Monetary policy topics

Heterogeneous-Agent Macro Workshop

Spring 2022
This morning: We started scratching the surface of monetary policy in HANK

Now: We go a little deeper by exploring a few key topics in the literature
Roadmap

1. Maturity structure
2. Nominal assets
3. Fiscal policy
4. Investment
5. Taylor rules
6. Takeaway
Maturity structure
Longer maturities

- So far, model had short maturities. In practice, maturities are long.
  - Think mortgage debt, bonds, etc.
- What are the implications of long maturities for monetary policy?
- First study real assets. For tractability, adopt Calvo bonds.
  - Buy one bond today for $q_t$, get stream of real payments $1, \delta, \delta^2, \ldots$
- New household problem:

$$V_t(\lambda_-, e) = \max u(c) + \beta\mathbb{E}\left[V_{t+1}(\lambda, e') | e\right]$$

$$c + q_t \lambda = (1 + \delta q_t) \lambda_- + e Y_t$$

$$q_t \lambda \geq a$$

where $\lambda$ is total number of bonds (total current coupon)

- Pricing equation (no arbitrage): $q_t = \frac{1 + \delta q_{t+1}}{1 + r^\text{ante}_t}$
Steady state

- In steady state $1 + \delta q = (1 + r) q$. Can redefine $a \equiv q \lambda$
  - Given $a$, $r$, $\beta$, steady state is exactly identical to before! Intuition?
- New useful statistic from steady state: bond duration

$$D = \frac{1}{1 + r} \sum_{s \geq 0} s \left( \frac{\delta}{1 + r} \right)^s = \frac{1}{1 + r} \left( \frac{1}{1 - \frac{\delta}{1 + r}} \right)^2 = \frac{1 + r}{1 + r - \delta}$$

- Use this result to map empirical duration $D$ into model $\delta$
  - eg $D = 18$ quarters in U.S. Doepke and Schneider (2006)
Transition dynamics

- Relabel $a_{it} \equiv q_t \lambda_{it}$, then for any $t \geq 1$, we can rewrite the Bellman as

$$V_t(a_-, e) = \max u(c) + \beta \mathbb{E} \left[ V_{t+1}(a, e') | e \right]$$

$$c + a = (1 + r_{t-1}^{ante}) a_- + eY_t$$

$$a \geq a$$

- What happens at $t = 0$? A revaluation:

$$1 + r_0 = (1 + r_{ss}) \frac{1 + \delta q_0}{1 + \delta q_{ss}} = \frac{1 + \delta q_0}{q_{ss}} \quad (1)$$

- Handle this using the hh block in its ex-post formulation, plus (1) and

$$r_t = r_{t-1}^{ante} \quad t \geq 1$$
DAG for the long-bonds model

Our new DAG is:

Not so different from before! Just use a SolvedBlock to get the $q$ first!
Impulse responses with longer maturities

- $\delta \uparrow$: more even distribution of s.s. “interest rate exposures” Auclert (2019)
- Intuition: low MPC rich get more capital gains, poor make capital losses
- This effect is enough to get us to other side of RA!
Decomposition into direct and indirect effects

- These income effects show up as lower direct effects in our decomposition.
Nominal assets
Nominal assets

- So far, assets were all real. But many assets are nominal.
  - Again, think mortgage debt, nominal bonds, etc.
  - Creates very large exposures to inflation risk via nominal positions
  - See estimates in Doepke and Schneider (2006)
- Here: analyze consequence of one-period nominal assets.
- Assume that now:

\[ P_t c_{it} + A_{it} = (1 + i_t) A_{it-1} + e_{it} W_t N_t \]

\[ A_{it} \geq P_t a \]

Note: nominal borrowing constraint relaxes with inflation.
In practice it’s probably not so simple (eg “tilt effect” in mortgages)
Incorporating unexpected revaluation

- Define real asset position \( a_{it} = A_{it}/P_t \). Household problem now

\[
V_t (a_-, e) = \max u (c) + \beta \mathbb{E} [V_{t+1} (a, e') | e] \\
c + a = (1 + r_t) a_- + eY_t \\
a \geq a
\]

where \( 1 + r_t = (1 + i_t) \frac{P_{t-1}}{P_t} \)

