Monetary Policy with Heterogeneous Agents

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Outline

Outline

Papers

- I will jump back and forth between references

- Most of the discussion will be around Kaplan, Moll, Violante (2018)

- I will refer to McKay, Nakamura, Steinsson (2016), and Debortoli Gali (2018) as well

Motivation

- Claim (proof left to the audience): Nowhere in economics the distance between theory, empirics and practice is smaller than in monetary economics
- Mark Gertler:
  Keynes famously ends the General Theory with a description of the "academic scribbler" whose ideas from "a few years back" eventually find their way into policy-making. When Marvin Goodfriend wrote "How the World Achieved Consensus on Monetary" in 2007 that time lag had largely disappeared, at least in central banking. [...] The most prominent example was the Federal Reserve chairman at the time, Ben Bernanke. It is also now the case that the research done by staff at the Fed and other central banks is as sophisticated as any that occurs in academia. As a result, ideas flow freely and instantly between the halls of academia and central banks. The time lag is gone.

Motivation

- So what caused the explotion of acronyms ending with NK?

1. From Policy: Increased focus on forward guidance. The NK model predicts some really counterintuitive outcomes (forward guidance puzzle)

2. From the data: High MPCs, even for *the rich hand to mouth*. NK model predicts very small MPCs out of transitory income

3. Before we go to the children (HANK, TANK, PRANK, ...), let's understand the parent (RANK)

Outline

References

- From Juan's perspective: Woodford's Interest and Prices is a book you really should have
- Gali's Monetary Policy, Inflation and Business Cycle, is a book you should probably have

The three equation NK Model

- The three equation model
- Obviously everything is determined in equilibrium
- But you can modify one block at a time
  1. The Phillips curve. Different models get you different curves (or not)
     - Recommendations: Gertler and Leahy (2008), Auclert, Rigato, Rognlie, Straub (2022)
  2. The Taylor rule, or something more complicated. How nominal interest rates are set
     - Large literature on discretion, commitment, optimality.
  3. The inter-temporal IS curve (Euler equation): determinants of consumption growth

The Euler equation

- In log-linear terms

$$\hat{c}_t = \mathbb{E}_t \hat{c}_{t+1} - \frac{1}{\gamma}(\hat{i}_t - \mathbb{E}_t \hat{\pi}_{t+1})$$

- Notice that consumption tomorrow enters with a coefficient of 1

- Iterate the Euler equation forward

$$\hat{c}_t = \mathbb{E}_t \hat{c}_T - \frac{1}{\gamma}\sum_{\tau=t}^{T}(\hat{i}_\tau - \mathbb{E}_t \hat{\pi}_{\tau+1})$$

Forward Guidance

$$\hat{c}_t = \mathbb{E}_t \hat{c}_T - \frac{1}{\gamma} \sum_{\tau=t}^{T} (\hat{i}_\tau - \mathbb{E}_t \hat{\pi}_{\tau+1})$$

- Let me assume the central bank controls the real rate

$$\hat{c}_t = \mathbb{E}_t \hat{c}_T - \frac{1}{\gamma} \sum_{\tau=t}^{T} \hat{r}_\tau$$

- Imagine the interest rate has been $\hat{r}_t = 0$
- And the economy is in steady state
- At time $t = 0$ the household learns about the following policy

$$\hat{r}_t = \begin{cases} 0 & \text{if } t < t^* \\ -\bar{r} & \text{if } t = t^* \\ 0 & \text{if } t > t^* \end{cases}$$

The Euler equation

$$\hat{r}_t = \begin{cases} 0 & \text{if } t < t^* \\ -\bar{r} & \text{if } t = t^* \\ 0 & \text{if } t > t^* \end{cases}$$

- Between $t = 0$ and $t = t^*$ $\hat{r}_t = 0$
  - So $c_t = \bar{c}_1 \; \forall \; 0 \leq t \leq t^*]$
- The interest rate between t^* and $t^* + 1$ falls
- the relative price of consumption fell, so you consume more in t^* than in $t^* + 1$
  - So $c_{t^*+1} = \bar{c}_2 < \bar{c}_1$
- The interest rate never changes again
  - So $c_t = \bar{c}_2 \; \forall \; t > t*$

Forward Guidance

- The policy we considered

$$\hat{r}_t = \begin{cases} 0 & \text{if } t < t^* \\ -\bar{r} & \text{if } t = t^* \\ 0 & \text{if } t > t^* \end{cases}$$

- Under perfect foresight
- Creates a step-function of consumption

$$\hat{c}_t = \begin{cases} \bar{c}_1 & \text{if } t \leq t^* \\ \bar{c}_2 & \text{if } t > t^* \end{cases}$$

- $\bar{c}_2 = 0$. Why? Monetary non-neutrality in the long-run
- $\bar{c}_1 = \frac{1}{\gamma}\bar{r}$

Forward Guidance

$$\hat{c}_t = \begin{cases} \frac{1}{\gamma}\bar{r} & \text{if } t \leq t^* \\ 0 & \text{if } t > t^* \end{cases}$$

- So what?

- Bizarre!

