

→ I compare effects of tax cut in low $A$ and high $A$ steady-state
Effect of a tax cut

Bad times, low $A$

Good times, high $A$

Employment

Labor market tightness

$dL$

$d\theta$

$\tau \downarrow$

$L$

$\theta$

$dL$

$d\theta$
Tax multiplier

Tax multiplier is increasing in $A$

\[ M \equiv -\frac{dL}{d\tau} = -\frac{\partial L^s}{\partial \tau} \cdot \frac{1}{1 + (\epsilon^s/\epsilon^d)} \]

- $L$ and $\theta$ higher in high $A$ steady-state

- $\epsilon^s \equiv (\partial L^s/\partial \theta) \cdot (\theta/L^s) > 0$ decreasing in $A$
  - $L^s$ steeper in high $A$ steady-state

- $\epsilon^d \equiv -(\partial L^d/\partial \theta) \cdot (\theta/L^d) > 0$ increasing in $A$
  - $L^d$ flatter in high $A$ steady-state

- $-\partial L^s/\partial \tau > 0$ is increasing in $A$
  - Effect of $\tau$ on $s$ is high, when $f(\theta)$ is high
Discussion

Main findings:
- **Good times**: tax shocks have large effects on output
- **Bad times**: tax shocks have small and insignificant effects

Interpretation:
- **Bad times**: search frictions do not matter much
  → An income tax cut incentivizes search effort & is ineffective
  → Policy should address low labor demand (payroll tax)

Calibrated version of the model:
- Effect of a tax cut triples when $u_t$ moves from 8% to 5%
Example tax changes

Exogenous long-run growth
- Tax cuts in 1948 passed over Truman's veto
- Kennedy-Johnson tax cuts 1964
- Reagan tax cuts 1981
- Bush tax cuts 2001 & 2003

Exogenous deficit-reduction
- Social security amendments 1982/83
- Omnibus Reconciliation Act 1990-93

Endogenous countercyclical
- Nixon tax cuts 1971
- Ford tax changes 1975
- Bush tax cuts 2001/2002

Endogenous government-spending
- Korea war 1951
Blanchard & Perotti (2002) identification

Linear specification

\[ X_t = A X_{t-1} + u_t \]
\[ u_t = C \epsilon_t \]
\[ \Sigma_u = C \Sigma \epsilon C' \]

- \( X_t = [T_t, G_t, Y_t]' \).
- \( c_{21} = c_{23} = 0 \)
- Output elasticity of taxes \( c_{13} = 2.4 \) from OECD data
Blanchard & Perotti (2002) identification
State-dependent specification

\[ X_t = l_{t-1}A^B X_{t-1} + (1 - l_{t-1})A^G X_{t-1} + u_t \]
\[ u_t = l_{t-1}C^B \epsilon_t + (1 - l_{t-1})C^G \epsilon_t \]
\[ \Sigma_t = l_{t-1} \Sigma^B + (1 - l_{t-1}) \Sigma^G \]

- \( X_t = [T_t, G_t, Y_t]' \).
- \( c_{23}^B = c_{23}^G = c_{21}^B = c_{21}^G = 0 \)
- Output elasticity for two subsamples: \( c_{13}^B = 0.7, c_{13}^G = 2.8 \)
Blanchard & Perotti (2002) identification

Results
## Peak effects of a tax shock on output

### Alternative identification

<table>
<thead>
<tr>
<th></th>
<th>Romer &amp; Romer Narrative Approach</th>
<th>Blanchard &amp; Perotti Structural VAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Local Projections-IV</td>
<td>VAR</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Linear Model</td>
<td>-2.03***</td>
<td>-1.61**</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h) )</td>
<td>(0.68)</td>
<td>(0.62)</td>
</tr>
<tr>
<td>Bad Times</td>
<td>-0.52</td>
<td>-0.47</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B) )</td>
<td>(1.34)</td>
<td>(0.75)</td>
</tr>
<tr>
<td>Good Times</td>
<td>-3.54***</td>
<td>-2.68***</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^G) )</td>
<td>(1.00)</td>
<td>(0.73)</td>
</tr>
<tr>
<td>Difference</td>
<td>3.02**</td>
<td>2.21*</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B) - \min(\hat{\theta}_h^G) )</td>
<td>(1.54)</td>
<td>(1.19)</td>
</tr>
</tbody>
</table>