- Perfect foresight Fisher equation gives again:

\[
r_t = r_{t-1}^{ante} \quad t \geq 1
\]

but also “Fisher effect” (capital gain/loss) from date-o revaluation

\[
1 + r_o = (1 + i_0) \frac{P_{-1}}{P_0} = (1 + r_{ss}) \frac{1 + \pi_{ss}}{1 + \pi_o}
\]

- Even with \( r^{ante} \) rule, inflation now directly matters for demand via expost \( r_o \)
Aggregate implication of Fisher channel: AR(1) shock to $r$

- Again simple to simulate with SSJ (what is your DAG?)

- **Fisher effect**: inflation redistributes towards agents with lower nominal positions, who have high MPCs. Bigger with steeper Phillips curve (lower $\theta_w$)
- Would be even more pronounced with long maturities
Fiscal policy
Fiscal-monetary interactions

- So far, abstracted from fiscal policy. But monetary-fiscal interactions potentially very important!
  - Changes in $r$ directly affect government budget
- Here: analyze consequences of fiscal response to monetary policy
- Go back to canonical model with government and linear taxation:

$$V_t(a, e) = \max u(c) + \beta \mathbb{E} \left[ V_{t+1}(a, e') \mid e \right]$$
$$c + a = (1 + r_{t-1}^{ante}) a_0 + (Y_t - T_t) e + \tau_t(e)$$
$$a \geq a$$

where $\tau_t(e)$ can be used to vary the tax incidence of shocks to mon. policy.
Setting up a fiscal rule

- Calibration as in lecture 4, with $\tau(e) = 0$ in steady state

- Government budget constraint:

$$B_t = (1 + r_{t-1}) B_{t-1} + G_t - T_t + \mathbb{E}[\tau_t(e)]$$

and in steady state, $\mathbb{E}[\tau(e)] = 0$ and $T = G + rB$.

- Consider following fiscal rules
  1. Constant $B$, all regular taxes: $T_t = G + r_{t-1}B$
  2. Constant $B$, all spending: $G_t = T - r_{t-1}B$
  3. Deficit-finance, using taxes to bring debt back, $T_t = T + \phi_T (B_{t-1} - B)$
  4. Deficit finance, using $G$ spending to bring debt back $G_t = G - \phi_G (B_{t-1} - B)$

need $\phi_G, \phi_T > r$. Why?

Alternative: tax one type only, $\tau_t(e) = \tau_t 1_{e = \bar{e}}$
Implications of deficit rules

- For instance with $G$ rule, deficits follow

$$B_t - B = (1 - (\phi_G - r)) (B_{t-1} - B) + (r_{t-1} - r) B_{t-1}$$

To first order around the steady state (recall $\phi_G > r$),

$$dB_t = (1 - (\phi_G - r)) dB_{t-1} + dr_{t-1}B$$

$$= \sum_{k=0}^{t-1} (1 - (\phi_G - r))^k Bdr_{t-1-k}$$

Past effect of high interest rates cumulate into current debt

- To set this up in code, again we’ll use a SolvedBlock
  - recall that takes in a function $H(U, Z) = 0$ and turns it into a mapping $U(Z)$
  - Here, we get $B(r)$ so $T(r)$ and $G(r)$.
Importance of fiscal rule for AR(1) shocks to policy

- Ordering of output respond corresponds to that of fiscal effect on demand
- With longer maturities, fiscal rule matters less Auclert et al. (2020)
Investment
Investment

- So far, model only featured consumption
  - But empirically, investment is a key component of response to mon. policy!
- Here: introduce investment. Reference: Auclert et al. (2020) appendix A

\[ C_t + I_t = Y_t = XK_t^\alpha N_t^{1-\alpha} \]

- Obvious: output is affected differently now since investment responds
- Not so obvious: does consumption respond differently?
- Not true in RA model: purely governed by Euler equation

\[ C_t^{-\sigma} = \beta (1 + r_t) C_{t+1}^{-\sigma} \]

