Monetary Policy According to HANK

Greg Kaplan
Ben Moll
Gianluca Violante

Conference for Bob’s Phoenix Prize
Congratulations, Bob!!!

And thank you for everything!
Congratulations, Bob!!!
And thank you for everything!
TFP Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?

Benjamin Moll
University of Chicago
September 21, 2009

1 Introduction

Underdeveloped countries often have underdeveloped financial markets. This leads to an inefficient allocation of capital, in turn translating into low aggregate total factor productivity (TFP) and per-capita income. While plausible, this simple argument ignores the effects of financial frictions on the accumulation of capital and wealth. For instance, while you may not be able to acquire capital in the market, in principle, you could just accumulate it yourself. Such issues are not well understood. This paper proposes a tractable dynamic theory featuring heterogeneous entrepreneurs and borrowing constraints to explore them. It also uses the theory to quantify TFP losses from financial frictions using plant-level panel data from two emerging market economies.

An entrepreneur has a business idea. In order to develop his idea, he requires some capital and labor. The quality of his idea translates into his productivity in using these resources. The
TFP Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?

Benjamin Moll
University of Chicago

September 21, 2009

1 Introduction

Underdeveloped countries often have underdeveloped financial markets. This leads to an inefficient allocation of capital, in turn translating into low aggregate total factor productivity (TFP) and per-capita income. While plausible, this simple argument ignores the effects of financial frictions on the accumulation of capital and wealth. For instance, while you may not be able to acquire capital in the market, in principle, you could just accumulate it yourself. Such issues are not well understood. This paper proposes a tractable dynamic theory featuring heterogeneous entrepreneurs and borrowing constraints to explore them. It also uses the theory to quantify losses from financial frictions using plant-level panel data from two emerging market economies.

Consider an entrepreneur with a business idea. In order to develop his idea, he requires some capital and labor. The quality of his idea translates into his productivity in using these resources.
HANK: Heterogeneous Agent New Keynesian models

- Framework for quantitative analysis of the transmission mechanism of monetary policy
HANK: Heterogeneous Agent New Keynesian models

• Framework for quantitative analysis of the transmission mechanism of monetary policy

• Three building blocks
  1. Uninsurable idiosyncratic income risk
  2. Nominal price rigidities
  3. Assets with different degrees of liquidity
How monetary policy works in RANK

- Total consumption response to a drop in real rates

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

- Direct response is everything, pure intertemporal substitution

- Direct response is everything, pure intertemporal substitution

\[ >95\% \]

\[ <5\% \]
How monetary policy works in RANK

- Total consumption response to a drop in real rates

\[ C \text{ response} = \underbrace{\text{direct response to } r}_{>95\%} + \underbrace{\text{indirect effects due to } Y}_{<5\%} \]

- 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 ΔY)
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 $\Delta Y$)

$$C \text{ response } = \underbrace{\text{direct response to } r}_\text{RANK: >95%} + \underbrace{\text{indirect effects due to } Y}_\text{RANK: <5%}$$

$$C \text{ response } = \underbrace{\text{direct response to } r}_\text{HANK: <1/3} + \underbrace{\text{indirect effects due to } Y}_\text{HANK: >2/3}$$
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 $\Delta Y$)

\[ C \text{ response} = \underbrace{\text{direct response to } r}_{\text{RANK: }>95\%} + \underbrace{\text{indirect effects due to } Y}_{\text{RANK: } <5\%} \]

\[ \text{HANK: } <1/3 \quad \text{HANK: } >2/3 \]

• Overall effect depends crucially on fiscal response, unlike in RANK where Ricardian equivalence holds
Households

- Face uninsured idiosyncratic labor income risk
- Consume and supply labor
- Hold two assets: liquid and illiquid
HANK: a framework for monetary policy analysis

Households

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

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

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

- In equilibrium: \( r^a > r^b \)
HANK: a framework for monetary policy analysis

Households

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

\[ b_t = r^b b_t + wz_t l_t - c_t - d_t - \chi(d_t, a_t) \]
\[ a_t = r^a a_t + d_t \]

- \( b_t \): 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 → final good
- Rent illiquid capital and labor services from hh
- Quadratic price adjustment costs à la Rotemberg (1982)

Government

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

Monetary Authority

- Sets nominal rate on liquid assets based on a Taylor rule
Three key aspects of parameterization

1. Measurement and partition of *asset categories* into: ▶ 50 shades of K
   - **Liquid** (cash, bank accounts + government/corporate bonds)
   - **Illiquid** (equity, housing)
Three key aspects of parameterization

1. Measurement and partition of asset categories into: ▶ 50 shades of K
   - Liquid (cash, bank accounts + government/corporate bonds)
   - Illiquid (equity, housing)

2. Income process with leptokurtic income changes ▶ income process
   - Nature of earnings risk affects household portfolio
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
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: \( u(c, \ell) = \log c - \frac{1}{2} \ell^2 \)
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>9%</td>
</tr>
<tr>
<td>Wealthy hand-to-mouth</td>
<td>20%</td>
<td>18%</td>
</tr>
</tbody>
</table>
Model generates high and heterogeneous MPCs

- Average quarterly MPC out of a $500 windfall: 16%
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 $C$

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 $C$

$$dC_0 = \int_{0}^{\infty} \frac{\partial C_0}{\partial r_t^b} dr_t^b \, dt + \int_{0}^{\infty} \left[ \frac{\partial C_0}{\partial r_t^a} dr_t^a + \frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial T_t} dT_t \right] \, dt$$