Peak effects of a tax shock on real GDP (in percent). Standard errors in parentheses. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively. (1) is the baseline specification: tax shocks are identified using the narrative approach. Estimates are from the linear local projections in Equation 1 and the state-dependent local projections in Equation 3. (2) tax shocks are identified using the BP structural VAR approach. Estimates are from the linear VAR model in Equation 4 and the state-dependent VAR in Equation 7.
Alternative state variable

- Baseline: \( I_t = 1 \) if \( U_t \geq 6.5\% \)

- HP-filtered: \( I_t = 1 \) if \( U_t \geq U^n_t \)
  - \( U^n_t \) from HP-filter with \( \lambda = 10^x \) and \( x = \{3, 5, 7\} \).

- NBER recession dates

- Auerbach & Gorodnichenko (2012) smooth transition function
  \[ I_t = F(s_t) = \frac{\exp(-\nu s_t)}{1 + \exp(-\nu s_t)} \]
  - \( s_t \) is standardized seven-month MA of output growth
  - \( \nu = 1.5 \) implies economy spends 20% of time in recession
Alternative state variable
Continuous unemployment rate

\[ x_{t+h} = a_h + \beta^1_h \hat{ATR}_t + \beta^2_h U_{t-1} \times \hat{ATR}_t + \gamma^1_h z_{t-1} + \gamma^2_h U_{t-1} \times z_{t-1} + \kappa U_{t-1} + u_{t+h} \]

- \[\theta^G_h = \left( \beta^1_h + \beta^2_h \times (\tilde{U} - \sigma_U) \right) \sigma_\tau\]
- \[\theta^B_h = \left( \beta^1_h + \beta^2_h \times (\tilde{U} + \sigma_U) \right) \sigma_\tau.\]
### Alternative state variable

<table>
<thead>
<tr>
<th></th>
<th>U 6.5%</th>
<th>U HP λ = 10³</th>
<th>U HP λ = 10⁵</th>
<th>U HP λ = 10⁷</th>
<th>NBER Dates</th>
<th>Smooth Trans.</th>
<th>U Cont.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linear Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \hat{\theta}_h )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h) )</td>
<td>-2.03***</td>
<td>-2.03***</td>
<td>-2.03***</td>
<td>-2.03***</td>
<td>-2.03***</td>
<td>-2.03***</td>
<td>-2.03***</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h) )</td>
<td>(0.68)</td>
<td>(0.68)</td>
<td>(0.68)</td>
<td>(0.68)</td>
<td>(0.68)</td>
<td>(0.68)</td>
<td>(0.68)</td>
</tr>
<tr>
<td>Bad Times ( \hat{\theta}_h^B )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B) )</td>
<td>-0.52</td>
<td>-0.78</td>
<td>-0.90</td>
<td>-1.31**</td>
<td>0.25</td>
<td>-1.34*</td>
<td>-0.71</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B) )</td>
<td>(1.34)</td>
<td>(0.75)</td>
<td>(0.78)</td>
<td>(0.64)</td>
<td>(0.84)</td>
<td>(0.79)</td>
<td>(1.43)</td>
</tr>
<tr>
<td>Good Times ( \hat{\theta}_h^G )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^G) )</td>
<td>-3.54***</td>
<td>-4.37***</td>
<td>-3.46**</td>
<td>-4.84***</td>
<td>-3.40***</td>
<td>-3.96***</td>
<td>-3.75***</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^G) )</td>
<td>(1.00)</td>
<td>(1.35)</td>
<td>(1.35)</td>
<td>(1.09)</td>
<td>(0.90)</td>
<td>(1.31)</td>
<td>(1.12)</td>
</tr>
<tr>
<td>Difference ( \hat{\theta}_h^B - \min(\hat{\theta}_h^G) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B - \min(\hat{\theta}_h^G)) )</td>
<td>3.02**</td>
<td>3.59**</td>
<td>2.55</td>
<td>3.53**</td>
<td>3.65**</td>
<td>2.62*</td>
<td>3.04**</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B - \min(\hat{\theta}_h^G)) )</td>
<td>(1.54)</td>
<td>(1.55)</td>
<td>(1.75)</td>
<td>(1.26)</td>
<td>(1.23)</td>
<td>(1.53)</td>
<td>(1.55)</td>
</tr>
</tbody>
</table>
## Distribution of exogenous tax changes

