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

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. – Mark Gertler

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. Deductive reasoning from a sense of plausibility

2. From the data: High MPCs, even for *the rich hand to mouth*. Inductive reasoning by comparing the data with the NK model

Outline

References

- Woodford's Interest and Prices has been my go to reference for years.

- Gali's book is fantastic due to how condense and to the point it is. Great reference to have near your desk

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 Phillips curve

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa x_t$$

- Can iterate forward:

$$\pi_t = \kappa \mathbb{E}_t \sum_{k=0}^{\infty} \beta^k x_{t+k}$$

- Inflation today $=$ expected discounted sum of future output gaps

The Euler equation

- Market clearing

$$x_t = y_t - y_t^n = \hat{c}_t = c_t - c_t^n$$

- In log-linear terms

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

- or

$$x_t = \mathbb{E}_t x_{t+1} - \frac{1}{\gamma}(i_t - \mathbb{E}_t \pi_{t+1})$$

- Notice that consumption tomorrow enters with a coefficient of 1
- Iterate the Euler equation forward

$$x_t = \mathbb{E}_t x_T - \frac{1}{\gamma} \sum_{\tau=t}^{T} (i_\tau - \mathbb{E}_t \pi_{\tau+1})$$

Partial Equilibrium - PIH

- Saw some confusion in a previous class regarding the PIH. Want to make sure we are all in the same page. Assume r_t is known and set at r
- Problem of one agent. Two ingredients.
  1. Feasibility: PV of c = PV of y. Intertemporal Budget Constraint
  2. Optimality: Sequence of Euler equations
- Feasibility:

$$\sum_{k=0}^{\infty} \frac{c_{t+k}}{(1+r)^k} = \sum_{k=0}^{\infty} \frac{y_{t+k}}{(1+r)^k}$$

- Optimality. For every pair of periods $t+k$, $t+k+1$ with CRRA

$$c_{t+k+1} = c_{t+k} \left((1+r)\beta\right)^{\gamma}$$

- Replace the euler equations into the ITBC

$$c_t \sum_{j=0}^{\infty} \beta^{\gamma j} (1+r)^{(\gamma-1)j} = \sum_{j=0}^{\infty} \frac{y_{t+j}}{(1+r)^j}$$

Partial Equilibrium - PIH

- What we call the consumption function
- Analogy to computational. Give me a sequence of y's and a sequence of r's, I give you a sequence for c's back

$$c_t \sum_{j=0}^{\infty} \beta^{\gamma j}(1+r)^{(\gamma-1)j} = \sum_{j=0}^{\infty} \frac{y_{t+j}}{(1+r)^j}$$

- $\frac{dc_t}{dy_t} = 1 - \beta^{\gamma}(1+r_t)^{\gamma-1}$
- if, $\beta(1+r) = 1$, then

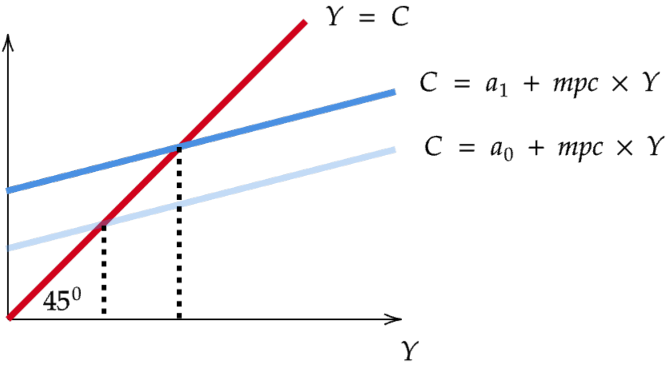
$$mpc_{t,t} = \frac{dc_t}{dy_t} = 1 - \beta$$

- A very small number. If $r = 2\%$ annual, then quarterly $mpc = 0.005$
- $mpc_{t,t+k} = \frac{dc_t}{dy_{t+k}} = (1-\beta)\left(\frac{1}{1+r}\right)^k$
- Intuition: PV of income increased by less than one dollar

