Workshop BCB: Macro com agentes heterogêneos

Aula 7 e 8: Monetary Policy According to HANK

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Insper

References

- Kaplan, Moll, and Violante (2018, AER)*. Monetary Policy According to HANK.
- Kaplan, and Violante (2018, JEP)*. Microeconomic heterogeneity and macroeconomic shocks.
- Mckay and Wolf (2023, JEP)*. Monetary Policy and Inequality.
- Referências adicionais: Auclert (2019, AER); McKay, Nakamura and Steison (2016, AER).

Introduction

- How monetary policy affects aggregate consumption?
- Look at the HH budget constraint:

$$c_t + a_{t+1} = (1 + r_t)a_t + (1 - \tau)w_t l_t z + T_t$$

where $(a,\ z)$ is the individual state of the household.

- **Direct Effect**:
  - r_t: intertemporal substitution effect;
- **Indirect Effects**:
  - w_t: equilibrium wage effect;
  - l_t: labor supply behavioral response;
  - T_t: fiscal policy response.

Introduction

- **Representative agent**:
  - $(a,\ z)$ the same for everybody $\Rightarrow$ Marginal propensity to consume the same for everybody;
  - The effect on income is the same for everybody $\Rightarrow$ same wealth, labor endowment and transfer;
  - **Ricardian Equivalence holds**, the timing of the fiscal rules does not matter.

- The representative agent is a **permanent income** agent.
  - MPC to a transitory shock is very small;
  - $> 95\%$ of the effect of monetary policy is through **intertemporal substitution**.
  - Euler Equation: $\downarrow r_t \Rightarrow$ decreases savings and increases consumption;
  - Very little empirical evidence of this mechanism.

Introduction

- **Heterogeneous agents**:
  - (a, z) heterogeneous $\Rightarrow$ MPC varies a lot and depend a lot of the household portfolio;
  - The income effect is also different (e.g., effect of r depends how much a you own);
  - Indirect effects can be very large ($> 2/3$ of the total effect).
- **Empirical Evidence:** most households hold very little liquid wealth a
  - Some hold a lot of illiquid wealth; some have no wealth at all;
  - Both have a small direct effect and a large indirect effect on consumption.
- **Ricardian Equivalence do not hold**, when and how large is the fiscal adjustment matters.

Introduction

Why does it matter?

- Questions on how large and persistent should monetary expansion should be to get the appropriate response on consumption.
- HANK model: highly depends on the response of fiscal policy.
- Relative size of direct vs indirect effect:
  - If direct effects are dominant, it is sufficient for the monetary authority to influence real rates;
  - If indirect effects are dominant, the monetary authority must rely on equilibrium feedbacks, which is potentially harder to fine-tune.

Example: RANK

- Let's see the effect of monetary policy on C_t through a very simple RANK (Representative Agent New-Keynesian) model.

- Suppose a model
  - HH has CRRA utility with parameter γ; discount at rate ρ;
  - HH receives transfers, T_t, and can save in a government bond at rate r_t;
  - Labor supply adjust so that labor income equals Y_t.
  - Production: $Y_t = N_t$. No capital/investment;
  - Prices/wages fully fixed and normalized to 1;
  - Goods market clearing: $C_t(\{r_t, Y_t, T_t\}_{t\geq 0}) = Y_t$.

- Monetary policy is just a **path for interest rate**:

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

The interest rate jump at t and mean reverts at rate η.

Example: RANK

- Solution of the HH problem implies the (continuous time) Euler Equation: $\dot{C}_t/C_t = \frac{1}{\gamma}(r_t - \rho)$.

- Given the assumption of mean reversion, we can solve the ODE and show that the elasticity of consumption:
$$\frac{\log C_0}{r_0} = -\frac{1}{\gamma\eta},$$
the response of C_0 is large if the elasticity of substitution $1/\gamma$ is high, and if the monetary expansion is persistent (η is low).

- We can decompose in the **direct** and **indirect** effect:
$$dC_0 = \underbrace{\int_0^\infty \frac{\partial C_0}{\partial r_t} dr_t dt}_{\textbf{direct response to r}} + \underbrace{\int_0^\infty \frac{\partial C_0}{\partial Y_t} dY_t dt}_{\textbf{indirect effects due to Y}} \quad .$$

Example: RANK

- In this simple model, the elasticity can be written as:

$$\frac{\log C_0}{r_0} = -\frac{1}{\gamma\eta}\Big(\underbrace{\frac{\eta}{\eta+\rho}}_{\textbf{direct}} + \underbrace{\frac{\rho}{\eta+\rho}}_{\textbf{indirect}}\Big)$$

- For any reasonable calibration of η and ρ, the direct effect dominates accounting for more than 90% of the effect.