### Alternative state variable

<table>
<thead>
<tr>
<th></th>
<th>U 6.5%</th>
<th>U HP $\lambda = 10^3$</th>
<th>U HP $\lambda = 10^5$</th>
<th>U HP $\lambda = 10^7$</th>
<th>NBER Dates</th>
<th>Smooth Transition</th>
<th>U Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Tax Shocks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periods</td>
<td>244</td>
<td>244</td>
<td>244</td>
<td>244</td>
<td>244</td>
<td>244</td>
<td>244</td>
</tr>
<tr>
<td>N Shocks</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Mean</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
</tr>
<tr>
<td>Negative</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td><strong>Bad Times</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periods</td>
<td>66</td>
<td>104</td>
<td>110</td>
<td>118</td>
<td>36</td>
<td>66</td>
<td>122</td>
</tr>
<tr>
<td>N Shocks</td>
<td>19</td>
<td>21</td>
<td>23</td>
<td>30</td>
<td>8</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Mean</td>
<td>.09</td>
<td>-.06</td>
<td>-.10</td>
<td>.09</td>
<td>-.18</td>
<td>-.40</td>
<td>.06</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>.49</td>
<td>.62</td>
<td>.58</td>
<td>.51</td>
<td>.65</td>
<td>.79</td>
<td>.49</td>
</tr>
<tr>
<td>Positive</td>
<td>13</td>
<td>12</td>
<td>12</td>
<td>19</td>
<td>4</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Negative</td>
<td>6</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>4</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td><strong>Good Times</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periods</td>
<td>178</td>
<td>140</td>
<td>134</td>
<td>126</td>
<td>206</td>
<td>178</td>
<td>122</td>
</tr>
<tr>
<td>N Shocks</td>
<td>26</td>
<td>24</td>
<td>22</td>
<td>15</td>
<td>37</td>
<td>35</td>
<td>14</td>
</tr>
<tr>
<td>Mean</td>
<td>-.06</td>
<td>.05</td>
<td>.10</td>
<td>-.19</td>
<td>.04</td>
<td>.11</td>
<td>-.14</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>.59</td>
<td>.48</td>
<td>.50</td>
<td>.60</td>
<td>.53</td>
<td>.40</td>
<td>.66</td>
</tr>
<tr>
<td>Positive</td>
<td>12</td>
<td>13</td>
<td>13</td>
<td>6</td>
<td>21</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>Negative</td>
<td>14</td>
<td>11</td>
<td>9</td>
<td>9</td>
<td>16</td>
<td>14</td>
<td>8</td>
</tr>
</tbody>
</table>
Impulse responses

Alternative state variable

Bad Times
Baseline
NBER dates
Smooth Transition
U continuous
HP10
HP10^3
HP10^5
HP10^7

Good Times

Quarters
Y (ppt)
Additional control variables

- 4 lags of log real federal government debt to the public

- 4 lags of monetary VAR variables
  - FFR, log CPI, log non-borrowed reserves

- Fiscal foresight
  - \( x_{t+h} = \alpha_h + \beta_h \hat{ATR}_t + \sum_{j=0}^{K} \delta_j E_t(\tau_{t+j}) + \gamma'_{h} z_{t-1} + u_{t+h} \)
  - Implicit tax rate from Leeper et al. (2011): \( E_t(\tau_{t+j}) = 1 - \frac{Y_{t+j}^M}{Y_{t+j}} \)
## Peak effects of a tax shock on output
### Additional control variables

