Macroeconomic Policy with Distributions

Most macroeconomic policies can be classified as one of

1. Monetary policy

2. Fiscal policy

This lecture: “distributional macro” perspective changes how to think about both of these
Fiscal Policy

• Main differences from rep agent models
  • high MPCs
  • violations of Ricardian equivalence

• Some useful references
  • Hagedorn, Manovskii and Mitman (2017) “The Fiscal Multiplier”

• These models are already used for actual policy advice
  • Penn Wharton Budget Model http://budgetmodel.wharton.upenn.edu/
  • PWBM dynamic OLG ≈ lifecycle Aiyagari (“2nd generation”)
  • compare http://budgetmodel.wharton.upenn.edu/dynamic-olg/ with Krueger-Mitman-Perri “Macroeconomics and Household Heterogeneity”
  • Wonder what Trump thinks of heterogeneous agent models? https://www.whitehouse.gov/articles/issues-penn-wharton-budget-model/ (mostly about other stuff)
HANK: Heterogeneous Agent New Keynesian models

- Combine two workhorses of modern macroeconomics:
  - **New Keynesian models** Gali, Gertler, Woodford
  - **Bewley models** Aiyagari, Bewley, Huggett

- Will present Kaplan-Moll-Violante incarnation, but many others
  - see related literature at end of slides

- Framework for quantitative analysis of aggregate shocks and macroeconomic policy

- **Three building blocks**
  1. Uninsurable idiosyncratic income risk
  2. Nominal price rigidities
  3. Assets with different degrees of liquidity

- **Today:** Transmission mechanism for conventional monetary policy
How monetary policy works in RANK

- Total consumption response to a drop in real rates

\[ C \text{ response} = \left( \text{direct response to } r \right) + \left( \text{indirect effects due to } Y \right) \]

- Direct response is everything, pure intertemporal substitution

- However, data suggest:
  1. Low sensitivity of \( C \) to \( r \)
  2. Sizable sensitivity of \( C \) to \( Y \)
  3. Micro sensitivity vastly heterogeneous, depends crucially on household balance sheets
How monetary policy works in HANK

- Once matched to micro data, HANK delivers realistic:
  - wealth distribution: small direct effect
  - MPC distribution: large indirect effect (depending on $\Delta Y$)

\[
C \text{ response} = \underbrace{\text{direct response to } r} + \underbrace{\text{indirect effects due to } Y}
\]

RANK: >95%  
HANK: <1/3

RANK: <5%  
HANK: >2/3

- Overall effect depends crucially on fiscal response, unlike in RANK where Ricardian equivalence holds
Decomposition into Direct and Indirect Effects
The Decomposition in a Two-Period Model

- Just to understand, consider even simpler two-period model
  - households solve

\[
\max_{C_0, C_1} U(C_0) + \beta U(C_1) \quad \text{s.t.} \quad C_0 + \frac{C_0}{1 + r} = Y_0 + \frac{Y_1}{1 + r}
\]

- market clearing $C_0 = Y_0, C_1 = Y_1$; long-run anchoring $Y_1 = \bar{Y}$
- monetary policy: drop $r$ from $\beta(1 + r) = 1$ to $\beta(1 + r) < 1$
More General RANK Models

• Paper: simple calibrated version in infinite-horizon RANK model

• Direct effects $> 95%$

• This result is very general and holds in any model with representative agent’s Euler equation at its core
HANK
Households

- Face uninsured idiosyncratic labor income risk
- Consume and supply labor
- Hold two assets: liquid and illiquid
- Budget constraints (simplified version)

\[
\begin{align*}
\dot{b}_t &= r^b b_t + wz_t\ell_t - c_t - d_t - \chi(d_t, a_t) \\
\dot{a}_t &= r^a a_t + d_t
\end{align*}
\]

- \(b_t\): liquid assets
- \(d_t\): illiquid deposits (\(\geq 0\))
- \(a_t\): illiquid assets
- \(\chi\): transaction cost function

