Inequality, business cycles and monetary-fiscal policy

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Introduction

- How should monetary and fiscal policy respond to aggregate shocks?
- Workhorse New Keynesian models assume the representative agent
- In the data agents are heterogeneous
  - differ in earnings and wealth
  - differ in exposure to aggregate shocks
- How should the Ramsey planner take this heterogeneity into account when setting policy?

Numerical methods

- Main difficulty: State space is big and its law of motion is governed by yet-unknown optimal policies
  - state = distribution of each agent's asset holdings and previous period marginal utilities
- Existing numerical tools are inapplicable
  - require knowing the LoM of the system or where it converges
- We develop novel tools to solve HA economies that does not rely on knowing anything about its LoM/invariant distribution
  - very fast: much faster than conventional techniques
  - easily extend to second- and higher-order: easy to capture risk, time-variant volatility,...

Economic insights

- Two objectives of the planner:
  - price stability: minimize welfare losses due to costly price setting
  - insurance: due to heterogeneity and market incompleteness
- Quantitatively, insurance concern swamp price stability
  - large cut in interest rates to negative demand (mark up) shock (cf: small increase in RANK)
  - lower real interest rate in response to supply (tfp) shock (cf: keep real rate unchanged in RANK)
  - Taylor rules approximate optimum poorly (cf: approximate well in RANK)

Environment

Households

Individual household of type i maximizes

$$\max_{c,n,b} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c^{1-\nu}}{1-\nu} - \frac{n^{1+\gamma}}{1+\gamma} \right)$$

subject to

$$c_{i,t} + Q_t b_{i,t} = (1 - \Upsilon_t) W_t \epsilon_{i,t} n_{i,t} + T_t + s_i D_t + \frac{b_{i,t-1}}{1 + \Pi_t}$$

Affine tax system: $\{\Upsilon_t, T_t\}$

$b_{i,t}$: real bond holdings

D_t, s_i : aggregate dividends and agent i share of them

$\epsilon_{i,t}$: idiosyncratic shocks

Q_t, Π_t: nominal interest rate, inflation rate

Firms

Competitive final good sector:

$$Y_t = \left[\int_0^1 y_t(j)^{\frac{\Phi_t - 1}{\Phi_t}} dj\right]^{\frac{\Phi_t}{\Phi_t - 1}}$$

Monopolistically competitive intermediate good sector:

- Production

$$y_t(j) = n_t^D(j)$$

- Profits net of Rotemberg menu costs

$$Pr_t(j) = \left[\frac{p_t(j)}{P_t} - \frac{W_t}{P_t}\right]\left(\frac{p_t(j)}{P_t}\right)^{-\Phi_t} Y_t - \frac{\psi}{2}\left(\frac{p_t(j)}{p_{t-1}(j)} - 1\right)^2$$

- Firms maximize: $\max_{\{p_t(j)\}_t} \mathbb{E}_0 \sum_t M_t Pr_t(j)$

  M_t is SDF based on shareholders consumption

Market clearing

$$n_t^D(j) = N_t^D = \int \epsilon_{i,t} n_{i,t} di$$

$$D_t = Y_t - W_t N_t - \frac{\psi}{2}\Pi_t^2$$

$$C_t + \bar{G} = Y_t - \frac{\psi}{2}\Pi_t^2$$

$$\int_i b_{i,t} di = B_t$$

Shocks

- Aggregate shocks:

$$\ln \Phi_t = \rho_\Phi \ln \Phi_{t-1} + (1-\rho_\Phi) \ln \bar{\Phi} + \mathcal{E}_{\Phi,t},$$

$$\ln \Theta_t = \ln \Theta_{t-1} + \mathcal{E}_{\Theta,t}$$

- Idiosyncratic shocks:

$$\ln \epsilon_{i,t} = \ln \Theta_t + \ln \theta_{i,t} + \varepsilon_{\epsilon,i,t}$$

$$\ln \theta_{i,t} = \rho_\theta \ln \theta_{i,t-1} + f\left(\theta_{i,t-1}\right) \mathcal{E}_{\Theta,t} + \varepsilon_{\theta,i,t}$$

  - $f(\cdot)$ generates heterogeneous exposures to aggregate shocks

Ramsey problem

Initial condition: $\{\theta_{i,-1}, b_{i,-1}, s_i\}_i$

Competitive equilibrium: Given an initial condition and a monetary-fiscal policy $\{Q_t, \Upsilon_t, T_t\}_t$, quantities and prices are such that all agents optimize and markets clear.