- The indirect effect is small because RA are **permanent income consumers**. Transitory income shocks do not matter for the decision of these guys.

- Adding government debt can slightly reduce the effect of the direct effect.
  - The effect is limited because **Ricardian Equivalence holds**.

Example: TANK

- Suppose two agents model (TANK): a fraction Λ are permanent income consumers, $1-\Lambda$ are hand-to-mouth consumers (no savings).

$$\frac{\log C_0}{r_0} = -\frac{1}{\gamma\eta}\Big(\underbrace{(1-\Lambda)\frac{\eta}{\eta+\rho}}_{\text{direct response to r}} + \underbrace{(1-\Lambda)\frac{\rho}{\eta+\rho} + \Lambda}_{\text{indirect effects due to Y}} \Big)$$

- A higher fraction of hand-to-mouth consumers increases the indirect effect.
  - Note that the overall effect is still the same.

- Government has stronger effects and the fiscal rule matters (i.e., **no Ricardian Equivalence**).
  - If the fiscal response increases T to hand-to-mouth consumers, the overall response of C is higher.

Comparison of Models

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.

HANK Model

- Continuous time; Consumption-savings with incomplete markets.
- **Households**: heterogeneous in labor productivity z; liquid asset b; illiquid asset a. Supply labor elastically.
- Stochastic death with probability ζ; Offspring is born with zero wealth; Upon death the estate is distributed according to their asset holdings.
- **New Keynesian Flavor**: price stickiness + monetary policy following a Taylor rule.
- **Government:** Tax labor income and transfer a lump-sum; Faces exogenous spending G; Can hold debt.

Households

- Households preference over consumption and working hours is:

$$\mathbb{E}_0 \int_0^\infty e^{-(\rho+\zeta)t} u(c_t, l_t) dt$$

where $\rho \geq 0$ is the discount factor; $c_t \geq 0$ and $l_t \in [0, 1]$.

- The per-period utility function is:

$$u(c_t, l_t) = \frac{c^{1-\gamma}}{1-\gamma} - \varphi \frac{l_t^{1+\nu}}{1+\nu},$$

where $1/\gamma$ is the intertemporal elasticity of substitution; and $1/\nu$ the Frisch elasticity of labor supply.

Households

- The budget constraint is:

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

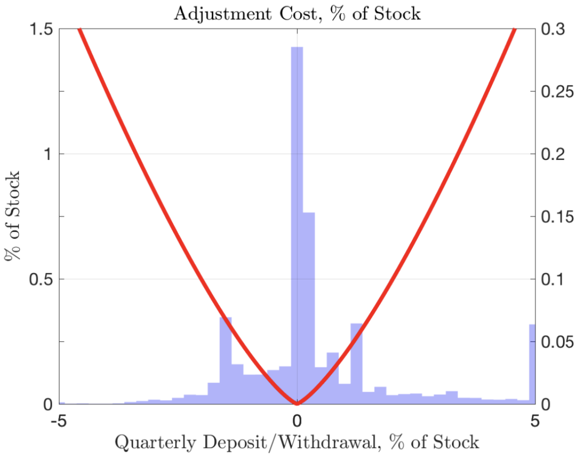
  where d_t is deposits in the illiquid asset account a_t; $\chi(d_t, a_t)$ is the transaction cost function; $b_t \geq -\underline{b}$ and $a_t \geq 0$.

- Households can borrow $(b_t < 0)$, but if they do it they face an exogenous interest rate wedge: $r_t^b(b) = r_t^b + \mathbf{1}_{\{b<0\}}\kappa$.

- Because there is an transaction cost, in equilibrium, returns between liquid and illiquid: $r_t^a > r_t^b$.

