Monetary policy

NBER Heterogeneous-Agent Macro Workshop

Adrien Auclert

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Class plan

Yesterday: The canonical HANK model & fiscal policy

This morning: Closed economy monetary policy

For simplicity, we maintain our focus on real interest rate rules

1. Review of monetary policy in the standard NK model
2. Monetary policy in the canonical HANK model
3. Direct and indirect effects of monetary policy
4. Cyclical income risk
5. Takeaway

Review of monetary policy in the standard NK model

The NK model

- Recall the standard 3-equation NK model
  - separable preferences, sticky prices or wages, perfect foresight

$$c_t = c_{t+1} - \sigma^{-1}(i_t - \pi_{t+1}) \tag{EE}$$

$$\pi_t = \kappa c_t + \beta \pi_{t+1} \tag{NKPC}$$

$$i_t = \pi_{t+1} + \epsilon_t \tag{r-rule}$$

- Taylor rule instead of (r-rule): $i_t = \phi \pi_t + \epsilon_t$ (usually $\phi > 1$)

Monetary propagation in the NK model

$$c_t = c_{t+1} - \sigma^{-1}(i_t - \pi_{t+1}) \quad \text{(EE)}$$

$$\pi_t = \kappa c_t + \beta \pi_{t+1} \quad \text{(NKPC)}$$

$$i_t = \pi_{t+1} + \epsilon_t \quad \text{(r-rule)}$$

What does a **monetary policy shock** do, e.g. $\epsilon_t \downarrow$?

1. expansion in c_t so output $y_t \uparrow$, inflation $\pi_t \uparrow$
2. far out shocks to ϵ_t with large t are not dampened (Del Negro et al. 2023's "forward guidance puzzle")

Two big questions re ...

- **transmission into consumption:** 100% via Euler equation (implausible?)
- **output response:** forward guidance puzzle, model too forward looking

HANK solutions?

Major goal of early HANK papers: solve these two issues!

- Auclert (2019), Kaplan et al. (2018): indirect channels become important for monetary transmission (e.g. redistribution or labor income)
- McKay et al. (2016): borrowing constraints make consumption less forward looking $\Rightarrow$ get something like

$$c_t = \delta c_{t+1} - \sigma^{-1} \left(i_t - \pi_{t+1} \right) \qquad \text{with } \delta < 1 \tag{DEE}$$

  This would dampen forward guidance!

Next: What HANK actually does!

Monetary policy in the canonical HANK model

- Take canonical HANK model, but abstract from fiscal policy
  - $T = \tau = G = B = 0$
  - but allow agents to borrow from each other: $\underline{a} < 0$ (as in Huggett model)
  - later bring back government to study monetary-fiscal interactions
- Real rate rule: monetary policy sets $r_t^{ante} = i_t - \pi_{t+1}$ directly
- Ask two questions:
  1. Output response relative to RA? (Magnitude? Any "discounting"?)
  2. Transmission channels relative to RA?

We'll start with 1.

Under these assumptions, the canonical HANK model can just be written as:

$$\max_{c_{it}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(u(c_{it}) - v\left(N_t\right)\right)$$

$$c_{it} + a_{it} \leq (1 + r_{t-1}^{ante}) a_{it-1} + e_{it} Y_t$$

$$a_{it} \geq \underline{a}$$

with

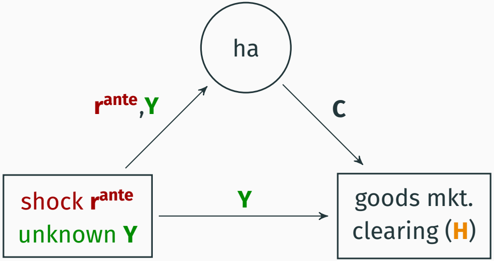
$$C_t \equiv \int c_{it} di = Y_t = N_t$$

$$A_t \equiv \int a_{it} di = 0$$

That's it!

DAG of this model

Let's visualize this as a DAG:



Here again, simple fixed point:

$$\mathcal{C}_t\left(\{r_s^{ante}, Y_s\}\right) = Y_t$$

Ex-ante vs ex-post r

- In practice, we usually write `HetBlocks` with “ex-post r” convention, i.e. here:

$$\max_{c_{it}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(u(c_{it}) - v\left(N_t\right)\right)$$
$$c_{it} + a_{it} \leq (1 + r_t)a_{it-1} + s_{it}Y_t$$
$$a_{it} \geq \underline{a}$$