  1. Announcing a cut tomorrow or in large T has the same effect on consumption today

  2. PV of CIRF of consumption is **increasing** on the horizon t^*

  3. Forward guidance infinitely powerful on quantities

Forward Guidance

- How about inflation?
- Bizarre as well
- Remember the iterated-forward Phillips Curve from lecture 3

$$\pi_t = \kappa \sum_{k=0}^{\infty} \beta^k \mathbb{E}_t \hat{y}_k$$

- In equilibrium $\hat{y} = \hat{c}$
- Inflation response is front-loaded
- Current inflation is increasing on the discounted sums of expected output gaps
- Current inflation is increasing on t^* keeping $\bar{r}$ fixed

Mechanical intuition of the problem

- The source of the problem comes from the Euler equation being extremely forward looking
- There is no discounting in the log-linear Euler equation
- Mechanically, if you “discount” the Euler equation this problem will be diminished
- But, the source of the discounting must be convincing and appealing empirically

Two possibilities (that I know of): A detour

- Angeletos and Huo (2021)
  - RA economy:
    $$a_t = \varphi \xi_t + \delta \mathbb{E}_t a_{t+1}$$
  - a could be consumption in the euler equation, or π in the PC.
  - Informational frictions (dispersed info, rational inattention)
  - The information friction outcome coincides with a representative agent economy with
    $$a_t = \varphi \xi_t + \delta \omega_f \mathbb{E}_t a_{t+1} + \omega_b a_{t-1}$$
  - for some $\omega_f < 1$ (myopia), and a $\omega_b > 0$ (anchoring)

Two possibilities (that I know of): Not a detour

- Households out of their Euler equations

- Borrowing constraints are a popular way of doing that

- Speaks closely to the Keynesian cross models

The intuition for HANK models

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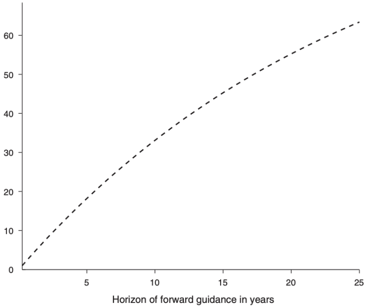


Figure 2. Response of Current Inflation to Forward Guidance about Interest Rates at Different Horizons Relative to Response to Equally Large Change in Current Real Interest Rate

Source: McKay, Nakamura, Steinsson (2016)

The intuition for HANK models

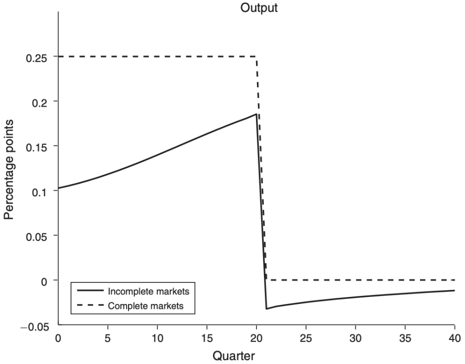


Figure 3. Response of Output to 50 Basis Point Forward Guidance about the Real Interest Rate in Quarter 20 (*With Real Interest Rates in All Other Quarters Unchanged*)

Source: McKay, Nakamura, Steinsson (2016)

THE INTUITION FOR HANK MODELS

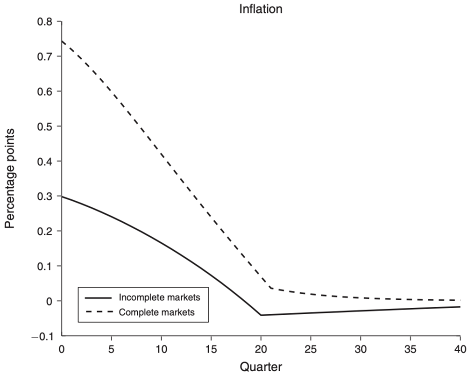


FIGURE 4. RESPONSE OF INFLATION TO 50 BASIS POINT FORWARD GUIDANCE ABOUT THE REAL INTEREST RATE IN QUARTER 20 (*With Real Interest Rates in all Other Quarters Unchanged*)

Source: McKay, Nakamura, Steinsson (2016)

The intuition for HANK models

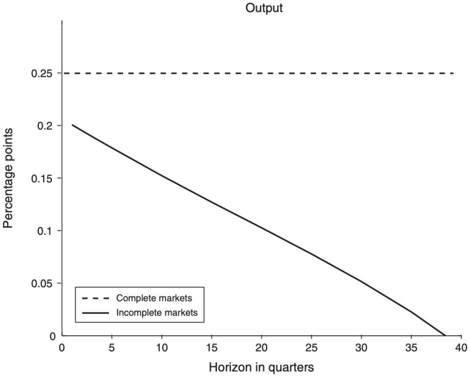


Figure 5. Initial Response of Output to 50 Basis Point Forward Guidance about the Real Interest Rate for a Single Quarter at Different Horizons

Source: McKay, Nakamura, Steinsson (2016)