- In equilibrium: \(r^a > r^b\)
- Full model: borrowing/saving rate wedge, taxes/transfers
Kinked adjustment cost function $\chi(d, a)$
Remaining model ingredients

Illiquid assets: \( a = k + qs \)

- No arbitrage: \( r^k - \delta = \frac{\Pi + \dot{q}}{q} := r^a \)

Firms

- Monopolistic intermediate-good producers \( \rightarrow \) final good
- Rent illiquid capital and labor services from hh
- Quadratic price adjustment costs à la Rotemberg (1982)

Government

- Issues liquid debt \( (B^g) \), spends \( (G) \), taxes and transfers \( (T) \)

Monetary Authority

- Sets nominal rate on liquid assets based on a Taylor rule
Summary of market clearing conditions

- Liquid asset market
  \[ B^h + B^g = 0 \]

- Illiquid asset market
  \[ A = K + q \]

- Labor market
  \[ N = \int z\ell(a, b, z) d\mu \]

- Goods market:
  \[ Y = C + I + G + \chi + \Theta + \text{borrowing costs} \]
Parameterization
Three key aspects of parameterization

1. Measurement and partition of asset categories into:
   - **Liquid** (cash, bank accounts + government/corporate bonds)
   - **Illiquid** (equity, housing)

2. Income process with leptokurtic income changes
   - Nature of earnings risk affects household portfolio

3. Adjustment cost function and discount rate
   - Match mean liquid/illiquid wealth and fraction HtM

- Production side: standard calibration of NK models
- Standard separable preferences: \( u(c, l) = \log c - \frac{1}{2} l^2 \)
Model matches key feature of U.S. wealth distribution

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean illiquid assets (rel to GDP)</td>
<td>2.920</td>
<td>2.920</td>
</tr>
<tr>
<td>Mean liquid assets (rel to GDP)</td>
<td>0.260</td>
<td>0.263</td>
</tr>
<tr>
<td>Poor hand-to-mouth</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Wealthy hand-to-mouth</td>
<td>20%</td>
<td>19%</td>
</tr>
</tbody>
</table>
Model generates high and heterogeneous MPCs

- Average quarterly MPC out of a $500 windfall: 16%
Evidende on MPCs – Norwegian Lotteries

Source: Fagereng, Holm and Natvik (2016)
Results
Transmission of monetary policy shock to $C$

Innovation $\epsilon < 0$ to the Taylor rule: \[ i = \bar{r}^b + \phi \pi + \epsilon \]

- All experiments: $\epsilon_0 = -0.0025$, i.e. $-1\%$ annualized
Transmission of monetary policy shock to $C$

$$dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b dt + \int_0^\infty \left[ \frac{\partial C_0}{\partial r_t^a} dr_t^a + \frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial T_t} dT_t \right] dt$$

\[\text{direct}\]  \[\text{indirect}\]
Transmission of monetary policy shock to $C$

$$dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r^b_t} dr^b_t dt + \int_0^\infty \left[ \frac{\partial C_0}{\partial r^a_t} dr^a_t + \frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial T_t} dT_t \right] dt$$

✓

Intertemporal substitution and income effects from $r^b \downarrow$
Transmission of monetary policy shock to $C$

\[ dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b dt + \int_0^\infty \left[ \frac{\partial C_0}{\partial r_t^a} dr_t^a + \frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial T_t} dT_t \right] dt \]

Portfolio reallocation effect from $r^a - r^b \uparrow$
Transmission of monetary policy shock to $C$

\[
dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b \, dt + \int_0^\infty \left[ \frac{\partial C_0}{\partial r_t^a} dr_t^a + \frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial T_t} dT_t \right] \, dt
\]