General Equilibrium - PIH

- In general equilibrium, $C = Y$
- Channels when r_t changes:
  - From r to c. Dictated by $1/\gamma$. Intertemporal substitution.
  - From c to y. Market clearing.
  - From y to c. Very small. MPC close to zero. Keynesian cross is flat
  - From y to π. Slope of the phillips curve
  - from y and π to r: depends on MP rule and inflation expectations

Keynesian Cross



Forward Guidance

$$x_t = \mathbb{E}_t \hat{c}_T - \frac{1}{\gamma} \sum_{\tau=t}^{T} (i_\tau - \mathbb{E}_t \pi_{\tau+1})$$

- Let me assume the central bank controls the real rate

$$x_t = \mathbb{E}_t x_T - \frac{1}{\gamma} \sum_{\tau=t}^{T} r_\tau$$

- Imagine the interest rate has been $r_t = 0$
- And the economy is in steady state
- At time $t = 0$ the household learns about the following policy

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

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 $x_t = \bar{x}_1 \ \forall \ [0 \leq t \leq t^*]$
- 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 $x_{t^*+1} = \bar{x}_2 < \bar{x}_1$
- The interest rate never changes again
  - So $x_t = \bar{x}_2 \ \forall \ t > t*$

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 for the output gap

$$x_t = \begin{cases} \bar{x}_1 & \text{if } t \leq t^* \\ \bar{x}_2 & \text{if } t > t^* \end{cases}$$

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

Forward Guidance

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

- So what?
- Bizarre!

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

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

- 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

Behavioral Explanation

- Angeletos and Huo (2021)
  - RA economy with no frictions:

$$a_t = \varphi \xi_t + \delta \mathbb{E}_t a_{t+1}$$

  - 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)

Incomplete Markets

- 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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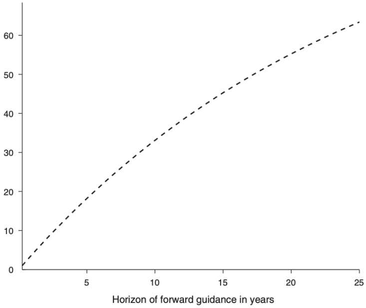


FIGURE 2. RESPONSE OF CURRENT INFLATION TO FORWARD GUIDANCE ABOUT INTEREST RATES AT DIFFERENT HORIZONS RELATIVE TO RESPONSE TO EQUALLY LARGE CHANGE IN CURRENT REAL INTEREST RATE

Source: McKay, Nakamura, Steinsson (2016)

The intuition for HANK models

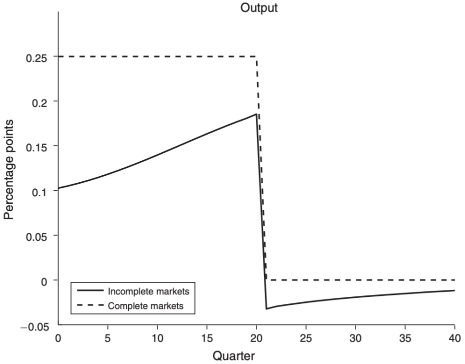


Figure 3. Response of Output to 50 Basis Point Forward Guidance about the Real Interest Rate in Quarter 20 (*With Real Interest Rates in All Other Quarters Unchanged*)

Source: McKay, Nakamura, Steinsson (2016)

The intuition for HANK models

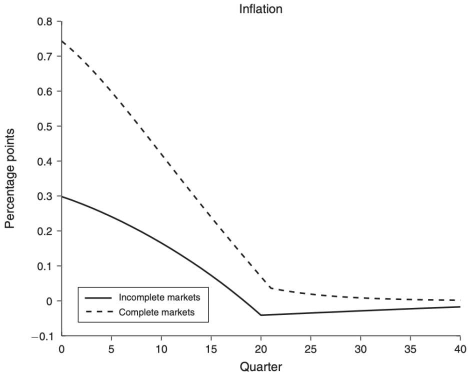


Figure 4. Response of Inflation to 50 Basis Point Forward Guidance about the Real Interest Rate in Quarter 20 (*With Real Interest Rates in all Other Quarters Unchanged*)