The intuition for HANK models

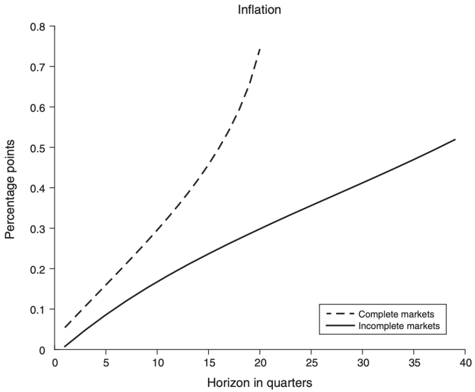


Figure 6. Initial Response of Inflation to 50 Basis Point Forward Guidance about the Real Interest Rate for a Single Quarter at Different Horizons

Source: McKay, Nakamura, Steinsson (2016)

Variation in MPCs

- Other than the interest on the power of forward guidance, notion that MPCs out of transitory income in the RA NK model are off
- In the textbook NK model the MPC out of transitory income is roughly zero
- Reason: the RA in the NK model lives in the PIH world

Decomposition of effects

- Total differentiation of C_0 (on impact)
- Similar to what we teach undergrads (tangency condition + ITBC)
- Allowing for partial price adjustment and GE responses

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

- Use a particular monetary policy rule

$$r_t = \rho + e^{-\eta t}(r_0 - \rho) \ \forall t \geq 0$$

Decomposition of effects

- Under that policy rule (+ demand determination)

$$dC_0 = \underbrace{-\frac{1}{\gamma}\int_0^{\infty} e^{-\rho t} dr_t dt}_{\text{direct effect}} \underbrace{-\frac{\rho}{\gamma}\int_0^{\infty} e^{-\rho t}\int_t^{\infty} dr_s ds dt}_{\text{indirect effect}}$$

- for ρ discount rate, η persistence of the monetary policy shock
- Can rewrite the semi-elasticity of consumption to interest rates as:

$$-\frac{d\log C_0}{dr_0} = \frac{1}{\gamma\eta}\left(\underbrace{\frac{\eta}{\eta+\rho}}_{\text{direct effect}} + \underbrace{\frac{\rho}{\rho+\eta}}_{\text{indirect effect}}\right)$$

- Anybody checked the proof?

Outline

The HJB equation

- The continuous time of the Bellman equation
- At some point read "Achdou, Yves, Jiequn Han, Jean-Michel Lasry, Pierre-Louis Lions, and Benjamin Moll. "Income and Wealth Distribution in Macroeconomics: A Continuous-Time Approach." The Review of Economic Studies 89, no. 1 (2022): 45-86."
- Perhaps in the next iteration of this lecture.

The HJB equation

$$(\rho+\zeta)V(a,b,y) = \max_{c,l,d} u(c,l) + V_b(a,b,y)\dot{b} +$$
$$V_a(a,b,y)\dot{a} + V_y(-\beta y) + \lambda \int_{-\infty}^{\infty} (V(a,b,x) - V(a,b,y))\phi(x)dx$$

- $(\rho+\zeta)$ capture discounting (time and death)
- V_x is the partial derivative of the HJB with respect to x
- last two terms capture the drift + jump process they assume

$$dy_{it} = -\beta y_{it} dt + dJ_{it}$$

- Changes in the distribution (0 in ss) are captured by a Kolmogorov Forward Equation

Law of motion and financial constraints

- The terms $\dot{b}$ and $\dot{a}$ in the HJB are given by

$$\dot{b}_t = (1-\tau_t)w_t z_t l_t + r_t^b(b_t)b_t + T_t - d_t - \chi(d_t, a_t) - c_t$$

$$\dot{a}_t = r_t^a a_t + d_t$$

$$b_t \geq -\underline{b}$$

$$a_t \geq 0$$

- b is "liquid". No adjustment costs
- a is illiquid. linear and convex adjustment costs
- Cannot short the illiquid asset
- Borrowing limit ($\neq$ to the natural debt limit) on the liquid asset
- is b a nominal or real bond?

Adjustment Costs

$$\chi(d,a) = \chi_0 |d| + \chi_1 \left|\frac{d}{a}\right|^{\chi_2} a$$

- Linear and convex costs of adjustment
- Linear costs are obvious. Need for inaction in adjustment
- Why do we need convex costs ($\chi_1 > 0$, $\chi_2 > 1$)?

Optimality conditions of HANK

- Useful to characterize the FOC of the HJB equation
- The first order condition with respect to consumption gives

$$u_c(c, l) = V_b(a, b, y)$$

- Note there are no expectations, and no evaluations in future periods
- One of the sources of efficiency in continuous time
- If you can take derivatives of your guess of the value function, then back-out the policy function of consumption:

$$c = u'^{-1}(V_b(a, b, y))$$

Optimality conditions of HANK

- Consumption

$$u_c(c,l) = V_b(a,b,y)$$

- Labor

$$-u_l(c,l) = V_b(a,b,y)(1-\tau)wz$$

- Very standard

Optimality conditions of HANK

- Optimal deposits on illiquid asset (conditional on depositing)

$$V_a(a,b,y) = V_b(a,b,y)\chi_d(d,a)$$

- where $\chi_d(d,a)$ is given by

$$\chi_d(d,a) = \chi_0 \frac{d}{|d|} + \chi_2 \chi_1 \frac{d}{a}$$

- Zero convex costs when (for example) $\chi_1 = 0$
- Pins down the deposit rate

$$\frac{V_a(a,b,y)}{V_b(a,b,y)} - \chi_0 \frac{d}{|d|} \frac{1}{\chi_1 \chi_2} = \frac{d}{a}$$