Transaction Cost

- $\chi(d_t, a_t) = \chi_0|d| + \chi_1|\frac{d}{a}|^{\chi_2}a.$



Continuous-Time Earnings Dynamics

- The stochastic process of log-earnings is the sum of two independent components:

$$\log z_{it} = z_{1,it} + z_{2,it}$$

- Each component is a "jump-drift" process:
  - Jumps occur at Poison rate λ_j;
  - Conditional on a jump, the new $z'_{j,it}$ comes from $N(0, \sigma_j^2)$;
  - Between jumps, the process drifts toward zero at rate β_j:

$$dz_{j,it} = -\beta_j z_{j,it} + dJ_{j,it}$$

  where $J_{j,it}$ captures jumps in the process.

- Intuitively, it is similar to a discrete time persistent-transitory stochastic process.

Households

- Households maximize the intertemporal utility, taken as given the equilibrium path of prices and policy variables over t: $\{w_t\}_{t\geq 0}$, $\{r_t^b\}_{t\geq 0}$, $\{r_t^a\}_{t\geq 0}$, $\{\tau_t\}_{t\geq 0}$, and $\{T_t\}_{t\geq 0}$.

- We can solve the sequential equilibrium by solving a **Hamilton-Jacobi-Bellman**. The stationary version (with only one z):

$$
\begin{aligned}
(\rho+\zeta)V(a,b,z) = \max_{c,\ l,\ d} u(c,l) &+ V_b(a,b,z)[(1-\tau)wzl + r^b b + T - d + \chi(d,a) - c] \\
&+ V_a(a,b,d)[r_t^a a_t + d_t] + V_z(a,b,z)(-\beta z) \\
&+ \lambda \int_{-\infty}^{\infty} (V(a,b,x) - V(a,b,z))\phi(x)dx
\end{aligned}
$$

where $\phi(x)$ is the density of a normal distribution and $V_x(a,b,z)$ the partial derivative of V.

Production: Final Good

- Final good producer aggregates a continuum of intermediate inputs j:

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \qquad \text{where } \varepsilon > 0.$$

- The solution for the final good producer implies a demand for each input j:

$$y_{j,t} = \left(\frac{p_{j,t}}{P_t} \right)^{-\varepsilon} Y_t \qquad \text{where the price index is } P_t = \left(\int_0^1 p_{j,t}^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}.$$

Production: Intermediate Good

- Each good j is produced by a intermediate monopolistic using capital and labor:

$$y_{j,t} = k_{j,t}^{\alpha} n_{j,t}^{1-\alpha}$$

- They choose prices/quantity to maximize profits. Prices are subject to quadratic adjustment cost a la Rotemberg (1982):

$$\Theta\left(\frac{\dot{p}_t}{p_t}\right) = \frac{\theta}{2}\left(\frac{\dot{p}_t}{p_t}\right)^2 Y_t$$

- It is useful to separate the problem in two steps:
  - First step (static problem): given prices (p_j, r^k, w) and demand y_j, choose inputs k_j and n_j;
  - Second step (dynamic problem): choose optimal price to maximize intertemporal profits.

Production: Intermediate Good

- **1st step:** given p_j, cost minimization problem is

$$my_j = \min_{k_j, n_j} wn_j + r^k k_j \quad \text{s.t.} \quad y_j = k_j^\alpha n_j^{1-\alpha} \quad \text{and} \quad y_j = \left(\frac{p_j}{P}\right)^{-\varepsilon} Y$$

- Solution implies factor demands and the marginal cost m of producing one extra unit of y:

$$k_j = y_j \left(\frac{\alpha}{1-\alpha}\frac{w}{r^k}\right)^{1-\alpha} \quad \text{and} \quad n_j = \frac{y_j}{\left(\frac{\alpha}{1-\alpha}\frac{w}{r^k}\right)^{\alpha}} \quad \Rightarrow \quad m = \left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{r^k}{\alpha}\right)^{\alpha}$$

- Operational profits (given prices):

$$\tilde{\Pi}(p_j) = \frac{p_j}{P} y_j - my_j = \left(\frac{p_j}{P} - m\right) y_j = \left(\frac{p_j}{P} - m\right)\left(\frac{p_j}{P}\right)^{-\varepsilon} Y$$

Production: Intermediate Good

- **2nd step:** choose a price path $\{p_{j,t}\}_{t\geq 0}$ that maximizes discounted profits:

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

where $e^{-\int_0^t r_s^a ds}$ is the stochastic discount factor.