Source: McKay, Nakamura, Steinsson (2016)

The intuition for HANK models

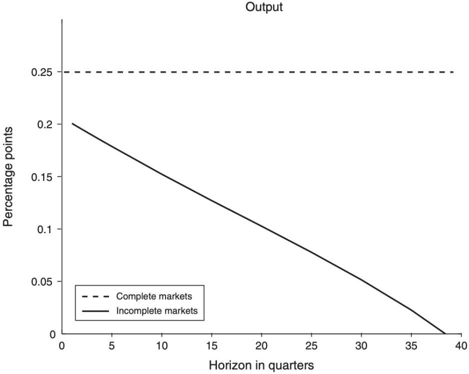


Figure 5. Initial Response of Output to 50 Basis Point Forward Guidance about the Real Interest Rate for a Single Quarter at Different Horizons

Source: McKay, Nakamura, Steinsson (2016)

The intuition for HANK models

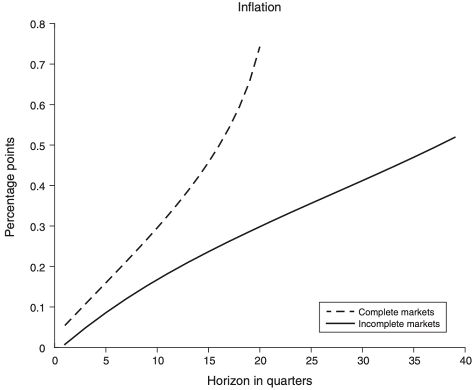


Figure 6. Initial Response of Inflation to 50 Basis Point Forward Guidance about the Real Interest Rate for a Single Quarter at Different Horizons

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 as we have seen

- 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

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

- $(\rho+\zeta)$ 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

Why Two Assets?

- The standard HA-NK model faces a tension
- W-to-Y ratios are “high” (roughly 2-4 depending on how you treat land)
- MPCs are “high”
- Difficult to have high MPCs for wealthy people
- Unless they cannot use their wealth to smooth consumption

Adjustment Costs

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

- Linear and convex costs of adjustment

- Thoughts?

Optimality conditions of HANK

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

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

- Implies a policy function for 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 than in Q-theory models of investment

Optimality conditions of HANK

- When to deposit money?

- When the value function of doing so is larger than of not doing so

- 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

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

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 under particular assumptions of the desired price
5. Auclert, Rigato, Ronglie, Straub (2023): Menu cost model the mixture of two Calvo models. Nest Gertler and Leahy (2008)

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?