- Without convex costs, conditional on adjustments deposits "jump"
- Same problem that in Q-theory models of investment

Optimality conditions of HANK

- When to deposit money?
- When the value function of doing it is larger than of not doing it
- My calculations (unchecked by anybody), deposit iff

$$\frac{V_b(a,b,y)}{V_a(a,b,y)} \leq \frac{d}{\chi(d,a)+d}$$

- evaluated in $d = d^*$ from the previous slide

$$\frac{V_a(a,b,y)}{V_b(a,b,y)} - \chi_0 \frac{d^*}{|d^*|} \frac{1}{\chi_1 \chi_2} = \frac{d^*}{a}$$

The economics of non-convexities

- I encourage you to become familiar with models of non-convexities
- Applications:
  - Household finance
  - Investment
  - Price-setting
  - Occupational choice
  - Technology choice
- Happy to share my ECON 210C lecture notes applied to investment theory to those interested

Firms

- Competitive final good sector

$$Y_t = \left(\int_0^1 y_{jt}^{\frac{\varepsilon}{\varepsilon-1}} dj \right)^{\frac{\varepsilon-1}{\varepsilon}}$$

- Downward sloping demand curve for each variety

$$y_{jt} = \left(\frac{p_{jt}}{P_t} \right)^{-\varepsilon} Y_t$$

- P_t the ideal price index

$$P_t = \left(\int_0^1 p_{jt}^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}$$

- Why do we use that price index?

Price setting frictions

- Rotemberg Pricing: Convex costs of changing prices. Some cool facts.

    1. Roberts (1995) shows that the Calvo Phillips curve and the Rotemberg (1982) look the same (up to a redefinition of parameters of course)
    2. Without the need to linearize around a zero-inflation steady state
    3. Roberts (1995) ... for the Taylor (1979) with a change in the timing of the output gap
    4. Gertler and Leahy (2008) show that a linear approx. of a Ss model looks like the Calvo model

Firm problem

- Firm managers want to maximize the value of the firm

$$\int_0^\infty e^{-\int_0^t r_s^a ds} \left\{ \tilde{\Pi}_t(p_t) - \Theta\left(\frac{\dot{p}_t}{p_t}\right) \right\} dt$$

- Why do they discount profits with the rate of return of the iliquid asset?
- No firm-specific shocks: all firms face the same marginal cost

$$m_t = \left(\frac{r_t^k}{\alpha}\right)^\alpha \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}$$

- Phillips curve iterated forward

$$\pi_t = \frac{\varepsilon}{\theta} \int_t^\infty e^{-\int_t^s r_\tau^a d\tau} \frac{Y_s}{Y_t}(m_s - m^*) ds$$

- Inflation increases following changes in expected future marginal costs

Monetary Policy

- Simple Taylor Rule

$$i_t = \bar{r}^b + \phi \pi_t + \varepsilon_t$$

- $\phi > 1$ satisfying the Taylor principle

- Fisher equation

$$r_t^b = i_t - \pi_t$$

Fiscal policy

- The government is the only issuer of liquid assets
- Faces exogenous expenditures G
- Imposes transfers T and income taxes τ
- Satisfies an ITBC

$$\dot{B}_t^g + G_t + T_t = \tau_t \int w_t z_t l_t(a,b,y) d\mu_t + r_t^b B_t^g$$

Market Clearing

- Market for liquid assets clears

$$\int b d\mu_t + B_t^g = 0$$

- Market for illiquid assets clears

$$\int a d\mu_t = K_t + q_t$$

- Labor market clears

$$N_t = \int z l_t(a,b,z) d\mu_t$$

- Goods market clears

$$Y_t = C_t + I_t + G_t + \Theta_t + \chi_t + \kappa \int \max(-b,0) d\mu_t$$

Direct and indirect effects

- Γ a vector of prices r^a, r^b, T, τ, w

- Aggregate consumption integrates over households

$$C_t(\{\Gamma_t\}_{t\geq 0}) = \int c(a, b, y; \{\Gamma_t\}_{t\geq 0}) d\mu_t$$

- slight abuse of notation. The distribution μ depends on past realizations of Γ

- Totally differentiate

- Direct effect: due to changes in the liquid rate holding other prices

- Indirect effect: due to changes in other prices keeping the liquid rate

- Direct effects are not due to temporal substitution only: there are income effects. Why?

$$dC_0 = \int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b dt + \int_0^\infty \Big(\frac{\partial C_0}{\partial r_t^a} dr_t^a dt + \frac{\partial C_0}{\partial T_t} dT_t dt + \frac{\partial C_0}{\partial w_t} dw_t dt + \frac{\partial C_0}{\partial \tau_t} d\tau_t dt \Big)$$

Small Note

- I'm not aware of an easy way of computing these terms

$$\int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b dt$$

- This is particularly tricky in linearized RA models
- where "keeping constant prices" prevents (for example) Dynare from giving you an IRF
- You need to get these partial derivatives from the model

$$\int \frac{\partial c(a, b, y; \{r_t^b, \bar{r}^a, \bar{T}, \bar{w}, \bar{\tau}\}_{t\geq 0})}{\partial r_t^b} d\mu_0 dr_t^b dt$$

- where μ_0 is the partial-equilibrium model consistent cross-sectional distribution of agents

Distribution of profits

- What did you think?

