Fiscal Multipliers with Time-inconsistent Preferences

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Benjamin Tengelsen

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Multiplier definitions and considerations

\[ \frac{dY_{t+s}}{dG_t} \quad \text{and} \quad \frac{dY_{t+s}}{dT_t} \]

- Short-term, medium-term, or long-term \( s \)
- Temporary or permanent shock
- How stimulus is financed (balanced budget or deficit)
- Where taxing comes from (capital or labor tax)
- Where is spending (household transfers, gov’t consumption, gov’t investment)
- How much slack (expansion or recession)
- Do constraints bind (ZLB, borrowing constraints)
Multiplier research: vast and varied

- Standard RBC models: -2.5 to 1.2
  - multipliers increase with:
    - shock permanence
    - deficit financing
  - Most multipliers less than 1

- New Keynesian RE models: 0.5 to 1.0
  - Price frictions increase multipliers
  - Demand determined employment increases multipliers
  - Cogan, Cwik, Taylor, and Weiland (2010): 0.64 at peak
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    - Up to 2.0 if:
      - 50% of workers are rule-of-thumb
      - employment demand determined
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- New Keynesian RE models with constraints: 1.0+
  - Zero lower bound: as high as 2.3
  - Borrowing constraints:
    - Parker (2011) argues for including these

- Keynesian non-RE models: 1.5 to 2+
  - Fixed expectations (irrationality) increases multiplier
  - Evans (1969): 2+
  - Romer and Bernstein (2009): 1.5
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Multiplier research: vast and varied

- Regression, VAR, SVAR: -0.5 to 2+
  - Many of these are above unity (0.6 to 1.5)
  - Notable exceptions (-0.5 to 0.0) are Taylor (2009,2011), Pereira and Lopes (2010), Kirchner, Cimadomo, and Hauptmeir (2010)
  - Auerbach and Gorodnichenko (2012): expansion -0.3 to 0.8; recession 1.0 to 3.6
Our question: rationality

We focus on the effect of time-inconsistent preferences on multipliers (a la Galí, López-Salido, and Vallés, 2007)

1. Estimate discount factor in standard model
   - stochastic capital tax
   - balanced budget spending
2. Estimate discount factors in quasi-hyperbolic model
3. Compare multipliers in each

Results
- We estimate quasi-hyperbolic parameters similar to micro-studies
- Multipliers bigger with quasi-hyperbolic households
- Estimation tempers how much bigger the multipliers can be
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Hyperbolic discounting

- **Standard exponential discounting**

  \[ E_0 \left[ \sum_{t=0}^{\infty} \xi_t u(c_t, h_t) \right] \]

  where \( \xi_t = \delta^t \)  \( \forall t \)

- **Quasi-hyperbolic discounting**

  \[
  \xi_t = \begin{cases} 
  1 & \text{if } t = 0 \\
  \beta \delta^{t-1} & \text{if } t \geq 1 
  \end{cases}
  \]

  with \( \beta < \delta \)

- Discount factors are \( \{1, \beta, \beta \delta, \beta \delta^2, \beta \delta^3, \ldots\} \)

- Implies two Euler equations, rather than one recursive
Hyperbolic discounting

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Hyperbolic discounting micro estimates

- Standard exponential discount factors: $\delta = 0.96$
  - Life cycle consumption and wealth data

- Quasi-hyperbolic estimates
  - Shui and Ausubel (2005): $\beta = 0.81 - 0.83$ and $\delta = 0.999$
  - Passereman (2008): $\beta = 0.52 - 0.90$ and $\delta = 0.99$
  - Fang and Silverman (2009): $\beta = 0.48$ and $\delta = 0.88$
  - Laibson, Repetto, and Tobacman: $\beta = 0.70$ and $\delta = 0.95$

- Percent population hyperbolic discounters
  - Eisenhauer and Ventura (2006)
  - Italian and Dutch survey data
  - Less than 25% hyperbolic
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Model