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Control for Public Debt</th>
<th>Control for Mon. Policy</th>
<th>Control for Foresight</th>
<th>Vars in Growth Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linear Model</strong></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h) )</td>
<td>-2.03***</td>
<td>-2.52**</td>
<td>-2.07**</td>
<td>-2.51***</td>
<td>-1.57**</td>
</tr>
<tr>
<td></td>
<td>(0.68)</td>
<td>(1.02)</td>
<td>(0.60)</td>
<td>(0.64)</td>
<td>(0.69)</td>
</tr>
<tr>
<td><strong>Bad Times</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B) )</td>
<td>-0.52</td>
<td>-0.74</td>
<td>-0.64</td>
<td>-0.68</td>
<td>-0.82</td>
</tr>
<tr>
<td></td>
<td>(1.34)</td>
<td>(1.29)</td>
<td>(0.64)</td>
<td>(1.09)</td>
<td>(0.64)</td>
</tr>
<tr>
<td><strong>Good Times</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^G) )</td>
<td>-3.54***</td>
<td>-3.67***</td>
<td>-3.05***</td>
<td>-3.59***</td>
<td>-3.28***</td>
</tr>
<tr>
<td></td>
<td>(1.00)</td>
<td>(1.12)</td>
<td>(0.99)</td>
<td>(0.96)</td>
<td>(1.01)</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \min(\hat{\theta}_h^B) - \min(\hat{\theta}_h^G) )</td>
<td>3.02**</td>
<td>2.93*</td>
<td>2.41**</td>
<td>2.91**</td>
<td>2.46**</td>
</tr>
<tr>
<td></td>
<td>(1.54)</td>
<td>(1.71)</td>
<td>(1.72)</td>
<td>(1.45)</td>
<td>(1.20)</td>
</tr>
</tbody>
</table>

*Standard errors in parentheses. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively.*
Impulse responses

Additional control variables

![Graph showing impulse responses in Bad Times and Good Times, with different control variables such as Baseline, + Public Debt, + Monetary Policy, and + Fiscal Foresight.](image)
Proxy SVAR
Mertens & Ravn, 2014

Linear proxy SVAR

\[ X_t = A X_{t-1} + u_t \]
\[ u_t = C \epsilon_t \]

- \( X_t = [T_t, G_t, Y_t]' \)
- First row of \( C \) from regressing \( u_t \) on \( RR_t \)

State-dependent proxy SVAR

\[ X_t = l_{t-1} A^B X_{t-1} + (1 - l_{t-1}) A^G X_{t-1} + u_t \]
\[ u_t = l_{t-1} C^B \epsilon_t + (1 - l_{t-1}) C^G \epsilon_t \]
\[ \Sigma_t = l_{t-1} \Sigma_u^B + (1 - l_{t-1}) \Sigma_u^G. \]
Proxy SVAR

Results

Bad Times

Good Times
Augmented VAR

Linear augmented VAR

\[ X_t = CRR_t + AX_{t-1} + u_t \]

- \[ X_t = [T_t, G_t, Y_t]' \]

State-dependent augmented VAR

\[ X_t = I_{t-1} \left[ C^B RR_t + A^B X_{t-1} \right] + (1-I_{t-1}) \left[ C^G RR_t + A^G X_{t-1} \right] + u_t \]
Augmented VAR

Results

![Graphs showing the results of Augmented VAR for different variables (T, G, Y) over different quarters in Bad Times and Good Times. The graphs depict the comparison between Linear VAR and the results obtained from the Augmented VAR model.](image-url)
Truncated structural MA
Romer & Romer, 2010

Linear MA

\[ Y_t = \alpha + \sum_{h=0}^{12} \theta_h RR_{t-h} + u_t \]