✓

Labor demand channel from $w \uparrow$
Transmission of monetary policy shock to $C$

$$dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r^b_t} dr^b_t dt + \int_0^\infty \left[ \frac{\partial C_0}{\partial r^a_t} dr^a_t + \frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial T_t} dT_t \right] dt$$

Fiscal adjustment: $T \uparrow$ in response to $\downarrow$ in interest payments on $B$
Transmission of monetary policy shock to $C$

\[ dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b dt + \int_0^\infty \left[ \frac{\partial C_0}{\partial r_t^a} dr_t^a + \frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial T_t} dT_t \right] dt \]

- 19%
- 81%

\begin{center}
\begin{tabular}{c}
- Total Response
- Direct: $r^b$
- Indirect: $r^a + q$
- Indirect: $w + \Gamma$
- Indirect: $T$
\end{tabular}
\end{center}

\begin{center}
\begin{tikzpicture}
\begin{axis}[
width=\textwidth,
height=0.5\textwidth,
axis lines=left,
axis line style={thick},
xtick={0,5,10,15,20},
xticklabels={0,5,10,15,20},
ytick={0,0.1,0.2,0.3,0.4,0.5},
yticklabels={0,0.1,0.2,0.3,0.4,0.5},
]
\addplot[black, thick] table [x=Quarters, y=Total Response] {data.csv};
\addplot[blue, thick] table [x=Quarters, y=Direct] {data.csv};
\addplot[red, dashed, thick] table [x=Quarters, y=Indirect] {data.csv};
\addplot[red, dotted, thick] table [x=Quarters, y=Indirect] {data.csv};
\addplot[red, dashdotted, thick] table [x=Quarters, y=Indirect] {data.csv};
\addplot[red, dashdotdotted, thick] table [x=Quarters, y=Indirect] {data.csv};
\addplot[red, dashdotdotdotted, thick] table [x=Quarters, y=Indirect] {data.csv};
\end{axis}
\end{tikzpicture}
\end{center}
Monetary transmission across liquid wealth distribution

- Total change = $c$-weighted sum of (direct + indirect) at each $b$

(b = 0) share = 0.2
Why small direct effects?

- Intertemporal substitution: (+) for non-HtM
- Income effect: (-) for rich households
- Portfolio reallocation: (-) for those with low but > 0 liquid wealth
Role of fiscal response in determining total effect

<table>
<thead>
<tr>
<th></th>
<th>T adjusts (1)</th>
<th>G adjusts (2)</th>
<th>B^g adjusts (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elasticity of C_0 to r^b</td>
<td>-2.21</td>
<td>-2.07</td>
<td>-1.48</td>
</tr>
<tr>
<td>Share of Direct effects:</td>
<td>19%</td>
<td>22%</td>
<td>46%</td>
</tr>
</tbody>
</table>

- Fiscal response to lower interest payments on debt:
  - \( T \) adjusts: stimulates AD through MPC of HtM households
  - \( G \) adjusts: translates 1-1 into AD
  - \( B^g \) adjusts: no initial stimulus to AD from fiscal side
When is HANK $\neq$ RANK? Persistence

- RANK: $\frac{C_t}{C_t} = \frac{1}{\gamma} (r_t - \rho) \Rightarrow C_0 = \bar{C} \exp \left( -\frac{1}{\gamma} \int_0^\infty (r_s - \rho) ds \right)$

- Cumulative $r$-deviation $R_0 := \int_0^\infty (r_s - \rho) ds$ is sufficient statistic

- Persistence $\eta$ only matters insofar as it affects $R_0$

$$- \frac{d \log C_0}{d R_0} = \frac{1}{\gamma} = 1 \quad \text{for all } \eta$$
In Contrast, Inflation-Output Tradeoff same as in \textbf{RANK}

(a) Inflation-Output Gap  
(b) Inflation-Marginal Cost  
(c) Marginal Cost-Output
Comparison to One-Asset HANK Model