Distribution of profits

- What did you think?
  Since equity is a component of illiquid assets, rather than liquid assets, the fall in profits associated with an expan- sionary monetary shock creates a downward pull on investment at a time when output is expanding. This feature is in stark contrast with the data where, quantitatively, investment is the most volatile and procyclical component of output.

CALIBRATION

- In the model, illiquid assets finance capital holdings
- In the calibration, housing is included in illiquid asset
- Would you improve the treatment of housing?

Optimal Portfolio Choice

- Liquid assets offer liquidity services
- The volatility and persistence of earning shocks matter
- Imagine productivity is permanent and without shocks: illiquid asset is better
- Productivity transitory and volatile: liquid asset is better

CALIBRATION

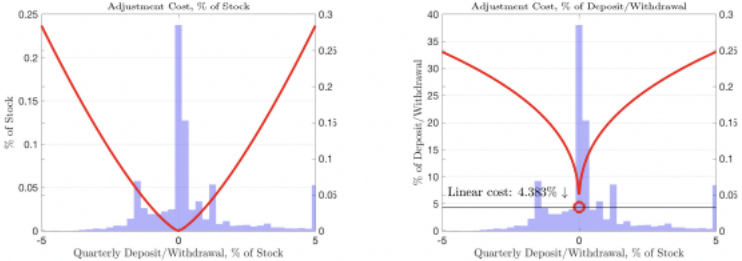


Figure D.3: Calibrated Adjustment Cost Function

Sense of how big the adjustment costs are

Calibration

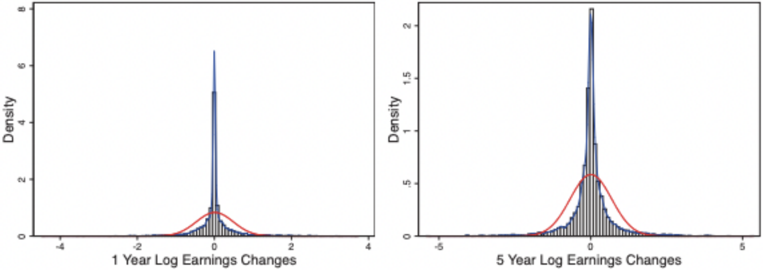


Figure D.1: Growth Rate Distribution of Estimated Earnings Process

The distribution of earnings shocks is leptokurtic

CALIBRATION

TABLE 5

	Data	Model
Mean illiquid assets	2.92	2.92
Mean liquid assets	0.26	0.23
Frac. with $b = 0$ and $a = 0$	0.10	0.10
Frac. with $b = 0$ and $a > 0$	0.20	0.19
Frac. with $b < 0$	0.15	0.15

	Liquid wealth		Illiquid wealth	
Moment	Data	Model	Data	Model
Top 0.1 percent share	17	2.3	12	7
Top 1 percent share	47	18	33	40
Top 10 percent share	86	75	70	88
Bottom 50 percent share	−4	−3	3	0.1
Bottom 25 percent share	−5	−3	0	0
Gini coefficient	0.98	0.86	0.81	0.82

Notes: Left panel: moments targeted in calibration and reproduced by the model. Means are expressed as ratios to annual output. Right panel: statistics for the top and bottom of the wealth distribution not targeted in the calibration.

Source: SCF 2004

Distribution of wealth holdings

CALIBRATION

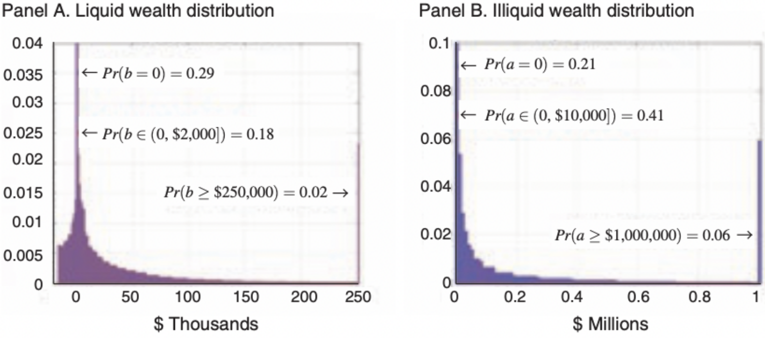
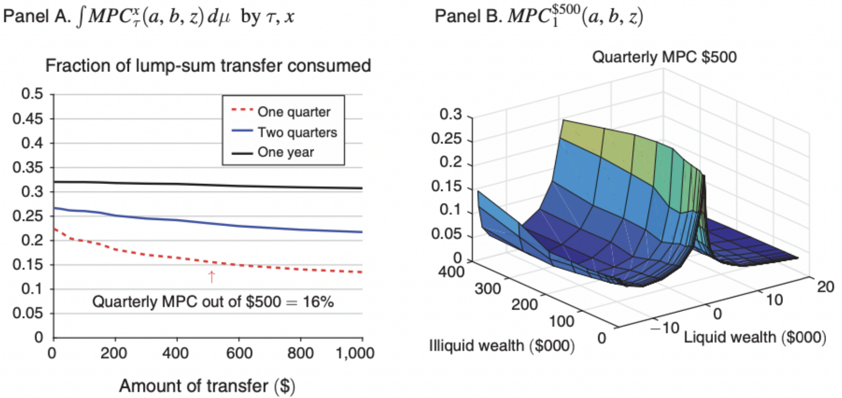