State-dependent MA

\[ Y_t = \alpha + \sum_{h=0}^{12} \left[ I_{t-1-h} \theta_h^B RR_{t-h} + (1 - I_{t-1-h}) \theta_h^G RR_{t-h} \right] + u_t \]
Truncated structural MA

Results

Bad Times

Good Times

-3
-2
-1
0
1
Y (ppt)

Quarters

-3
-2
-1
0
1

Quarters

Linear MA

-3
-2
-1
0
1

Linear MA
## Peak effects of a tax shock on output

### Alternative empirical models

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Proxy SVAR</th>
<th>Augmented VAR</th>
<th>Truncated MA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(5)</td>
</tr>
<tr>
<td>Linear Model</td>
<td>-2.03***</td>
<td>-1.22**</td>
<td>-1.61**</td>
<td>-1.95*</td>
</tr>
<tr>
<td>$\min(\hat{\theta}_h)$</td>
<td>(0.68)</td>
<td>(0.60)</td>
<td>(0.67)</td>
<td>(1.02)</td>
</tr>
<tr>
<td>Bad Times</td>
<td>-0.52</td>
<td>-0.34</td>
<td>-0.75</td>
<td>-0.54</td>
</tr>
<tr>
<td>$\min(\hat{\theta}_B^h)$</td>
<td>(1.34)</td>
<td>(0.82)</td>
<td>(0.87)</td>
<td>(1.02)</td>
</tr>
<tr>
<td>Good Times</td>
<td>-3.54***</td>
<td>-2.52***</td>
<td>-2.70***</td>
<td>-3.06***</td>
</tr>
<tr>
<td>$\min(\hat{\theta}_G^h)$</td>
<td>(1.00)</td>
<td>(0.73)</td>
<td>(0.72)</td>
<td>(0.78)</td>
</tr>
<tr>
<td>Difference</td>
<td>3.02**</td>
<td>2.18*</td>
<td>1.95*</td>
<td>2.52**</td>
</tr>
<tr>
<td>$\min(\hat{\theta}_B^h) - \min(\hat{\theta}_G^h)$</td>
<td>(1.54)</td>
<td>(1.10)</td>
<td>(1.13)</td>
<td>(1.28)</td>
</tr>
</tbody>
</table>

Peak effects of a tax shock on real GDP (in percent). Standard errors in parentheses. *, **, *** indicates statistical significance at the 10%, 5% and 1% level, respectively. (1) uses the linear local projections in Equation 1 and the state-dependent local projections in Equation 3. (2) uses the linear proxy SVAR in Equation B.2 and the state-dependent proxy SVAR in Equation B.3. (3) uses the linear augmented VAR in Equation B.4 and the state-dependent VAR in Equation B.5. (4) uses the linear truncated MA in Equation B.6 and the state-dependent truncated MA in B.7.
Sign-dependent specification

\[ x_{t+h} = a_h + \theta^+_h R^+_R + \theta^-_h R^-_R + \gamma'_h z_{t-1} + u_{t+h} \]

- \( R^+_R \) are tax increases
- \( R^-_R \) are tax reductions
Sign-dependent effects of tax changes

Results

![Graphs showing sign-dependent effects of tax changes](image)

- **Tax Increase**
  - Y (ppt) vs. Quarters
  - Graphs illustrate the impact of tax increases over time.

- **Tax Reduction**
  - Y (ppt) vs. Quarters
  - Graphs illustrate the impact of tax reductions over time.
Personal and corporate income taxes

Use decomposition of $RR_t$ from Mertens and Ravn (2013)

PI: 6 in good, 8 in bad times | CI: 11 in good bad times, 5 in bad times
Personal and corporate income taxes