(d) Average MPC and Wealth-to-GDP Ratio

(e) Total and Direct Effects
Monetary transmission in RANK and HANK

\[ \Delta C = \text{direct response to } r + \text{indirect GE response} \]

\[ \text{RANK: 95%} \quad \text{RANK: 5%} \]
\[ \text{HANK: 1/3} \quad \text{HANK: 2/3} \]

• **RANK view:**
  - High sensitivity of \( C \) to \( r \): *intertemporal substitution*
  - Low sensitivity of \( C \) to \( Y \): the RA is a PIH consumer

• **HANK view:**
  - Low sensitivity to \( r \): income effect of *wealthy* offsets int. subst.
  - High sensitivity to \( Y \): sizable share of *hand-to-mouth* agents

⇒ **Q:** Is Central Bank *less in control* of \( C \) than we thought?

• Work in progress: *perturbation methods* ⇒ estimation, inference
HANK’s friends (other papers in this literature)

1. **New Keynesian models with limited heterogeneity**
   - Campell-Mankiw, Gali-Lopez-Salido-Valles, Iacoviello, Bilbiie,
   - Challe-Matheron-Ragot-Rubio-Ramirez, Broer-Hansen-Krusell-Öberg

2. **Bewley models with sticky prices**
   - Oh-Reis, Guerrieri-Lorenzoni, Ravn-Sterk, Gornemann-Kuester-Nakajima,
   - DenHaan-Rendal-Riegler, Bayer-Luetticke-Pham-Tjaden, McKay-Reis, Wong,
   - McKay-Nakamura-Steinsson, Huo-RiosRull, Werning, Luetticke, Auclert, Auclert-Rognlie

   • Very useful: Werning’s “as if” result. In benchmark HANK model
     • direct and indirect effects exactly offset each other
     • overall effect same as in RA model
     • true even though incomplete markets ⇒ smaller direct effects
     • same logic as in spender-saver (TANK) model

   \[
   - \frac{d \log C_0}{d r_0} = \frac{1}{\gamma \eta} \left[ (1 - \Lambda) \frac{\eta}{\rho + \eta} + (1 - \Lambda) \frac{\rho}{\rho + \eta} + \Lambda \right].
   \]
   
   - Direct response to \( r \)
   - Indirect effects due to \( Y \)
Open Questions

• Loads left to do! Just see Janet Yellen’s speech:
  http://www.federalreserve.gov/newsevents/speech/yellen20161014a.htm

  • “the various linkages between heterogeneity and aggregate demand are not yet well understood, either empirically or theoretically.”
  • “More broadly, even though the tools of monetary policy are generally not well suited to achieve distributional objectives, it is important for policymakers to understand and monitor the effects of macroeconomic developments on different groups within society.”

• Two more or less random examples of great questions:

  1. Does inequality affect level of aggregate consumption/saving?
     some progress in Auclert and Rognlie (2016) “Inequality and Aggregate Demand”

  2. How does housing/mortgages affect monetary transmission?
     some progress in Hedlund-Karahan-Mitman-Ozkan (2016) “Monetary Policy, Heterogeneity and the Housing Channel”

• Particularly useful: empirical evidence but through lens of model
Illiquid return and monopoly profits

- Illiquid assets = part capital, part equity
  \[ a = k + qs \]
  - \( k \): capital, pays return \( r - \delta \)
  - \( s \): shares, price \( q \), pay dividends \( \omega \Pi = \omega (1 - m)Y \)
- Arbitrage:
  \[ \frac{\omega \Pi + q}{q} = r - \delta := r^a \]
- Remaining \((1 - \omega)\Pi\)? Scaled lump-sum transfer to hh’s:
  \[ \Gamma = (1 - \omega) \frac{Z}{Z} \Pi \]
- Set \( \omega = \alpha \) ⇒ neutralize asset redistribution from markups
  total illiquid flow = \( rK + \omega \Pi = \alpha mY + \omega (1 - m)Y = \alpha Y \)
  total liquid flow = \( wL + (1 - \omega)\Pi = (1 - \alpha)Y \)
Monetary Policy in Benchmark NK Models