FIGURE 1. DISTRIBUTIONS OF LIQUID AND ILLIQUID WEALTH

Distribution of liquid and illiquid wealth

Calibration



Distribution of MPCs. Size dependency as in Kaplan Violante (2014)

CALIBRATION

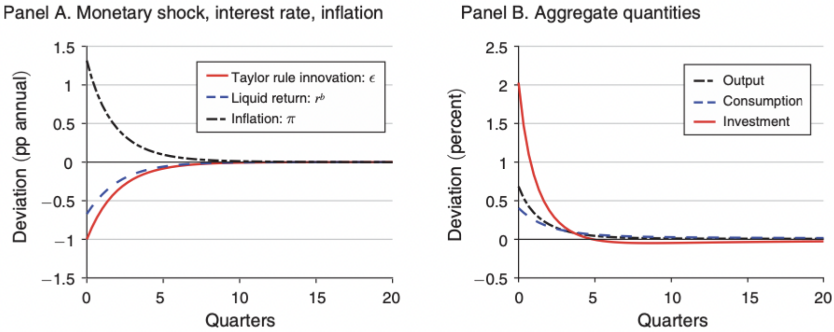


FIGURE 3. IMPULSE RESPONSES TO A MONETARY POLICY SHOCK
(*A Surprise, Mean-Reverting Innovation to the Taylor Rule*)

Aggregate effects

CALIBRATION

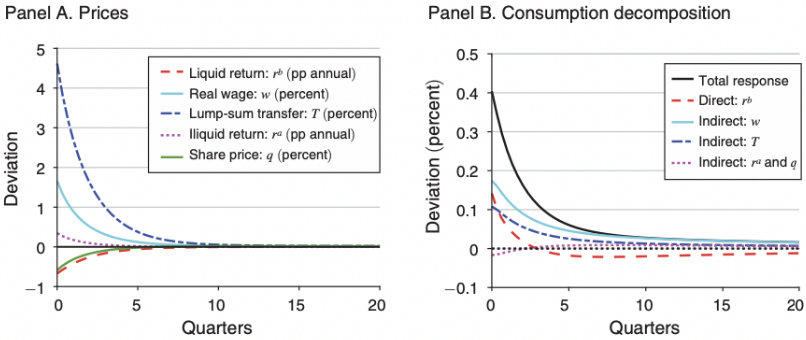


FIGURE 4. DIRECT AND INDIRECT EFFECTS OF MONETARY POLICY IN HANK

Notes: Returns are shown as annual percentage point deviations from steady state. Real wage and lump-sum transfers are shown as log deviations from steady state.

Price effects and Consumption decomposition

Calibration

Table 7—Decomposition of the Effect of Monetary Shock on Aggregate Consumption

	Baseline (1)	$\omega = 1$ (2)	$\omega = 0.1$ (3)	$\frac{\varepsilon}{\theta} = 0.2$ (4)	$\phi = 2.0$ (5)	$\frac{1}{\nu} = 0.5$ (6)
Change in r^b (pp)	−0.28	−0.34	−0.16	−0.21	−0.14	−0.25
Elasticity of Y	−3.96	−0.13	−24.9	−4.11	−3.94	−4.30
Elasticity of I	−9.43	7.83	−105	−9.47	−9.72	−9.79
Elasticity of C	−2.93	−2.06	−6.50	−2.96	−3.00	−2.87
Partial eq. elasticity of C	−0.55	−0.45	−0.99	−0.57	−0.59	−0.62
Component of percent change in C due to						
Direct effect: r^b	19	22	15	19	20	22
Indirect effect: w	51	56	51	51	51	38
Indirect effect: T	32	38	19	31	31	45
Indirect effect: r^a and q	−2	−16	15	−2	−2	−4

Notes: Average responses over the first year. Column 1 is the baseline specification. In column 2, profits are all reinvested into the illiquid account. In column 3, 10 percent of profits are reinvested in the illiquid account. In column 4, we reduce the stickiness of prices by lowering the cost of price adjustment θ. In column 5, we increase ϕ, which governs the responsiveness of the monetary policy rule to inflation. In column 6, we lower the Frisch elasticity of labor supply from 1 to 0.5.