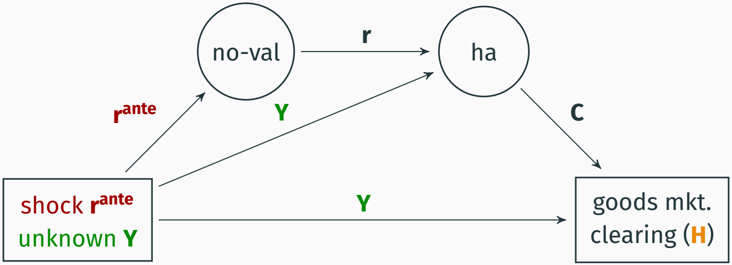
- This is more general: allows us to handle valuation effects (see next lecture)
- Here there are no valuation effects, so we just have

$$r_t = r_{t-1}^{ante} \quad t \geq 1$$
$$r_0 = r_{ss}$$

- This adds one “no valuation” block to the DAG

DAG including the valuation block

Our new DAG is:



If we are fancy, we could use `CombinedBlock` in SSJ to do the convolution

$$\tilde{\mathcal{C}}_t\left(\{r_s^{ante}, Y_s\}\right) \equiv \mathcal{C}_t\left(\{r_j\left(r_s^{ante}\right), Y_s\}\right)$$

So that we are back to our simple fixed point:

$$\tilde{\mathcal{C}}_t\left(\{r_s^{ante}, Y_s\}\right) = Y_t$$

Jacobians again

- As in fiscal lecture, let's linearize this sequence space equation
- Define $d\mathbf{r}^{ante} \equiv \left(dr_0^{ante}, dr_1^{ante}, \ldots\right)$, and let $d\mathbf{Y} = (dY_0, dY_1, \ldots)$ as before. Define Jacobian $\mathbf{M}^r \equiv \left(\partial\tilde{\mathcal{C}}_t/\partial r_s^{ante}\right)_{t,s}$ capturing direct effect of r on C. Then:

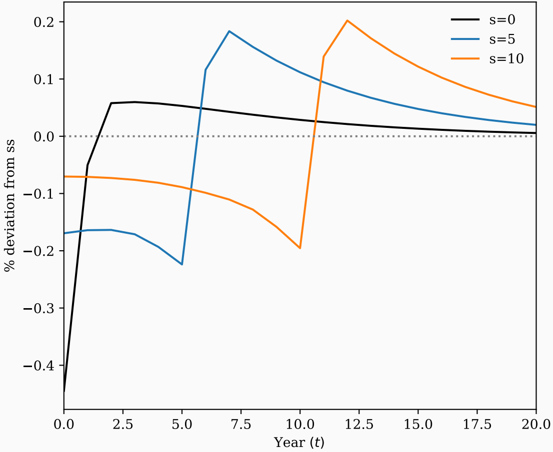
$$d\mathbf{Y} = \mathbf{M}^r d\mathbf{r}^{ante} + \mathbf{M}d\mathbf{Y}$$

- Almost like the IKC, except that partial eqbm demand shock is no longer coming from fiscal policy, $d\mathbf{G} - \mathbf{M}d\mathbf{T}$, but instead from monetary policy!
- Just as with fiscal, the PE demand shock has zero NPV (Why?)
- General solution uses same linear mapping $\mathcal{M}$ (recall "$(\mathbf{I}-\mathbf{M})^{-1}$")

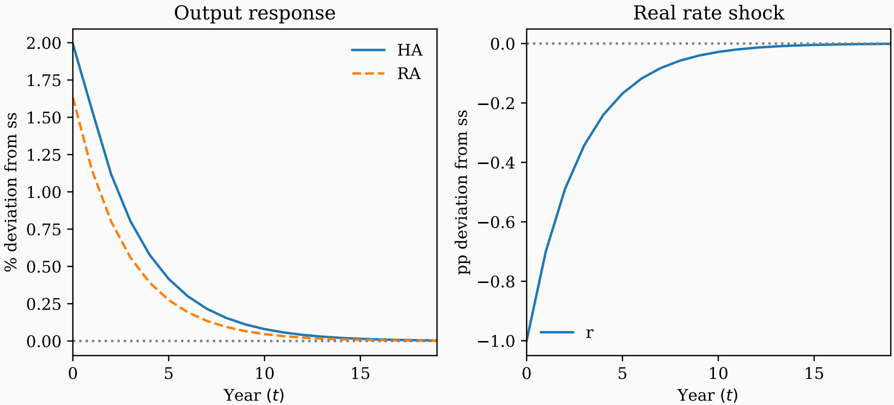
$$d\mathbf{Y} = \mathcal{M}\mathbf{M}^r d\mathbf{r}^{ante}$$

Next: Let's visualize $\mathbf{M}^r$; then the solution $d\mathbf{Y}$ for an AR(1) shock to $d\mathbf{r}^{ante}$

Columns of Jacobian $\mathbf{M}^r$



Monetary policy shock in HA (AR(1) with $\rho = 0.7$)



- HA $>$ RA! Interesting! But why?