- Standard representative agent RBC model
- Quasi-hyperbolic discounting
- Flexible prices
- Perfectly competitive firms
- Aggregate uninsurable shocks
- Distortionary stochastic capital tax
- Balanced budget constraint with public goods
Model: Households and firms

- **Households**
  
  \[
  \max_{c_t, h_t} E_0 \left[ \sum_{t=0}^{\infty} \xi_t u(c_t, h_t, G_t) \right]
  \]
  
  s.t. \( c_t + k_{t+1} = w_t h_t + (1 + r_t - \tau_t - \kappa) k_t + X_t \)
  
  where \( u(c_t, h_t, G_t) = \frac{c_t^{1-\sigma_c} - 1}{1 - \sigma_c} + A \frac{(1 - h_t)^{1-\sigma_h} - 1}{1 - \sigma_h} + \chi \frac{G_t^{1-\sigma_g} - 1}{1 - \sigma_g} \)

- **Firms**
  
  \[ Y_t = e^{z_t} K_t^\theta L_t^{1-\theta} \]
  
  where \( U_t = \begin{bmatrix} 1 & U_{t-1} \end{bmatrix} \Gamma + \varepsilon_t \), \( U_t = [z_t \ \tau_t] \), and \( \varepsilon_t \sim N(0, \Sigma) \)

  \[
  r_t = \theta e^{z_t} \left( \frac{L_t}{K_t} \right)^{1-\theta}
  \]

  \[
  w_t = (1 - \theta) e^{z_t} \left( \frac{K_t}{L_t} \right)^\theta
  \]
Model: Households and firms

- **Households**

  \[ \max_{c_t, h_t} E_0 \left[ \sum_{t=0}^{\infty} \xi_t u(c_t, h_t, G_t) \right] \]

  s.t.  \[ c_t + k_{t+1} = w_t h_t + (1 + r_t - \tau - \kappa) k_t + X_t \]

  where  \[ u(c_t, h_t, G_t) = \frac{c_t^{1-\sigma_c} - 1}{1 - \sigma_c} + A \frac{(1 - h_t)^{1-\sigma_h} - 1}{1 - \sigma_h} + \chi \frac{G_t^{1-\sigma_g} - 1}{1 - \sigma_g} \]

- **Firms**

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Model: Households and firms

- **Households**

$$\max_{c_t, h_t} E_0 \left[ \sum_{t=0}^{\infty} \xi_t u(c_t, h_t, G_t) \right]$$

subject to

$$c_t + k_{t+1} = w_t h_t + (1 + r_t - \tau_t - \kappa)k_t + X_t$$

where

$$u(c_t, h_t, G_t) = \frac{c_t^{1-\sigma_c} - 1}{1 - \sigma_c} + A \frac{(1 - h_t)^{1-\sigma_h} - 1}{1 - \sigma_h} + \chi \frac{G_t^{1-\sigma_g} - 1}{1 - \sigma_g}$$

- **Firms**

$$Y_t = e^{zt} K_t^\theta L_t^{1-\theta} \quad \text{where} \quad U_t = \begin{bmatrix} 1 & U_{t-1} \end{bmatrix} \Gamma + \varepsilon_t,$$

$$U_t = \begin{bmatrix} z_t & \tau_t \end{bmatrix}, \quad \text{and} \quad \varepsilon_t \sim N(0, \Sigma)$$

$$r_t = \theta e^{zt} \left( \frac{L_t}{K_t} \right)^{1-\theta}$$

$$w_t = (1 - \theta) e^{zt} \left( \frac{K_t}{L_t} \right)^{\theta}$$

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Model: Households and firms

**Households**

\[
\max_{c_t, h_t} \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \xi_t u(c_t, h_t, G_t) \right]
\]

s.t. \( c_t + k_{t+1} = w_t h_t + (1 + r_t - \tau_t - \kappa) k_t + X_t \)

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Model: Market clearing and government