Price effects and Consumption decomposition

Calibration

TABLE 1—ELASTICITY OF AGGREGATE CONSUMPTION AND SHARE OF DIRECT EFFECTS IN SEVERAL VERSIONS OF THE RANK AND TANK MODELS

	RANK				TANK		
	$B=0$	$B>0$	S–W	$B,K>0$	$B=0$	$B>0$	$B,K>0$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Elasticity of C	−2.00	−2.00	−0.74	−2.07	−2.00	−2.43	−2.77
PE. elast. of C	−1.98	−1.96	−0.73	−1.95	−1.38	−1.39	−1.39
Direct effects (%)	99	98	99	94	69	57	50

Notes: "$B=0$" denotes the simple models of Section I with wealth in zero net supply. "$B>0$" denotes the extension of these models with government bonds in positive net supply. In RANK, we set $\gamma = 1, \eta = 0.5, \rho = 0.005$, and $B_0/Y = 1$. In addition, in TANK we set $\Lambda = \Lambda^T = 0.3$. "S − W" is the medium-scale version of the RANK model described in online Appendix A.4 based on Smets-Wouters. "$B,K>0$" denotes the richer version of the representative-agent and spender-saver New Keynesian model featuring a two-asset structure, as in HANK. See online Appendix A.5 for a detailed description of this model and its calibration. In all economies with bonds in positive supply, lump-sum transfers adjust to balance the government budget constraint. "PE. elast of C" is the partial equilibrium (or direct) elasticity computed as total elasticity times the share of direct effects.

Price effects and Consumption decomposition

Calibration

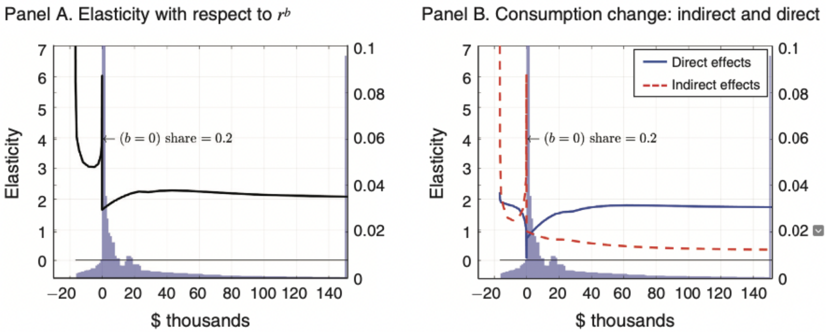


Figure 5. Consumption Responses by Liquid Wealth Position

Decomposition through the wealth distribution

Further Decomposition of the Direct Effect

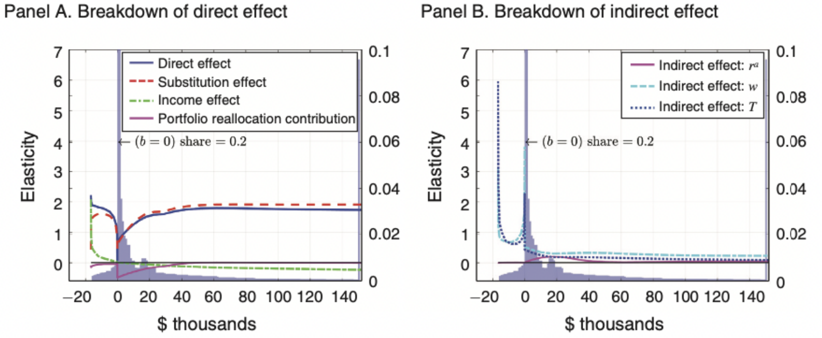


Figure 6. Consumption Responses by Liquid Wealth Position

Decomposition through the wealth distribution

Importance of Margin of adjustment

Table 8—Importance of Fiscal Response to Monetary Shock

	T adjusts (1)	G adjusts (2)	τ adjusts (3)	B^g adjusts (4)
Change in r^b (pp)	−0.28	−0.23	−0.33	−0.34
Elasticity of Y	−3.96	−7.74	−3.55	−2.17
Elasticity of I	−9.43	−14.44	−8.80	−5.07
Elasticity of C	−2.93	−2.80	−2.75	−1.68
Partial eq. elasticity of C	−0.55	−0.60	−0.56	−0.71
Component of percent change in C due to				
Direct effect: r^b	19	21	20	42
Indirect effect: w	51	81	62	49
Indirect effect: T	32	–	–	9
Indirect effect: τ	–	–	18	–
Indirect effect: r^a and q	−2	−2	0	0

Notes: Average responses over the first year. Column 1 is the baseline specification in which transfers T adjust to balance the government budget constraint. In column 2 government expenditure G adjusts, and in column 3 the labor income tax τ adjusts. In column 4 government debt adjusts, as described in the main text.

Margin of fiscal adjustment

Why Two Assets?

- The standard HA-NK model faces a tension
- W-to-Y ratios are “high” (roughly 2-3)
- MPCs are “high”
- Difficult to have high MPCs for wealthy people
- Unless they cannot use their wealth to smooth consumption

Persistence-Size Tradeoff

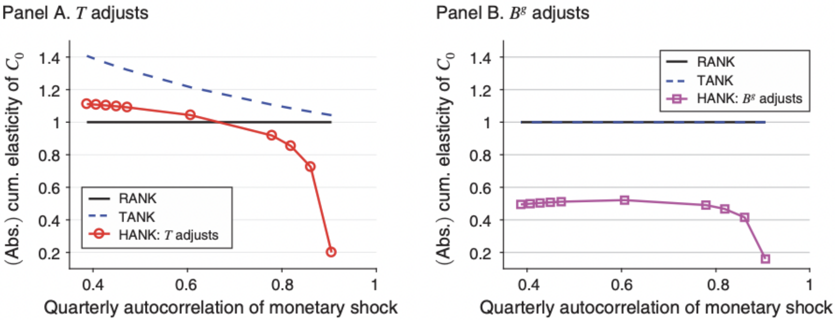


Figure 8. Cumulative Elasticity of Aggregate Consumption by Persistence of the Shock

Margin of fiscal adjustment

Outline

Why TANK?