Use decomposition of $RR_t$ from Mertens and Ravn (2013)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (Y)</td>
<td>Nominal GDP divided by its implicit price deflator</td>
<td>FRED</td>
</tr>
<tr>
<td>Government spending (G)</td>
<td>Federal government consumption expenditures and gross investment divided by the GDP deflator.</td>
<td>FRED</td>
</tr>
<tr>
<td>Average tax rate (ATR)</td>
<td>Nominal federal tax revenues minus transfers divided by nominal GDP.</td>
<td>FRED</td>
</tr>
<tr>
<td>Narrative tax measure (RR)</td>
<td>Narrative measure of exogenous tax changes.</td>
<td>Romer and Romer (2010)</td>
</tr>
<tr>
<td>Average personal income tax rate (APITR)</td>
<td>Federal personal income tax revenues including contributions to government social insurance divided by personal income tax base.</td>
<td>Mertens and Ravn (2013)</td>
</tr>
<tr>
<td>Average corporate income tax rate (ACITR)</td>
<td>Federal corporate income tax revenues divided by corporate income tax base.</td>
<td>Mertens and Ravn (2013)</td>
</tr>
<tr>
<td>Narrative personal income tax measure (RRp)</td>
<td>Narrative measure of exogenous personal income tax changes.</td>
<td>Mertens and Ravn (2013)</td>
</tr>
<tr>
<td>Narrative corporate income tax measure (RRc)</td>
<td>Narrative measure of exogenous corporate income tax changes.</td>
<td>Mertens and Ravn (2013)</td>
</tr>
<tr>
<td>Tax revenues (T)</td>
<td>Nominal federal tax revenues minus transfers divided by the GDP deflator.</td>
<td>FRED</td>
</tr>
<tr>
<td>Consumption (C)</td>
<td>Consumers nominal expenditure divided by its deflator.</td>
<td>FRED</td>
</tr>
<tr>
<td>Investment (I)</td>
<td>Private sector gross investment divided by its deflator.</td>
<td>FRED</td>
</tr>
<tr>
<td>Hours (L)</td>
<td>Product of hours per worker and civilian non-farm employment divided by population. Combined with Francis and Ramey (2002) hours worked series.</td>
<td>Mertens and Ravn (2012)</td>
</tr>
<tr>
<td>Wage (W)</td>
<td>Average hourly earning of private employees.</td>
<td>FRED</td>
</tr>
<tr>
<td>Unemployment rate (U)</td>
<td>Civilian unemployment rate.</td>
<td>FRED</td>
</tr>
<tr>
<td>Public Debt</td>
<td>Federal government debt held by the public divided by the GDP deflator.</td>
<td>Favero and Giavazzi (2012)</td>
</tr>
<tr>
<td>Nonborrowed reserves</td>
<td>Nonborrowed reserves.</td>
<td>FRED</td>
</tr>
<tr>
<td>Federal funds rate</td>
<td>Effective federal funds rate.</td>
<td>FRED</td>
</tr>
<tr>
<td>Price level (CPI)</td>
<td>Consumer price index for all urban consumers.</td>
<td>FRED</td>
</tr>
<tr>
<td>Implicit tax rate</td>
<td>Expected future tax rate implied by tax exempt municipal bond yields and perfect arbitrage. Based on bonds with maturity of one year.</td>
<td>Leeper et al. (2011)</td>
</tr>
<tr>
<td>Defense news</td>
<td>Professional forecasters' projections of the path of future military spending</td>
<td>Ramey (2011)</td>
</tr>
</tbody>
</table>
Alternative modeling approaches

- Standard RBC and NK model
  - Generate little state-dependence
  - Tax cut causes wage reduction → counterfactual

- Real wage rigidities (Erceg, Henderson & Levin, 2000)
  - No labor supply decision
  - If households choose $L^s$ at given wage → extreme case of presented model

- Downward (nominal) wage rigidity
  - Sign-dependent effects → counterfactual

- Financially constrained households
  - Larger effects in bad times (higher MPC)
Micro- and macroelasticity

- Landais et al. (2016) conclude

\[ e^m \approx 0.5 \text{ and } e^M \approx 0.3 \]

\[ 1 - \frac{e^M}{e^m} \approx 0.4 \]
Micro evidence
Effect of higher search effort