Welfare criterion: Utilitarian

Optimal monetary-fiscal policy: A sequence $\{Q_t, \Upsilon_t, T_t\}_t$ that maximizes C.E. welfare for a given initial condition

Optimal monetary policy: For a given $\bar{\Upsilon}$, a sequence $\{Q_t, T_t\}_t$ and $\Upsilon_t = \bar{\Upsilon}$ for all t that maximizes C.E. welfare for a given initial condition

Solution Method

Ramsey problem

Optimality conditions

$$(1-\Upsilon_t) W_t \epsilon_{i,t} c_{i,t}^{-\nu} = n_{i,t}^{\gamma},$$

$$Q_{t-1} c_{i,t-1}^{-\nu} = \mathbb{E}_{t-1} c_{i,t}^{-\nu} \left(1+\Pi_t\right)^{-1},$$

$$\frac{1}{\psi} Y_t \left[1 - \Phi_t \left(1 - \frac{W_t}{\alpha N_t^{\alpha-1}}\right)\right] - \Pi_t(1+\Pi_t)$$
$$+\beta \mathbb{E}_t \left(\frac{C_{t+1}}{C_t}\right)^{-\nu} \Pi_{t+1}(1+\Pi_{t+1}) = 0$$

Ramsey problem: maximize expected utility subject to these + feasibility + budget constraints

State-space

- "Pareto-Negishi" weight $m_{i,t} \equiv \left(\frac{c_{i,t}}{C_t}\right)^{\nu}$ + multipliers on budget constraints
  - Ω_t is cdf over $\boldsymbol{m}_{i,t}$
- Policy functions
  - ag variables: $\tilde{\boldsymbol{X}}\left(\mathcal{E}, \Omega\right)$
  - indiv variables: $\tilde{\boldsymbol{x}}\left(\varepsilon, \mathcal{E}, \boldsymbol{m}, \Omega\right)$

State-space

- All optimality conditions can be written as

$$F\left(\mathbb{E}_{-}\tilde{\boldsymbol{x}}, \tilde{\boldsymbol{x}}, \mathbb{E}_{+}\tilde{\boldsymbol{x}}, \tilde{\boldsymbol{X}}, \varepsilon, \mathcal{E}, \boldsymbol{m}\right) = \mathbf{0} \quad \forall \varepsilon, \mathcal{E}, \boldsymbol{m}$$

$$R\left(\int \tilde{\boldsymbol{x}} \, d\Omega, \tilde{\boldsymbol{X}}, \mathcal{E}\right) = \mathbf{0} \quad \forall \mathcal{E}$$

$$\widetilde{\Omega}\left(\mathcal{E}, \Omega\right)\left(\boldsymbol{z}\right) = \int \iota\left(\tilde{\boldsymbol{m}}\left(\varepsilon, \mathcal{E}, y, \Omega\right) \leq \boldsymbol{z}\right) d\Pr\left(\varepsilon\right) d\Omega\left(\boldsymbol{y}\right) \quad \forall \boldsymbol{z}, \mathcal{E}$$

- LoM is depends on yet-unknown optimal policy choices
  - standard techniques (e.g. approx around known ergodic distribution) are inapplicable

Our approach

- Parameterize uncertainty by σ: $\tilde{\boldsymbol{X}}\left(\sigma\mathcal{E},\Omega;\sigma\right), \tilde{\boldsymbol{x}}\left(\sigma\varepsilon,\sigma\mathcal{E},\boldsymbol{m},\Omega;\sigma\right)$

- Construct Taylor expansion w.r.t. σ around any current state Ω

$$\begin{aligned}\tilde{\boldsymbol{X}}\left(\sigma\mathcal{E},\Omega;\sigma\right) &= \tilde{\boldsymbol{X}}\left(0,\Omega;0\right)+\left[\tilde{\boldsymbol{X}}_{\mathcal{E}}\left(0,\Omega;0\right)\mathcal{E}+\tilde{\boldsymbol{X}}_{\sigma}\left(0,\Omega;0\right)\right]\sigma+\ldots\\ &\equiv \bar{\boldsymbol{X}}\left(\Omega\right)+\left[\bar{\boldsymbol{X}}_{\mathcal{E}}\left(\Omega\right)\mathcal{E}+\bar{\boldsymbol{X}}_{\sigma}\left(\Omega\right)\right]\sigma+\end{aligned}$$

  and similarly for $\tilde{\boldsymbol{x}}\left(\sigma\varepsilon,\sigma\mathcal{E},\boldsymbol{m},\Omega;\sigma\right)$