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

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

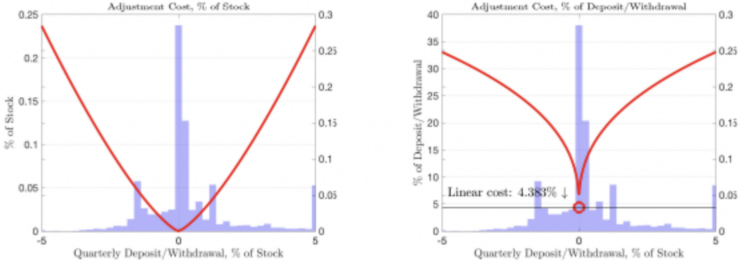


Figure D.3: Calibrated Adjustment Cost Function

Sense of how big the adjustment costs are

CALIBRATION

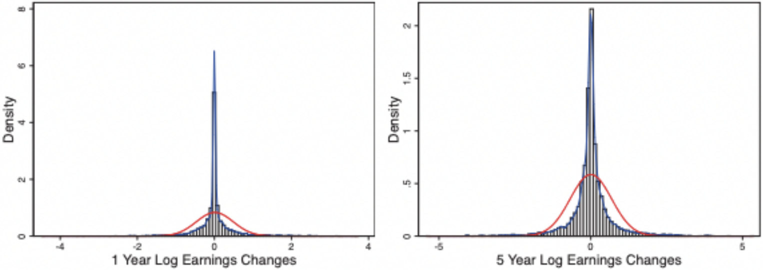


Figure D.1: Growth Rate Distribution of Estimated Earnings Process

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

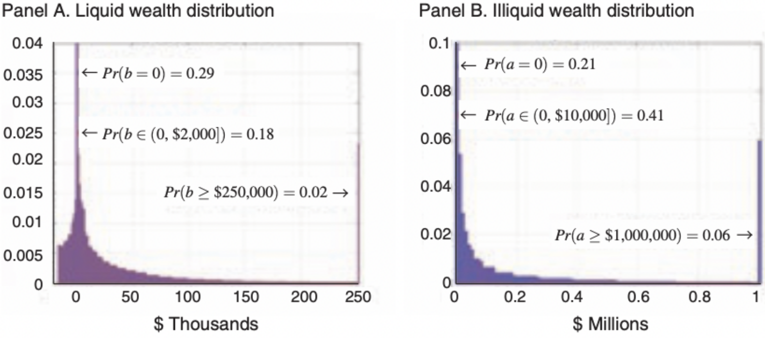
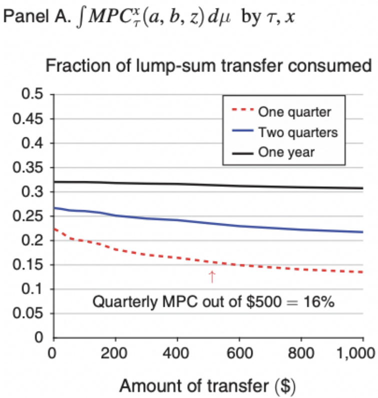


Figure 1. Distributions of Liquid and Illiquid Wealth

Distribution of liquid and illiquid wealth

Calibration



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

Calibration

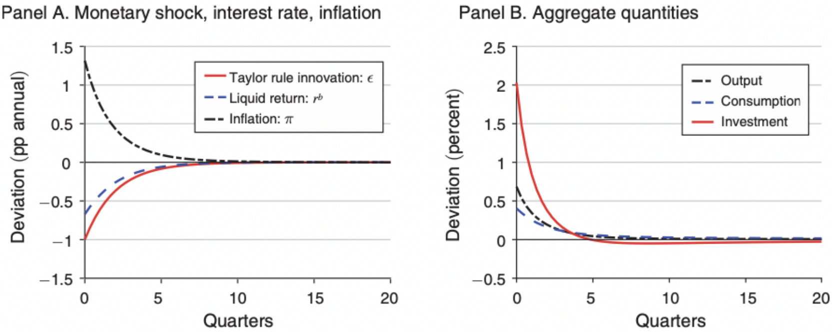


Figure 3. Impulse Responses to a Monetary Policy Shock
(*A Surprise, Mean-Reverting Innovation to the Taylor Rule*)