Benchmark result with zero liquidity

- One way to make progress is to simplify the model $\Rightarrow$ ZL model: $\underline{a} \to 0$
- Recall that in ss only Euler equation of agents in high income state $\bar{s}$ holds

$$(Y_t \bar{s})^{-\sigma} = \beta \left(1 + r_t^{ante}\right) \mathbb{E}_t \left[\left(Y_{t+1} s'\right)^{-\sigma} | \bar{s}\right]$$

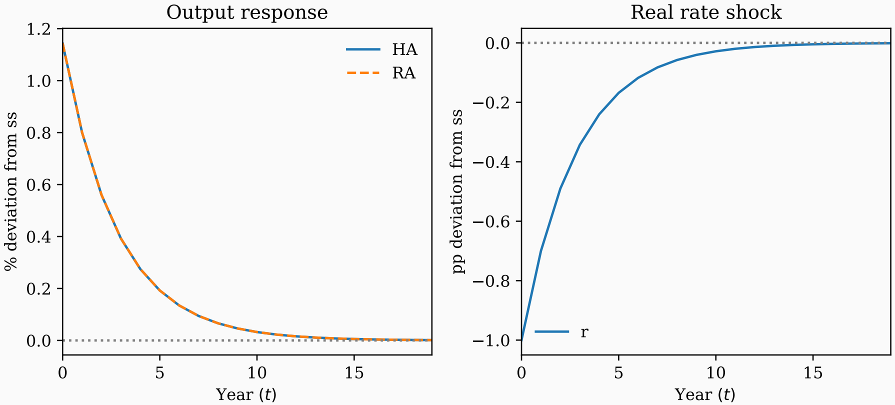
- Define $\overline{\rho} \equiv \mathbb{E}\left[(s'/\bar{s})^{-\sigma} | \bar{s}\right]$. Then, we always have

$$Y_t^{-\sigma} = \beta\overline{\rho} \left(1 + r_t^{ante}\right) Y_{t+1}^{-\sigma} \quad \Rightarrow \quad y_t = y_{t+1} - \sigma^{-1} \left(r_t^{ante} - \log\left(\beta\overline{\rho}\right)\right)$$

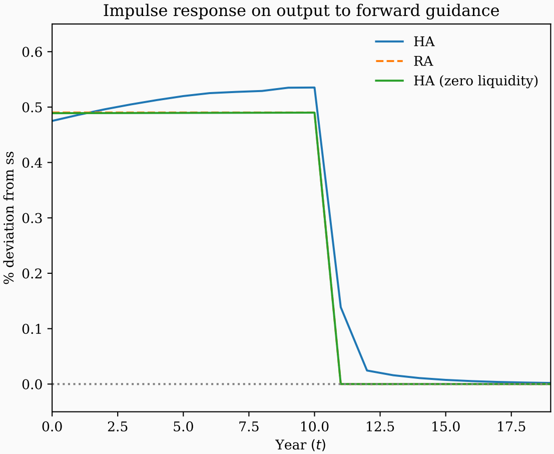
- **This is like our representative agent Euler equation!**
    - HA = RA with effective discount factor $\beta\overline{\rho}$

  $\to$ Werning (2015)'s **neutrality result** for zero liquidity and acyclical income risk
- In particular: No discounting in log-linearized Euler equation!

Neutrality for monetary policy in the ZL limit



Neutrality also implies the forward guidance puzzle is not solved by HA



Summary: Output response of monetary policy in HA

- No robust result that HA $\neq$ RA !
    - in fact, with zero liquidity, we showed that HA $=$ RA!
    - forward guidance can be equally powerful
- But how can that be, given that HA breaks the Euler equation?
- **Next: study transmission channels**

Direct and indirect effects of monetary policy

Direct and indirect effects

- To see what's going on, let's go back to our IKC-like equation:

$$d\mathbf{Y} = d\mathbf{C} = \underbrace{\mathbf{M}^r \cdot d\mathbf{r}^{ante}}_{\text{Direct effect}} \downarrow + \underbrace{\mathbf{M} \cdot d\mathbf{Y}}_{\text{Indirect effect}} \uparrow$$