- In HANK models borrowing constraints are not either or
- How far are you from the constraint?
- The probability of hitting the borrowing constraint is important
- The problem has substantial heterogeneity
- Simulate aggregate shocks is not trivial
- Although Johannes will cover some neat state-of-the-art methods next week
- Restore to simulations

Is TANK enough

- Metric: Is TANK close enough to HANK
- Note that this metric is not the only potential one
- It may be that HANK implies counterfactual behavior
- And that TANK approximates better household behavior
- Not the avenue that Debortoli and Gali (2016) take
- But perhaps an interesting research possibility

The simplified HANK

- Here agents are hand to mouth, or unconstrained

$$\hat{c}_t = \mathbb{E}_t \hat{c}_{t+1} - \frac{1}{\gamma}\hat{r}_t - \frac{1}{\sigma}\mathbb{E}_t \Delta z_{t+1} - \mathbb{E}_t \Delta \hat{h}_{t+1}$$

- For demand shifters z and heterogeneity index h

$$\hat{h}_t = \hat{h}_t^{\gamma} + \hat{h}_t^{\theta} + \hat{h}_t^{\lambda}$$

- In words: the aggregate Euler equation can differ because:

  1. λ: The share of constrained households changes
  2. γ: A shock induces a redistribution form low to high MPC households
  3. θ: There is increased dispersion in consumption within a group

The TANK limit

- In TANK

$$\hat{h}_t = \hat{h}_t^{\gamma}$$

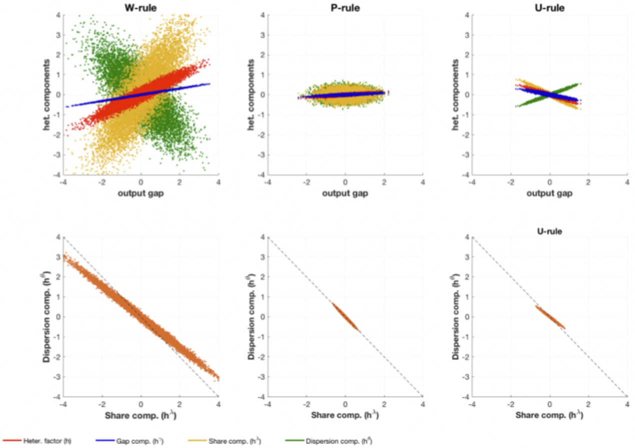
- No changes in the mass of constrained agents $h^{\lambda} = 0$

- No dispersion within types $h^{\theta} = 0$

- Still can have redistribution across types h^{γ}.

TANK close to HANK

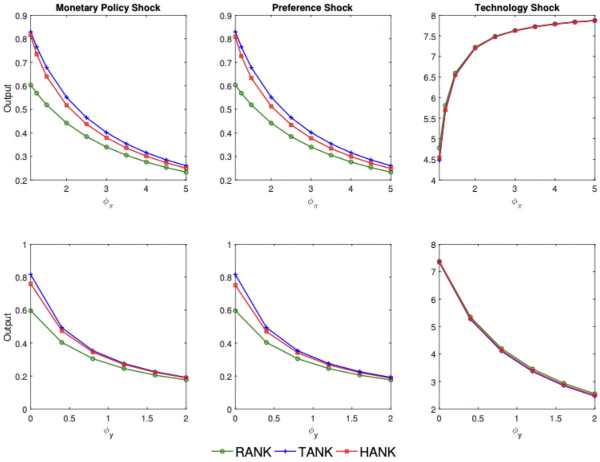
Figure 2: Output-gap and Heterogeneity Components in HANK- Real Rate Shocks



Note: The first row shows scatterplots of the output gap (horizontal axis) and the heterogeneity components (vertical axis) for the HANK models under the W-rule (first column), the P-rule (second column) and the U-rule (third column), generated from a random simulation (of 10,000 periods) of the model in response to real rate shocks. The second row shows the associated scatterplots for the share component $\hat{h}^{\lambda}$ (horizontal axis) and the dispersions component $\hat{h}^{\theta}$ (vertical axis).

TANK CLOSE TO HANK

Figure 6: Changes in Environment - Monetary Policy Rule



Note: The figure compares the cumulative response of output over 16 quarters under alternative values for the interest rule parameters ϕ_π(first row) and ϕ_y (second row), for the RANK, TANK and HANK models under the W-rule, conditional on monetary policy (first column), preference (second column) and technology (third column) shocks.

How I understand the paper

- They are saying that the TANK model is sufficiently close to the HANK model they wrote
- Which is different from KMV in a number of ways
- Particularly on having households close to the borrowing constraint
- KMV seem to claim that TANK is sufficiently far away from HANK
- Thoughts?

Outline

My HANK reading list

- McKay and Wolf (2022): "Optimal Policy Rules in HANK"
- Acharya Dogra (2020): "Understanding HANK: Insights from a PRANK" Econometrica, 2020, Vol 88 (May), 1113-1158