Aggregate effects

Calibration

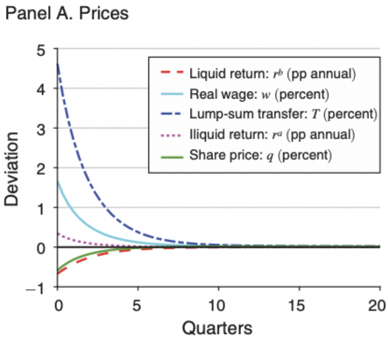


Figure 4. Direct and Indirect Effects of Monetary Policy in HANK

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

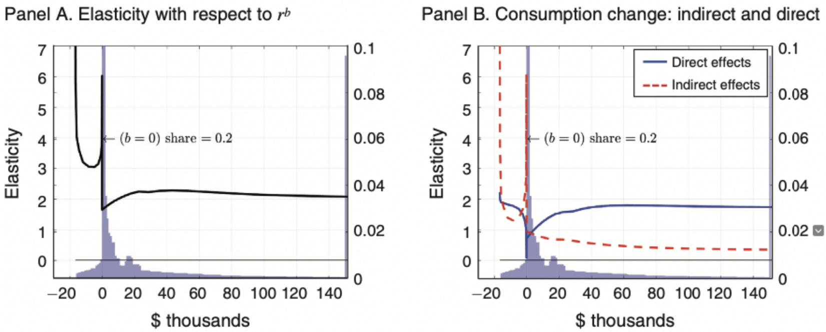


FIGURE 5. CONSUMPTION RESPONSES BY LIQUID WEALTH POSITION

Decomposition through the wealth distribution

Further Decomposition of the Direct Effect

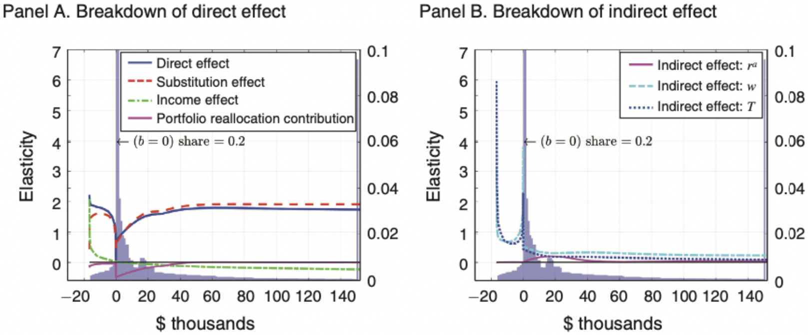


Figure 6. Consumption Responses by Liquid Wealth Position

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

Persistence-Size Tradeoff

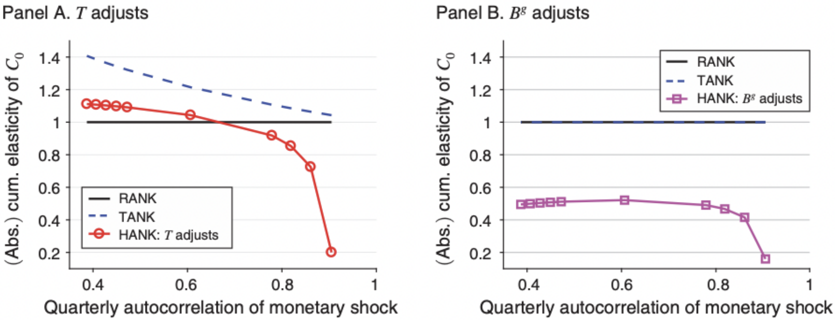


Figure 8. Cumulative Elasticity of Aggregate Consumption by Persistence of the Shock

Margin of fiscal adjustment

Outline

Debortoli Gali (2024)

- HANK computationally involved
- Hopefully 281 Computational is helping to demystify these models!
- Still, analytical expressions and simpler models are useful
- Specially if you do not care too much about the micro source of, high MPCs

Is TANK enough

- Model-based metric: Is TANK close enough to HANK?
- Not the only possible metric
- It may be that HANK implies counterfactual behavior on MPCs, on the extent of precautionary savings, ...
- And that TANK approximates household behavior better
- Not the avenue that Debortoli and Gali (2016) take
- But perhaps an interesting research possibility

Dictionary of Nomenclature - Mostly in case I get confused

- RANK: Representative Agent NK
- HANK I: Borrowing constraints not binding in eq. Idiosyncratic income risk. Stocks fully iliquid.
- HANK II: Borrowing constraints may bind. The share of households on the borrowing constraint is endougenous and time-varying
- HANK III: Partial illiquidity
- TANK I: Exogenous share of households are hand-to-mouth. No idiosyncratic income risk
- TANK II: HtM hold same amount of stocks, have lower labor productivity, pay interest on max debt allowed by the borrowing constraint
- TANK III: Introduce distinction between poor and wealthy hand to mouth

Where RANK differs compared to HANK

- HANK I

$$\hat{c}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\hat{r}_{t+k} - \frac{\sigma+1}{2}\sum_{k=0}^{\infty}\mathbb{E}_t\hat{v}_{t+k}$$

  - where $\hat{v}$ is the (deviation versus ss) consumption-weighted measure of individual consumption risk
  - Policy will induce changes in levels and redistribution of resources, affecting v