- General approach
  - expand mappings F and R w.r.t. σ and use method of undetermined coefficients to find coefficients $\bar{\boldsymbol{X}}_{\mathcal{E}}\left(\Omega\right), \bar{\boldsymbol{X}}_{\sigma}, \ldots$
  - use that to find next period state $\widetilde{\Omega}\left(\mathcal{E},\Omega\right)$
  - repeat expansion next period around $\widetilde{\Omega}\left(\mathcal{E},\Omega\right)$

Making it work fast

1. Zeroth order expansion is $\bar{\Omega}(\Omega) = \Omega$ for all Ω
   - Pareto-Nigishi weights are always constant in deterministic economy
   - true even if other agg variables have deterministic dynamics
2. Due to #1, coefficients $\bar{\boldsymbol{X}}_{\mathcal{E}}(\Omega)$,$\{\bar{\boldsymbol{x}}_{\mathcal{E}}(\Omega, m)\}_m$ solve a linear system of equations
   - corresponding to eqm fixed point
   - but very large, grows exponentially in $K \equiv$ dim of grid Ω
3. We prove Factorization theorem: can instead solve K independent systems simultaneously of $2 \dim \boldsymbol{X}$ eqn and unknowns
   - lots of cool economics behind this result
   - works very fast: $\approx$ the speed of inversion of 14×14 matrix for any K
   - extends to other coefficients and higher order approx

Application

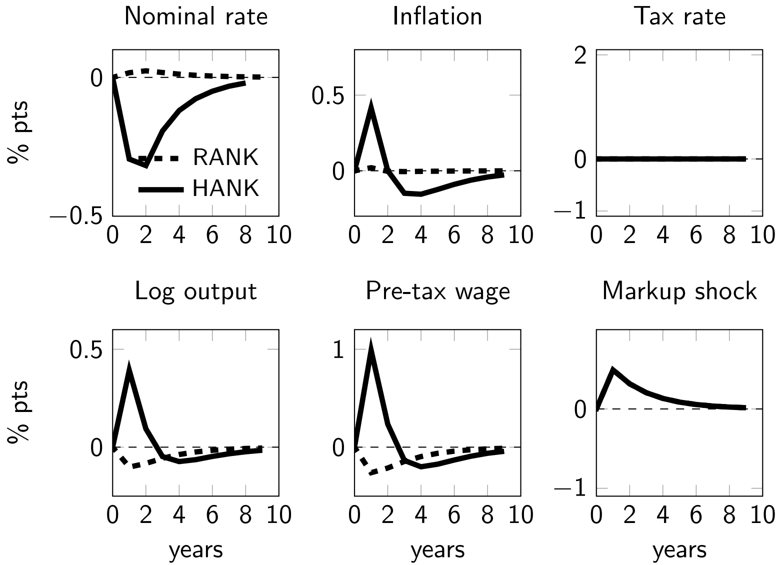
Calibration

- Standard parameterization of preferences, agg shocks
  - to be comparable with RANK models
- Initial conditions are matched to SCF 2007 cross-section
  - assets holdings and wages are positively correlated
- Idiosyncratic shocks: match facts in Storesletten et al (2004) and Guvenen et al (2014) under a stylized model of U.S. monetary-fiscal policy

Monetary response to markup shock

- Optimal monetary response to a "demand" shock $\mathcal{E}_{\Phi,t}$
  - increases desired markup $1/(\Phi_t - 1)$
  - $\bar{\mathrm{Y}}$ is set to maximize welfare
- Compare to RANK economy under the same assumptions
  - easy to see that $\bar{\mathrm{Y}} = -1/\bar{\Phi}$

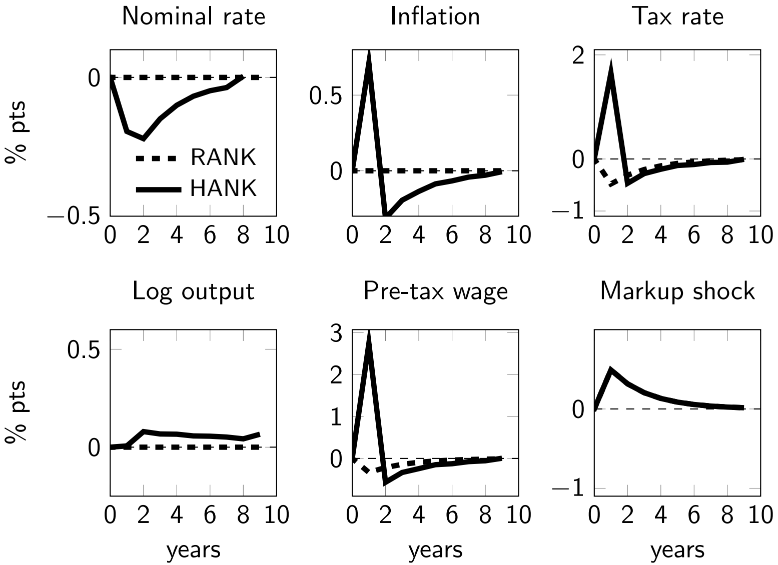
Monetary response to 1 s.d. markup increase