Goal:
• Introduce decomposition of $C$ response to $r$ change

Setup:
• Prices and wages perfectly rigid $= 1$, GDP=labor $= Y_t$
• Households: CRRA($\gamma$), income $Y_t$, interest rate $r_t$

$$\Rightarrow C_t(\{r_s, Y_s\}_{s \geq 0})$$
• Monetary policy: sets time path $\{r_t\}_{t \geq 0}$, special case

$$r_t = \rho + e^{-\eta t}(r_0 - \rho), \quad \eta > 0$$

(*)
• Equilibrium: $C_t(\{r_s, Y_s\}_{s \geq 0}) = Y_t$
• Overall effect of monetary policy

$$- \frac{d \log C_0}{d r_0} = \frac{1}{\gamma \eta}$$
Monetary Policy in RANK

• Decompose $C$ response by totally differentiating $C_0(\{r_t, Y_t\}_{t \geq 0})$

\[
dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r_t} dr_t dt + \int_0^\infty \frac{\partial C_0}{\partial Y_t} dY_t dt .
\]

direct response to $r$  \hspace{2cm} indirect effects due to $Y$

• In special case (*)

\[
- \frac{d \log C_0}{dr_0} = \frac{1}{\gamma \eta} \left[ \frac{\eta}{\rho + \eta} + \frac{\rho}{\rho + \eta} \right] .
\]

direct response to $r$  \hspace{2cm} indirect effects due to $Y$

• Reasonable parameterizations ⇒ very small indirect effects, e.g.

• $\rho = 0.5\%$ quarterly
• $\eta = 0.5$, i.e. quarterly autocorr $e^{-\eta} = 0.61$

\[
\Rightarrow \frac{\eta}{\rho + \eta} = 99\%, \quad \frac{\rho}{\rho + \eta} = 1\%
\]
What if some households are hand-to-mouth?

- “Spender-saver” or Two-Agent New Keynesian (TANK) model
- Fraction $\Lambda$ are HtM “spenders”: $C_{t}^{sp} = Y_{t}$
- Decomposition in special case (*)

\[
- \frac{d \log C_0}{dr_0} = \frac{1}{\gamma \eta} \left[ (1 - \Lambda) \frac{\eta}{\rho + \eta} + (1 - \Lambda) \frac{\rho}{\rho + \eta} + \Lambda \right].
\]

- ⇒ indirect effects $\approx \Lambda = 20\text{-}30\%$
What if there are assets in positive supply?

- Govt issues debt $B$ to households sector
- Fall in $r_t$ implies a fall in interest payments of $(r_t - \rho) B$
- Fraction $\lambda^T$ of income gains transferred to spenders
- Initial consumption response in special case (*)

$$-\frac{d \log C_0}{d r_0} = \frac{1}{\gamma \eta} + \underbrace{\frac{\lambda^T B}{1 - \lambda \bar{Y}}}_{\text{fiscal redistribution channel}}.$$  

- Interaction between non-Ricardian households and debt in positive net supply matters for overall effect of monetary policy
### Fifty shades of K

<table>
<thead>
<tr>
<th></th>
<th>Liquid</th>
<th>Illiquid</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-productive</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household deposits net of revolving debt Corp &amp; Govt bonds $B^h = 0.26$</td>
<td></td>
<td>$0.6 \times \text{net housing}$</td>
<td>$1.05$</td>
</tr>
<tr>
<td>Corp &amp; Govt bonds</td>
<td></td>
<td>$0.6 \times \text{net durables}$</td>
<td></td>
</tr>
<tr>
<td><strong>Productive</strong></td>
<td></td>
<td>$\omega A = 0.79$</td>
<td></td>
</tr>
<tr>
<td>Indirectly held equity</td>
<td></td>
<td>Directly held equity</td>
<td></td>
</tr>
<tr>
<td>Noncorp bus equity</td>
<td></td>
<td>Noncorp bus equity</td>
<td></td>
</tr>
<tr>
<td>$0.4 \times \text{housing, durables}$</td>
<td></td>
<td>$(1 - \omega)A = 2.13$</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$-B^g = 0.26$</td>
<td>$A = 2.92$</td>
<td>$3.18$</td>
</tr>
</tbody>
</table>