- Crepon et al. (2013): large scale experiment in France

- Randomization of search assistance over individuals and space

- Treated higher job-finding-prob. than untreated in same area

- Untreated in treated area lower job-finding prob. than untreated in untreated area

→ Search effort ↑ → employment ↑ and tightness ↓

- Gautier et al. (2012) find similar results in Denmark
Micro evidence
State-dependent effects of higher search effort

- Toohey (2017) studies effects of UI job-search-requirements
- Uses variation across US states and over time
- UI requires unemployed to contact a minimum number of employers per week
- Higher requirements $\rightarrow$ higher search effort
- Search measured as contacted employers
- Search has larger effect on employment in good times
New Keynesian model

A Symmetric equilibrium

→ Aggregate labor demand from monopolists’ labor demand

\[ s \mu_t \cdot \alpha \cdot L_t^{\alpha - 1} = \frac{w_t}{A_t} + \frac{r}{q(\theta_t)} - \beta \cdot (1 - \lambda) \cdot \mathbb{E}_t \left[ \frac{C_t}{C_{t+1}} \cdot \frac{A_{t+1}}{A_t} \cdot \frac{r}{q(\theta_{t+1})} \right]. \]

→ Philips curve from monopolists’ optimal price setting equation

\[ \pi_t \cdot (\pi_t + 1) = \frac{1}{\gamma} \cdot \frac{Y_t}{C_t} \cdot [\epsilon \cdot \mu_t - (\epsilon - 1)] + \beta \cdot \mathbb{E}_t [\pi_{t+1} \cdot (\pi_{t+1} + 1)]. \]
New Keynesian model

– Combining budget constraints

\[ Y_t = C_t \cdot \left( 1 + \frac{\gamma}{2} \cdot \pi_t^2 \right) + \frac{r \cdot A_t}{q(\theta_t)} \cdot H_t. \]

– Resources allocated to consumption, price adjustment, hiring

– Two exogenous disturbances

\[
\begin{align*}
\log(A_t) &= \rho_A \cdot \log(A_{t-1}) + \epsilon_t^A \\
\tau_t - \tau &= \rho_\tau \cdot (\tau_{t-1} - \tau) + \epsilon_t^\tau,
\end{align*}
\]
### Calibration

**Table 6: Calibration of the New Keynesian model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
<th>Target/Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>steady-state Targets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A$</td>
<td>1.00</td>
<td>Steady-state technology</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$u$</td>
<td>0.064</td>
<td>Steady-state unemployment</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.43</td>
<td>Steady-state labor market tightness</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$s$</td>
<td>1</td>
<td>Steady-state job-search effort</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td><strong>Parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.7</td>
<td>Elasticity of matching to unemployment</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$r$</td>
<td>0.21</td>
<td>Recruiting cost</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.01</td>
<td>Job-destruction rate</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.5</td>
<td>Elasticity of real wage to technology</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\phi_r$</td>
<td>1.5</td>
<td>Elasticity of monetary rule to inflation</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\rho_r$</td>
<td>0.96</td>
<td>Elasticity of monetary rule to lagged interest rate</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>61</td>
<td>Price adjustment cost</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\rho_A$</td>
<td>0.992</td>
<td>Autocorrelation of technology</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\rho_\tau$</td>
<td>0.992</td>
<td>Autocorrelation of taxes</td>
<td>Matches empirical impulse response function of the average tax rate to a tax shock</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.66</td>
<td>Marginal returns to labor</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.999</td>
<td>Discount factor</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td>11</td>
<td>Elasticity of substitution across goods</td>
<td>Michailiat (2014)</td>
</tr>
<tr>
<td>$m$</td>
<td>0.17</td>
<td>Matching effectiveness</td>
<td>Matches steady-state targets (Michailiat, 2014)</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.64</td>
<td>Real wage level</td>
<td>Matches steady-state targets (Michailiat, 2014)</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.22</td>
<td>Disutility from job search: convexity</td>
<td>Landais et al. (2199a)</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.33</td>
<td>Disutility from job search: level</td>
<td>Matches steady-state targets (Landais et al., 2199a)</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.26</td>
<td>steady-state labor income tax rate</td>
<td>Matches estimate of the average effective labor income tax rate by Mendoza et al. (1994)</td>
</tr>
</tbody>
</table>
Real wage rigidity

\[ w_{s,t} = a_s + \nu w_{s,t-1} + \beta u_{s,t} + \text{state dummies} + e_t \]