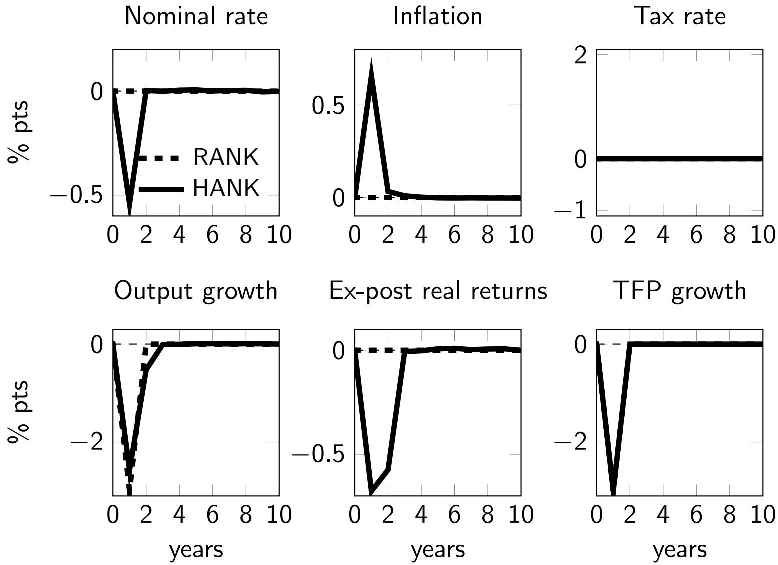
Discussion

- RANK: planner wants to stabilize nominal prices
  - higher markup over marginal cost push prices up
  - "lean against the wind": increase nominal interest rates to lower output/marginal cost, offset inflationary pressure
  - effects are quantitatively small
- HANK: planner also cares about insurance
  - markup shock is a windfall for firmowners, loss for workers
  - cannot be insured away due to lack of Arrow securities
  - to provide insurance planner needs to cut interest rate to boost wages/marginal costs
- Quantitatively, insurance motive dominates, an order of magnitude larger than price stability
  - losses from mild temporary inflations are tiny in standard NK models
  - losses from lack of insurance are large since agents' asset holdings are very unequal

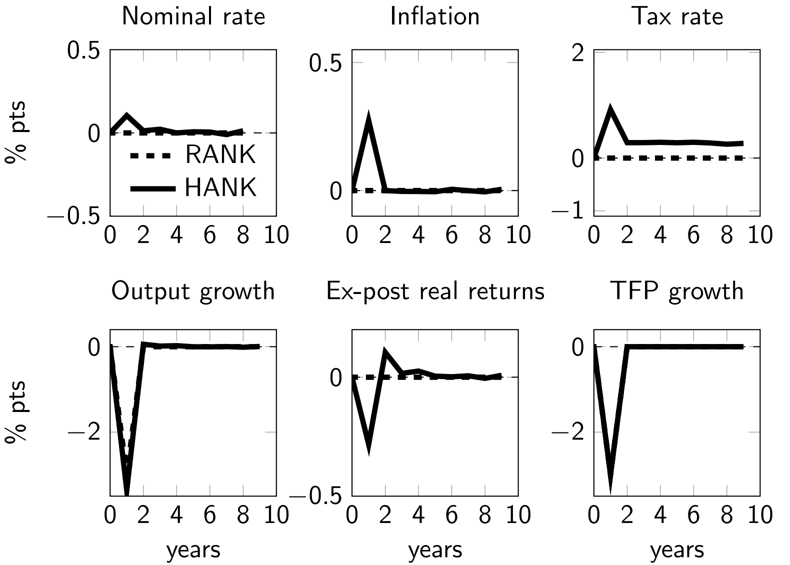
Monetary-fiscal response to 1 s.d. markup increase