- Quantities are multiples of annual GDP
- Sources: Flow of Funds and SCF 2004
Leptokurtic earnings changes (Guvenen et al.)

**Key idea**: normally distributed jumps = kurtosis at discrete time intervals

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance: annual log earns</td>
<td>0.70</td>
<td>0.70</td>
<td>Frac 1yr change &lt; 10%</td>
<td>0.54</td>
<td>0.56</td>
</tr>
<tr>
<td>Variance: 1yr change</td>
<td>0.23</td>
<td>0.23</td>
<td>Frac 1yr change &lt; 20%</td>
<td>0.71</td>
<td>0.67</td>
</tr>
<tr>
<td>Variance: 5yr change</td>
<td>0.46</td>
<td>0.46</td>
<td>Frac 1yr change &lt; 50%</td>
<td>0.86</td>
<td>0.85</td>
</tr>
<tr>
<td>Kurtosis: 1yr change</td>
<td>17.8</td>
<td>16.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kurtosis: 5yr change</td>
<td>11.6</td>
<td>12.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

back
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Target / Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preferences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda$ Death rate</td>
<td>1/180</td>
<td>Av. lifespan 45 years</td>
</tr>
<tr>
<td>$\gamma$ Risk aversion</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$\varphi$ Frisch elasticity (GHH)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$\rho$ Discount rate (pa)</td>
<td>4.8%</td>
<td>Internally calibrated</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon$ Demand elasticity</td>
<td>10</td>
<td>Profit share 10 %</td>
</tr>
<tr>
<td>$\alpha$ Capital share</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>$\delta$ Depreciation rate (p.a.)</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>$\theta$ Price adjustment cost</td>
<td>100</td>
<td>Slope of Phillips curve, $\varepsilon/\theta = 0.1$</td>
</tr>
<tr>
<td><strong>Government</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau$ Proportional labor tax</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>$T$ Lump sum transfer (rel GDP)</td>
<td>$6,900</td>
<td>6% of GDP</td>
</tr>
<tr>
<td>$\bar{g}$ Govt debt to annual GDP</td>
<td>0.233</td>
<td>government budget constraint</td>
</tr>
<tr>
<td><strong>Monetary Policy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi$ Taylor rule coefficient</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>$r^b$ Steady state real liquid return (pa)</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td><strong>Illiquid Assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r^a$ Illiquid asset return (pa)</td>
<td>5.7%</td>
<td>Equilibrium outcome</td>
</tr>
<tr>
<td><strong>Borrowing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r^{borr}$ Borrowing rate (pa)</td>
<td>7.9%</td>
<td>Internally calibrated</td>
</tr>
<tr>
<td>$b$ Borrowing limit</td>
<td>$16,500$</td>
<td>$\approx 1 \times$ quarterly labor inc</td>
</tr>
<tr>
<td><strong>Adjustment Cost Function</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi_0$ Linear term</td>
<td>0.04383</td>
<td>Internally calibrated</td>
</tr>
<tr>
<td>$\chi_1$ Coef on convex term</td>
<td>0.95617</td>
<td>Internally calibrated</td>
</tr>
<tr>
<td>$\chi_2$ Power on convex term</td>
<td>1.40176</td>
<td>Internally calibrated</td>
</tr>
<tr>
<td>$\bar{a}$ Min $a$ in denominator</td>
<td>$360$</td>
<td>Internally calibrated</td>
</tr>
</tbody>
</table>