- Market clearing

\[ K_t = k_t \]
\[ L_t = h_t \]

- Government balanced budget constraint

\[ \tau_t k_t = \gamma G_t + (1 - \gamma) X_t \]

(revenues)

(expenditures)
Equilibrium definition

Recursive rational expectations equilibrium

Policy functions $c(k, z, \tau)$, $k'(k, z, \tau)$, and $h(k, z, \tau)$ and price functions $r(k, z, \tau)$ and $w(k, z, \tau)$ such that:

- households maximize lifetime expected utility
- firms maximize profits
- markets clear
- government budget constraint holds
Equilibrium: standard exponential households

\[ u_c(c_t, h_t) = \delta E_t [ (1 + r_{t+1} - \tau_{t+1} - \kappa) u_c(c_{t+1}, h_{t+1}) ] \]

\[ w_t u_c(c_t, h_t) = - u_h(c_t, h_t) \]

\[ r_t = \theta e^{zt} \left( \frac{L_t}{K_t} \right)^{1-\theta} \]

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\[ K_t = k_t \]

\[ L_t = h_t \]

\[ \tau_t k_t = \gamma G_t + (1 - \gamma) X_t \]
Equilibrium: quasi-hyperbolic households

\[ u_c(c_t, h_t) = \beta E_t [(1 + r_{t+1} - \tau_{t+1} - \kappa)u_c(c_{t+1}, h_{t+1})] \]
\[ E_t [u_c(c_{t+1}, h_{t+1})] = \delta E_t [(1 + r_{t+2} - \tau_{t+2} - \kappa)u_c(c_{t+2}, h_{t+2})] \]
\[ w_t u_c(c_t, h_t) = -u_h(c_t, h_t) \]
\[ r_t = \theta e^{z_t} \left( \frac{L_t}{K_t} \right)^{1-\theta} \]
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\[ \tau_t k_t = \gamma G_t + (1 - \gamma)X_t \]
Calibrated parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source to match</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_c, \sigma_h, \sigma_g$</td>
<td>log utility</td>
<td>1</td>
</tr>
<tr>
<td>$A$</td>
<td>shape parameter on leisure $1 - h_t$ in utility function, set to match steady-state hours worked $\bar{h} = 0.3$.&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.72</td>
</tr>
<tr>
<td>$\chi$</td>
<td>shape parameter on public goods spending $G_t$ in utility function</td>
<td>1</td>
</tr>
<tr>
<td>$\theta$</td>
<td>capital share of income</td>
<td>0.36</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>annual depreciation rate</td>
<td>0.06</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>percent of government revenues spent on public goods $G_t$, set to match avg. household transfers percent of revenues.&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.7</td>
</tr>
</tbody>
</table>

<sup>a</sup> This approach to calibrating $A$ follows Hansen (1984).

<sup>b</sup> Total tax revenue data (SCTAX+W055RC1+AFLPITAX) and household transfers (PCTR) come from St. Louis Fed FRED, 1947-2011.

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Fiscal Multipliers with Time-inconsistent Preferences
Other government expenditures: $\gamma$

![Graph of government spending as a percentage of tax receipts from 1950 to 2010.](chart.png)
Calibration: VAR estimation $[z_t, \tau_t]$

- $\tau_t$, use real federal corporate tax revenues as percent of total revenues
- $z_t$, use Solow residual approach from production function

$$z_t = \log(Y_t) - \theta \log(K_t) - (1 - \theta) \log(L_t)$$

- $Y_t$, real GDP 1951-2011
- $K_t$, capital stock series from BEA
- $L_t$, nonfarm employment times average annual hours

VAR: $$\tilde{U}_t = \tilde{U}_{t-1} \hat{\Gamma} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \hat{\Sigma}), \quad \tilde{U}_t = [\tilde{z}_t, \tilde{\tau}_t]$$

$$\hat{\Gamma} = \begin{bmatrix} 0.1298 & 0.2551 \\ -0.0571 & 0.9030 \end{bmatrix} \quad \text{and} \quad \hat{\Sigma} = \begin{bmatrix} 0.000057 & 0.000007 \\ 0.000007 & 0.000062 \end{bmatrix}$$