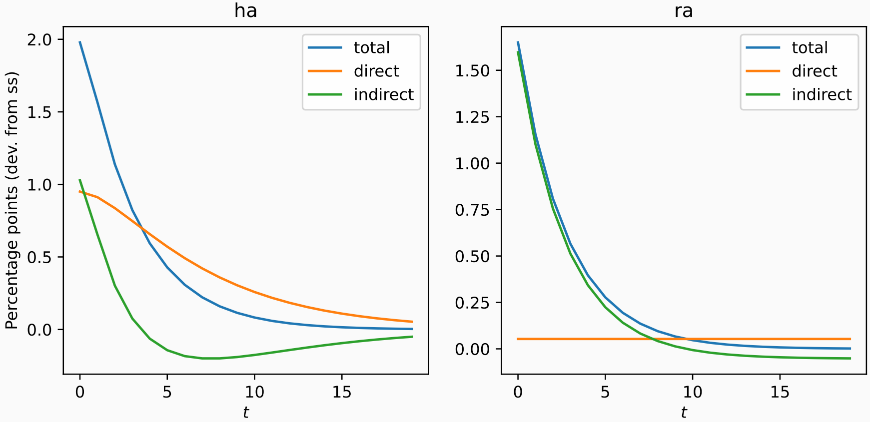
- **Two competing effects** of market incompleteness! direct $\downarrow$, indirect $\uparrow$

  [Kaplan et al. (2018) showed this in their two-account HA model]

- Why? High MPCs make C more sensitive to Y but also **less sensitive to** r^{ante}!
  - cf Auclert (2019): substitution effect of dr^{ante} scales with $-\sigma^{-1}(1 - MPC)$
  - In ZL model, can actually prove that $\mathbf{M}^r = -\sigma^{-1}(\mathbf{I} - \mathbf{M})\mathbf{U}$ so

$$d\mathbf{C} = -\sigma^{-1}(\mathbf{I} - \mathbf{M})\,\mathbf{U} \cdot d\mathbf{r}^{ante} + \mathbf{M} \cdot d\mathbf{Y}$$

- Let's implement $d\mathbf{C} = \mathbf{M}^r d\mathbf{r}^{ante} + \mathbf{M} \cdot d\mathbf{Y}$ in our canonical HA model:



Cyclical income risk

Introducing cyclical income risk

- A simple way to introduce cyclical income risk by adopting different labor allocation rule. Auclert and Rognlie (2018) propose

$$n_{it} = Y_t \frac{(e_{it})^{\zeta \log Y_t}}{\mathbb{E}\left[e_i^{1+\zeta \log Y_t}\right]} \equiv Y_t \Gamma\left(e_{it}, Y_t\right)$$

- Distribution of income $y_{it} \equiv e_{it} n_{it}$ now reacts to monetary policy

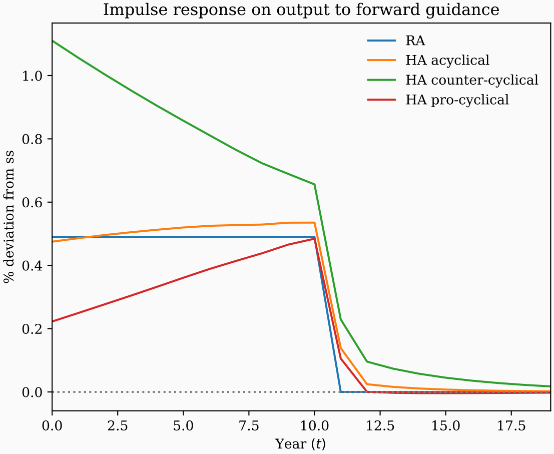
$$\text{sd}\left(\log y_{it}\right) = \left(1 + \zeta \log Y_t\right) \text{sd}\left(\log e_i\right)$$

  - $\zeta > 0$: procyclical inequality and income risk
  - $\zeta < 0$: countercyclical inequality and income risk
  - $\zeta = 0$ is benchmark from above (acyclical inequality & risk)

- Matters because:
  - current shocks redistribute between different MPCs ("cyclical inequality")
  - future shocks change income risk ("cyclical risk")

Countercyclical income risk makes the forward guidance puzzle worse!