- \( \nu \approx 1 \) in the US

- \( \nu \approx 1 \) in other OECD countries
  Bell (1996)
Optimal search effort

- Utility of representative worker at time $t$:

$$
(1 - L^s_t) \cdot U(C^u_t) + L^s_t \cdot U(C^e_t) - \left[1 - (1 - \lambda) \cdot L^s_{t-1} \right] \cdot \Psi(s_t)
$$

- Chooses $\{s_t\}_{t=0}^{\infty}$

- Takes $\{\theta_t\}_{t=0}^{\infty}$, $\{w_t\}_{t=0}^{\infty}$, and $\{\tau_t\}_{t=0}^{\infty}$ as given

- Subject to the probability of being employed in the next period

$$
L^s_t = (1 - \lambda) \cdot L^s_{t-1} + (1 - (1 - \lambda) \cdot L^s_{t-1}) \cdot s_t \cdot f(\theta_t)
$$
Optimal search effort

- The first-order-condition is

\[
\frac{\Psi'(s_t)}{f(\theta_t)} - \beta \cdot (1 - \lambda) \cdot \mathbb{E}_t \frac{\Psi'(s_{t+1})}{f(\theta_{t+1})} \cdot [1 - s_{t+1} \cdot f(\theta_{t+1})] = \Delta U_t
\]

→ Optimal search increasing and concave in $\theta_t$ & $\Delta U_t$

→ Search path $\mathbb{E}_t s_{t+1}/s_t$ increasing in $\mathbb{E}_t f(\theta_{t+1})/f(\theta_t)$. 
Cost of opening a vacancy

- Cost of opening vacancy proportional to $A$

  A1 Recruiting technology is independent of technology

  A2 Recruiting uses labor as unique input

  → Appealing because recruiting time-intensive

Local projections-IV
First to use LP-IV

- Jorda, Schularick & Taylor (2015)
  - Effects of monetary policy

- Jorda & Taylor (2016); Ramey & Zubairy
  - Effects of government spending

- Stock & Watson (2017)
  - Theoretical underpinnings of LP-IV
Focus on search & matching framework

- Tax cuts affect output mainly through substitution effects
  Barrlo & Redlick (2011)
- Tax cuts have positive effect on hours worked
  Keane (2011)
- Most variation in hours is due to number of employed workers
Additional evidence

Effect of increase in utility gain from work

- Microelasticity $\epsilon^m = (\partial L^s / \partial \Delta U) \cdot (\Delta U / L^s) |_{\theta}$
- Effect of $\Delta U$ on $L^s$ for given labor market tightness

- Macroelasticity $\epsilon^M = (\partial L / \partial \Delta U) \cdot (\Delta U / L)$
- Effect of $\Delta U$ on $L$ after labor demand has adjusted

- Landais et al. (2016) review evidence: $\epsilon^M / \epsilon^m < 1$.
  $\rightarrow \epsilon^M / \epsilon^m < 1 \rightarrow L^d$ is downward-sloping
  $\rightarrow \epsilon^M / \epsilon^m$ procyclical $\rightarrow L^s$ is convex
Additional evidence
Effect of increase in job-search effort

– Tightness ↓ and employment ↑
  Gautier et al. (2012), Crepon et al. (2013), Marinescu (2017)

– Effects larger in good times
  Toohey (2017)
Elasticities in competing models

Fixed wage, diminishing returns to labor

Pissarides (2005)