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\end{bmatrix}
\]
Tax rates: $\frac{R_t}{Y_t}$

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Fiscal Multipliers with Time-inconsistent Preferences
MSM Estimation

- Data moments (1951-2011, annual)
  - mean($I/Y$), mean($K/Y$), mean($C/Y$), mean($MPK$)
  - standard deviation($I/Y$)
  - corr($C_{t+1}, C_t$), corr($C_t, h_t$), PCE, detrended

- Estimate standard exponential model $\beta = \delta$ and $\bar{z}$

- Estimate quasi-hyperbolic model $\beta$, $\delta$, and $\bar{z}$

- Choose parameters to minimize error between model moments and data moments

- 2,000 simulations per iteration of 61 periods each

- Log-linear solution technique for policy functions
## MSM Estimation

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data(^a)</th>
<th>Exponential Model</th>
<th>Quasi-hyperbolic Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>moment std. err.(^b)</td>
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</tr>
<tr>
<td>mean(I/Y)</td>
<td>0.129</td>
<td>0.125 (0.003)</td>
<td>0.132 (0.004)</td>
</tr>
<tr>
<td>mean(C/Y)</td>
<td>0.653</td>
<td>0.507 (0.002)</td>
<td>0.478 (0.002)</td>
</tr>
<tr>
<td>mean(K/Y)</td>
<td>2.204</td>
<td>2.090 (0.038)</td>
<td>2.209 (0.043)</td>
</tr>
<tr>
<td>mean(MPK)</td>
<td>0.164</td>
<td>0.172 (0.003)</td>
<td>0.163 (0.003)</td>
</tr>
<tr>
<td>st.dev.(I/Y)</td>
<td>0.021</td>
<td>0.030 (0.004)</td>
<td>0.033 (0.004)</td>
</tr>
<tr>
<td>corr(C(<em>t),C(</em>{t+1}))</td>
<td>0.269</td>
<td>0.624 (0.118)</td>
<td>0.589 (0.127)</td>
</tr>
<tr>
<td>corr(C(_t),h(_t))</td>
<td>0.108</td>
<td>-0.843 (0.031)</td>
<td>-0.856 (0.037)</td>
</tr>
</tbody>
</table>

**Estimated parameters**

<p>| | | | |</p>
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<tr>
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<tbody>
<tr>
<td>(\beta)</td>
<td></td>
<td>0.774</td>
<td>(?)</td>
</tr>
<tr>
<td>(\delta)</td>
<td>0.921</td>
<td>(0.160)</td>
<td>0.948 (?)</td>
</tr>
<tr>
<td>(\bar{z})</td>
<td>1.170</td>
<td>(0.469)</td>
<td>1.388 (?)</td>
</tr>
</tbody>
</table>

\(^a\) Data sample is 1948 to 2011 annual data.

\(^b\) MSM standard errors are derived from 50,000 simulations.
We set $z_t = \bar{z}$ for all $t$ and set $\tau_t = \bar{\tau}$ for all $t$ except for impulse $\tau_1 = \bar{\tau} - \sigma_{\tau,\tau}^{1/2}$.

Multiplier definition:

$$\frac{\Delta Y_{t+s}}{\Delta \tau_t k_t}$$

for $s \geq 0$.

Look at both short-run and medium-run multipliers.
Output multipliers

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We estimate quasi-hyperbolic discount factors in DSGE model with values close to Laibson, et al (2012)

Degree of “irrationality” probably not large

Increase in multipliers minimal
Further work

- Use better tax series
- Add two types and estimate percent quasi-hyperbolic
- Add price or wage frictions
- Deficit financing
- Try nonlinear solution methods: DYNARE
  - VFI probably not feasible