- **direct**
- **indirect**
Transmission of monetary policy shock to $C$

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

- **Direct**
- **Indirect**
Transmission of monetary policy shock to $C$

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

\[ \checkmark \]

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

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

Portfolio reallocation effect from $r^a - r^b \uparrow$

![Graph showing the response of Deviation (%) over Quarters for Total Response, Direct: $r^b$, and Indirect: $r^a$.]
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 $w \uparrow$

<table>
<thead>
<tr>
<th>Quarters</th>
<th>Deviation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>10</td>
<td>0.3</td>
</tr>
<tr>
<td>15</td>
<td>0.2</td>
</tr>
<tr>
<td>20</td>
<td>0.1</td>
</tr>
</tbody>
</table>

- **Total Response**
- **Direct:** $r^b$
- **Indirect:** $r^a$
- **Indirect:** $w + \Gamma$
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 $C$

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

19% \hspace{1cm} 81%
Monetary transmission across liquid wealth distribution

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

- Intertemporal substitution: (+) for non-HtM
- Income effect: (-) for rich households
- Portfolio reallocation: (-) for those with low but > 0 liquid wealth

(b = 0) share = 0.19
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
Monetary transmission in RANK and HANK

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

RANK: 95%  
HANK: 2/3

RANK: 5%  
HANK: 1/3

• 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 Fed less in control of \( C \) than we thought?

• Work in progress: perturbation methods estimation, inference
Monetary transmission in RANK and HANK

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

- **RANK**: 95%
- **RANK**: 5%
- **HANK**: 2/3
- **HANK**: 1/3

- **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

\[ \Rightarrow \textbf{Q: Is Fed less in control of } C \text{ than we thought?} \]
Monetary transmission in RANK and HANK

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

RANK: 95%  \quad \text{RANK: 5%}

HANK: 2/3  \quad \text{HANK: 1/3}

- **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

\[ \Rightarrow \text{Q: Is Fed less in control of } C \text{ than we thought?} \]

- Work in progress: *perturbation methods* \( \Rightarrow \) estimation, inference
Congratulations, Bob!!!
And thank you for everything!
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 \( \omega \Pi = \omega (1 - m)Y \)
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:
  \[ \frac{\omega \Pi + q}{q} = r - \delta := r^a \]
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:
  \[ \frac{\omega \Pi + \dot{q}}{q} = r - \delta := r^a \]
- Remaining \((1 - \omega)\Pi\)? Scaled lump-sum transfer to hh’s:
  \[ \Gamma = (1 - \omega)\frac{Z}{Z} \Pi \]
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:
  \[ \frac{\omega \Pi + \dot{q}}{q} = r - \delta := r^a \]

- Remaining \((1 - \omega)\Pi\)? Scaled lump-sum transfer to hh’s:
  \[ \Gamma = (1 - \omega)\frac{Z}{\bar{Z}} \Pi \]

- Set \( \omega = \alpha \) ⇒ neutralize asset redistribution from markups
  \[ \text{total illiquid flow} = rK + \omega \Pi = \alpha mY + \omega (1 - m)Y = \alpha Y \]
  \[ \text{total liquid flow} = wL + (1 - \omega)\Pi = (1 - \alpha)Y \]
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(γ), income Y_t, interest rate r_t
  \[ C_t({\{r_s, Y_s\}_s \geq 0}) \]
• Monetary policy: sets time path \{r_t\}_{t \geq 0}, special case
  \[ r_t = \rho + e^{-\eta t}(r_0 - \rho), \quad \eta > 0 \quad (\ast) \]
• Equilibrium: \[ C_t({\{r_s, Y_s\}_s \geq 0}) = Y_t \]
• Overall effect of monetary policy
  \[ -\frac{d \log C_0}{dr_0} = \frac{1}{\gamma \eta} \]
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 $r$
  - 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 $r$
  - indirect effects due to $Y$

- Reasonable parameterizations $\Rightarrow$ 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 (*):

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

  - direct response to $r$
  - indirect effects due to $Y$

• $\Rightarrow$ 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 (*)

$$- \frac{d \log C_0}{d r_0} = \frac{1}{\gamma \eta} + \frac{\lambda^T B}{1 - \lambda \bar{Y}}$$

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>Household deposits net of revolving debt</td>
<td>0.6× net housing</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>Corp &amp; Govt bonds</td>
<td>0.6× net durables</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$B^h = 0.26$</td>
<td>$\omega A = 0.79$</td>
<td></td>
</tr>
<tr>
<td><strong>Productive</strong></td>
<td></td>
<td>Indirectly held equity</td>
<td>2.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Directly held equity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Noncorp bus equity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4× housing, durables</td>
<td></td>
</tr>
<tr>
<td></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>
</tr>
</thead>
<tbody>
<tr>
<td>Variance: annual log earns</td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td>Variance: 1yr change</td>
<td>0.23</td>
<td>0.23</td>
</tr>
<tr>
<td>Variance: 5yr change</td>
<td>0.46</td>
<td>0.46</td>
</tr>
<tr>
<td>Kurtosis: 1yr change</td>
<td>17.8</td>
<td>16.5</td>
</tr>
<tr>
<td>Kurtosis: 5yr change</td>
<td>11.6</td>
<td>12.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moment</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frac 1yr change &lt; 10%</td>
<td>0.54</td>
<td>0.56</td>
</tr>
<tr>
<td>Frac 1yr change &lt; 20%</td>
<td>0.71</td>
<td>0.67</td>
</tr>
<tr>
<td>Frac 1yr change &lt; 50%</td>
<td>0.86</td>
<td>0.85</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</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>$\epsilon$ 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, $\epsilon/\theta = 0.1$</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>