Monetary response to 1 s.d. TFP drop



Monetary-fiscal response to 1 s.d. TFP drop

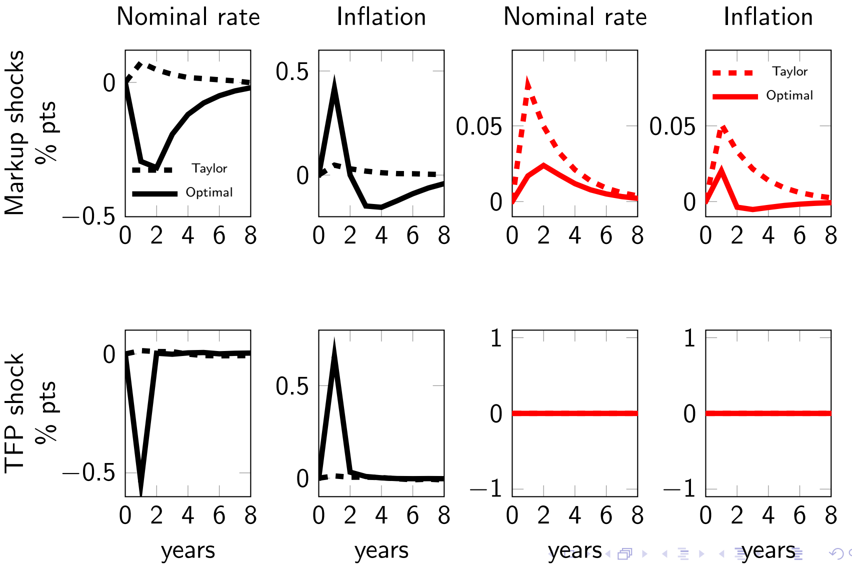


Discussion

- RANK: “target real interest rate” to maintain price stability
  - constant with growth rate shocks, time-variant with AR(1)
- HANK: lower real rate to provide insurance
  - low wage/low asset agents hurt the most
  - lower returns on high wage/high asset agents equalizes losses
- Quantitatively, insurance motive dominates

Comparison to Taylor Rules

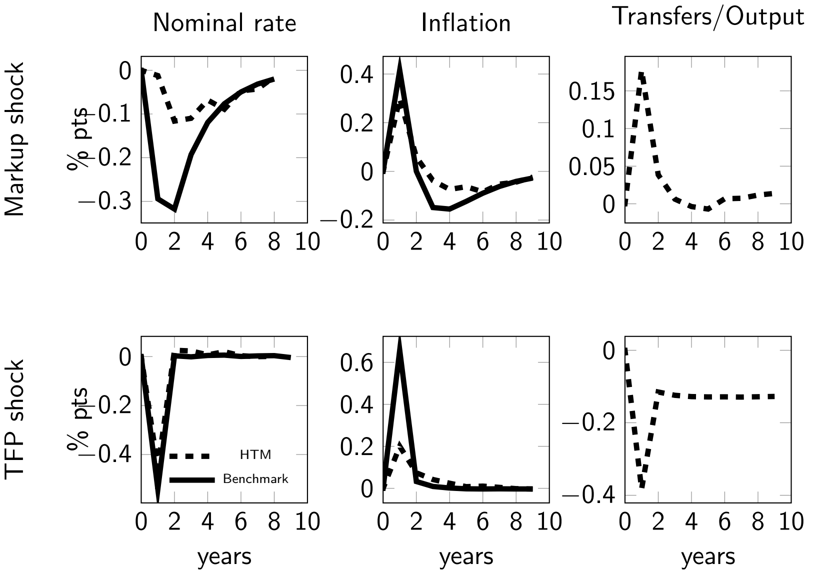
A simple Taylor rule $i_t = \bar{i} + 1.5\pi_t$



MPC heterogeneity

- In baseline economy agents borrow subject to natural debt limit
  - MPCs are similar across agents
- Jappelli and Pistaferri (2014): MPCs are lower for richer households
  - also Kaplan et al (2018), Auclert (2017)
- Extension: populate economy with hand-to-mouth types
  - probability of being hand-to-mouth depends on stock ownship status
  - chosen so that model matches Jappelli and Pistaferri (2014) regressions

Role of MPC heterogeneity



Timing of transfers

- MPC heterogeneity affects response of interest rates to markup but not TFP shock
  - interest rates directly affect only agents who can trade
  - this attenuates it affect on agg quantities, less so on asset prices determined by the marginal investor
- With credit constraints and mpc heterogeneity timing of transfers matters
  - optimal to raise aggregate demand through higher transfers rather than exclusively lowering nominal rate
- Much intuition follows from insights in Kaplan et al (2018)

Conclusions

- New methods to tackle planning problems with heterogeneity + incomplete markets + aggregate shocks
- Heterogeneity has a large impact on the conduct of monetary and fiscal policy