What about in HA?
Detour: why we need adjustment costs

• As in any model with nom. rigidities and \( l_t \), we need adjustment costs. Why?
• Without, firm optimality implies \( \alpha X (K_{t+1}/N_{t+1})^{\alpha-1} = r_t + \delta \), so given \( N \),

\[
\frac{dK_{t+1}}{K} = \frac{-1}{1 - \alpha} \frac{1}{r + \delta} dr_t
\]

and since \( l_t = K_{t+1} - (1 - \delta) K_t \), initial \( l \) response is

\[
\frac{dl_o}{l} = \frac{-1}{1 - \alpha} \frac{1}{r + \delta} \frac{1}{\delta} dr_o
\]

Ex: with \( \delta = 4\% \), \( r = 1\% \), \( \alpha = 0.3 \), semielasticity is -715!!

• ie, 1% decline in \( r \) leads to a 715% increase in \( l \) on impact

• This is really important for all models of monetary policy with investment. Neoclassical effect that is there even in models with fixed costs, etc.

• Usual solution: convex adjustment costs (e.g. quadratic)
Model setup

- Now final goods firm rents capital and labor, flexible prices,

\[ w_t = X (1 - \alpha) K_t^\alpha N_t^{-\alpha} \quad r^K_t = X \alpha K_t^{\alpha-1} N_t^{1-\alpha} \]

Capital firm owns \( K_t \) and rents it out, invests s.t. quadratic costs, so

\[ D_t = r^K_t K_t - I_t - \frac{\Psi}{2} \left( \frac{K_{t+1} - K_t}{K_t} \right)^2 K_t \]

- Delivers standard Q theory equations, \( \frac{I_t}{K_t} - \delta = \frac{1}{\Psi} (Q_t - 1) \) and

\[ p_t = Q_t K_{t+1} = \frac{p_{t+1} + D_{t+1}}{p_t} \]

- GE asset market clearing:

\[ A_t = p_t \]
Neutrality result with inelastic investment

- Suppose that investment inelastic is $\Psi = \infty$, $\delta = 0$ (fixed $K$), and EIS=1.
- Version of Werning (2015), with positive liquidity and $\sigma = 1$. 

![Graph](image-url)
Elastic investment: HA>RA!

- Now consider elastic investment $\Psi < \infty$: amplification!!

![Graph showing HA and RA models with $\Psi = 1$](attachment:image.png)
• For the consumption response to $r$ shock:

<table>
<thead>
<tr>
<th></th>
<th>RA</th>
<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>no $l$</td>
<td>Benchmark</td>
<td>Same (Werning)</td>
</tr>
<tr>
<td>with $l$</td>
<td>Same (Euler eq.)</td>
<td><strong>Amplification</strong></td>
</tr>
</tbody>
</table>

• This is one direct reason why we should care that MPCs are large!
Taylor rules
Taylor rule

• So far, all monetary policy analyzed using $r$ rule.
  • In practice, Taylor rule intermediates response to many shocks
  • Here, study shocks to TFP $X_t$ in addition to monetary $\epsilon_t$

• Since real rate is

$$r_t = i_t - \pi_{t+1} + \epsilon_t = i_t + \phi_t \pi_t - \pi_{t+1} + \epsilon_t$$

We now set up the DAG with $\pi$ as an unknown

• This model has all the basic elements one needs for estimation
  • See tomorrow’s lecture!!
Response to AR(1) monetary shock

- Endogenous tightening to inflation mitigates $r_t$ drop for given $\epsilon_t$
• Deflationary effect of TFP shock leads to $r$ cut, so boost in demand
Takeaway
Conclusion

- HANK substantially enriches the analysis of monetary policy.

- Key points:
  1. Indirect effects much larger than RA, though no robust result that HA \geq RA
  2. Countercyclical income risk has large amplification effects
  3. Importance of maturity structure and nominal asset positions
  4. Relevance of fiscal-monetary interactions (esp. with short maturities)
  5. Complementarity between investment and high MPCs

- The literature is growing and there is still a lot to do!
References