- RANK

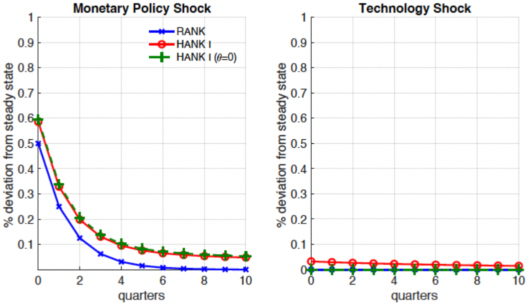
$$\hat{c}_t = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\mathbb{E}_t\hat{r}_{t+k}$$

- Difference is small. Intuitive reason:
- Idiosyncratic income risk caused by an aggregate shock is only important for poor households. Rich households use their buffer stock
- But poor households do not count much on aggregate consumption consumption. So $\hat{v}$ is small.

Message 1

Figure 1: RANK vs HANK-I

Panel (a)



Idiosyncratic income risk on its own is not too important

HANK II vs. TANK I

- Two types of differences

  1. those related to Unconstrained households:

     - ★ In HANK there are compositional changes.
     - ★ In HANK there is idiosyncratic consumption risk

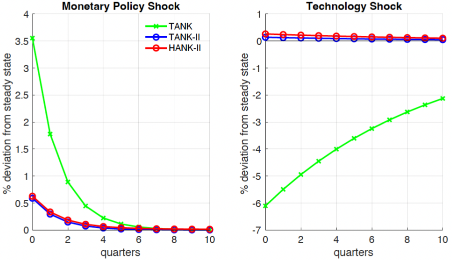
  2. Those related to Constrained households

     - ★ In TANK not exposed to interest rates directly. In HANK they are: they are paying interests
     - ★ In TANK, given Y, higher markups depress wages (the only source of income). In HANK higher markups yield higher dividend income

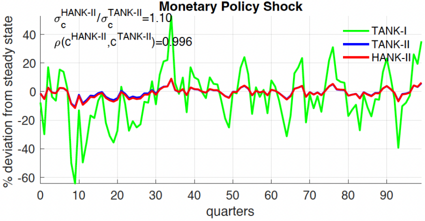
MESSAGE 2

Figure 5: Simple Alternatives to HANK-II

Panel (a): Impulse Responses

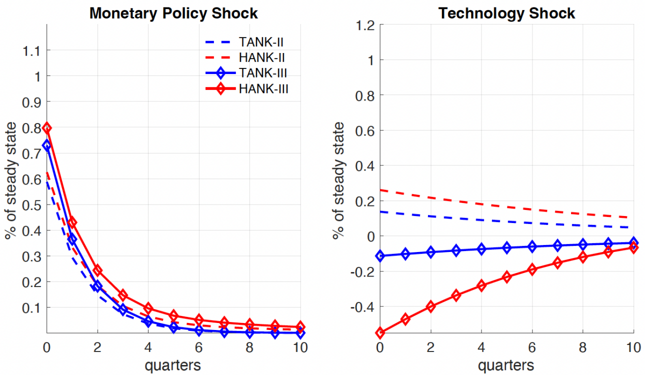


Panel (b): Simulations



Message 2

Figure 8: The Role of Portfolio Adjustment Costs: HANK-III vs TANK-III



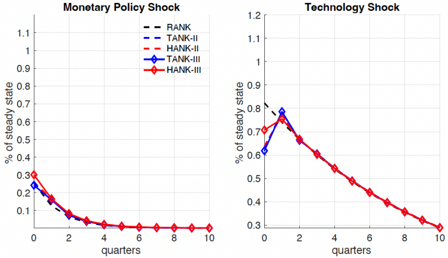
Notes: The figure shows the response of output to a 1 percent decrease in the (annualized) real interest rate (left column), and to a 1 percent positive technology shock (right column) in the heterogeneous agent models (red lines) and two-agent models (blue lines), for the case without portfolio adjustment costs (HANK-II and TANK-II, dashed lines), and with portfolio adjustment costs (HANK-III and TANK-III, lines with diamonds).

Assumptions about HtM more important than about U

MESSAGE 3

Figure 10: Heterogeneity, Nominal Bonds and Endogenous Monetary Policy

Panel (a): Impulse Responses



Panel (b): Simulations

Assumptions about HtM more important than about *U*