- Consider a r_T shock with three calibrations for ζ in HA model



Zero liquidity limit with cyclical income risk

details

What's going on? In ZL limit, we get an **exact** discounted Euler equation

$$y_t = \delta \cdot \mathbb{E}_t [y_{t+1}] - \sigma^{-1} \cdot \text{const} \cdot \left(r_t^{ante} - \log(\beta \overline{\rho})\right)$$

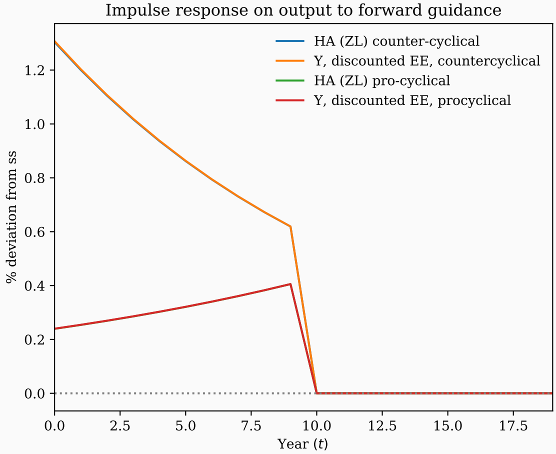
where δ depends on cyclicality of income risk ζ.

1. Dynamic discounting ($\delta < 1$) $\Leftrightarrow \zeta > 0$ procyclical risk (less common)
2. Dynamic amplification ($\delta > 1$) $\Leftrightarrow \zeta < 0$ countercyclical risk (more common)
    - microfound w/ u: Ravn and Sterk (2017), den Haan et al. (2018), Challe (2020)
    - lots of evidence: Storesletten et al. (2004), Guvenen et al. (2014)
3. Dynamic neutrality ($\delta = 1$) $\Leftrightarrow \zeta = 0$ acyclical risk, as in Werning

Why? Precautionary savings. Think about logic of discounted Euler equation.

Forward guidance in the ZL model

- In the empirically plausible case, the fwd guidance puzzle is **aggravated**!
  Bilbiie (2021), Acharya and Dogra (2020)



Indirect ways to make income risk cyclical

- In richer models income of agents typically involves multiple components,

$$y_{it} = \frac{W_t}{P_t} n_{it} s_{it} - \underbrace{\tau_{it}}_{\text{taxes}} + \underbrace{T_{it}}_{\text{transfers}}$$

- These also matter for cyclicality of income risk
- For example, suppose taxes are set to keep balanced budget, $\tau_t \equiv \int \tau_{it} di = r_t^{ante} B$ and transfers T_t are div's from firms with sticky prices
  $\Rightarrow$ both τ_t and T_t fall after expansionary r_t^{ante} (why?)
- If τ_t allocated to highest income state and T_t to all $\Rightarrow$ procyclical risk!
- These are the assumptions in McKay et al. (2016).
  - Reason why that paper "solves" the forward guidance puzzle!

Summary: Cyclical income risk

- Cyclical income risk matters
- Procyclical income risk $\Rightarrow$ weakens monetary policy + fwd guidance
  - … but not empirically supported
- Countercyclical income risk is empirically more plausible
  - … but aggravates forward guidance puzzle!

Takeaway

Takeaway: Monetary policy with heterogeneous agents

1. HA model does not imply robustly different output response
    - Except to the extent that income risk is pro/countercyclical
2. But it *does* change transmission: indirect effects are more important!
    - This is the main result in KMV. Why do we care about that per se?
    - KMV: labor & financial market institutions matter more than we thought
    - We'll see other reasons for why we should care in the next lecture

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Zero liquidity limit with cyclical income risk

back

- Take ZL model with cyclical income risk. Euler for $\overline{s}$:

$$\left(Y_t \Gamma\left(\overline{s}, Y_t\right)\right)^{-\sigma} = \beta\left(1 + r_t^{ante}\right) \mathbb{E}_t \left[\left(Y_{t+1} \Gamma\left(s', Y_{t+1}\right)\right)^{-\sigma} | \overline{s}\right]$$

- Log-linearize around steady state $\Rightarrow$

$$y_t = \delta \mathbb{E}_t \left[y_{t+1}\right] - \sigma^{-1} \gamma(\overline{s})^{-1} \left(r_t^{ante} - \log\left(\beta \overline{\rho}\right)\right)$$

where, if $\gamma\left(s\right) \equiv 1 + \frac{\Gamma_Y Y}{\Gamma}$ is the elasticity of income wrt Y for agent in s:

$$\delta \equiv \overline{\rho}^{-1} \mathbb{E}\left[\left(s/\overline{s}\right)^{-\sigma} \frac{\gamma\left(s\right)}{\gamma\left(\overline{s}\right)} | \overline{s}\right] = \sum \omega\left(s\right) \frac{\gamma\left(s\right)}{\gamma\left(\overline{s}\right)} \qquad \text{where } \sum_s \omega(s) = 1$$

- What matters is cyclicality of $y(\overline{s})$ relative to other income states
- Example with two states: $\delta = 1 - \omega + \omega \frac{\gamma_L}{\gamma_H}$ with $\omega \in (0, 1)$