- Note that in the steady-state, $\dot{p}_t = 0$, and the optimal price implies the usual **price = markup $\times$ marginal cost**:

$$\frac{p_j}{P} = \frac{\varepsilon}{\varepsilon - 1} m^* \qquad \Rightarrow \qquad m^* = \frac{\varepsilon - 1}{\varepsilon}$$

since all firms are equal ($p_j = P$)..

Production: Intermediate Good

- Let $\dot{\pi}_t = \dot{P}_t / P_t$ be the inflation rate. Outside of the steady-state, the solution of problem implies in the New Keynesian Phillips curve:

$$\left(r_t^a - \frac{\dot{Y}_t}{Y_t}\right)\pi_t = \frac{\varepsilon}{\theta}(m_t - m^*) + \dot{\pi}_t$$

or in present-value form:

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

Production: Intermediate Good

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

- Inflation is **forward-looking** and is the result of the firm's decision:
  - It is the discounted sum of the deviations of the marginal cost (or markup) from its desired value.
  - Firms raise prices if they expect a high marginal cost in the future (or low markup).
  - Marginal payoff to a firm from increasing its price at time s: $\tilde{\Pi}_t'(p_s) = \varepsilon Y_s (m_s - m^*)$.
  - Marginal cost of adjusting prices: $\theta \pi Y_t$ is equal
- **Inflation**: Mg. cost of adjust price today = sum of all future Mg. Benefits of changing prices.

Composition of Illiquid Wealth

- Illiquid wealth a can be (i) capita, k_t, or (ii) equity shares of intermediate firms, s_t. The share represent a claim of all future profits: $\Pi_t = \tilde{\Pi}_t - \Theta(\pi_t)$.
- Let q_t be the share price, so: $a_t = k_t + q_t s_t$.
- Assuming that within the illiquid asset account, the resources can be moved costless between capital and shares result in the following no-arbitrage condition:

$$\frac{\Pi_t + \dot{q}_t}{q_t} = r_t^k - \delta \equiv r_t^a.$$

Government

- **Monetary Policy.** Follows a standard Taylor rule type:

$$i_t = \overline{r}^b + \phi\pi_t + \epsilon_t$$

  where $\phi > 1$ and $\epsilon_t = 0$ in the steady state.

- Given inflation π_t and nominal interest rate i_t, the fisher equation holds: $r_t^b = i_t - \pi_t$.
- **Fiscal Policy.** Taxes, transfers and debt satisfy the budget constraint:

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

  where G_t is the exogenous government expenditures. The fiscal instrument chosen to balance the budget matters.

Equilibrium

- Let μ_t be the distribution of agents over (a, b, z).
- Four markets in the economy: liquid assets (bonds), illiquid assets (capital and shares), labor market, goods market.

$$B_t^h + B_t^g = 0$$
$$K_t + q_t = A_t$$
$$N_t = \int z l_t(a, b, z) d\mu$$
$$Y_t = C_t + I_t + G_t + \Theta_t + \chi_t + \kappa \int \max\{-b, 0\} d\mu_t$$

where $B_t^h = \int b d\mu_t$, $A_t = \int a d\mu_t$, q_t is the equity value of the monopolistic producers (number of shares is normalized to one).

Distribution of Profits

- **NK models**: since prices are sticky, markup are counter-cyclical.
  - Expansionary monetary policy $\Rightarrow \uparrow m$ and $\downarrow$ markup $\rightarrow \downarrow$ profits.

- How you distribute the monopolist profits matter.

- A fraction $\omega \Pi_t$ is reinvested directly into the illiquid account (in a way to sterilizes the impact of fluctuating markups).

- The fraction of $(1-\omega)\Pi_t$ is paid as a proportion of z:

$$\Pi_t(z) = \frac{z}{\bar{z}}(1-\omega)\Pi_t.$$

- Think as bonuses and commissions.

Transmission of Monetary Policy

- Analyze the effect of a one-time unexpected expansionary monetary shock $\epsilon < 0$ (an MIT shock!).
- Let $\Gamma_t = (r_t^b, r_t^a, w_t, \tau_t, T_t)$. Aggregate consumption is the average of consumption of all agents.

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

where $c_t(a, b, z; \{\Gamma_t\}_{t\geq 0})$ is the policy function of a household (a, b, z).

- We can decompose the effect of consumption at C_0:

$$dC_0 = \underbrace{\int_0^\infty \frac{\partial C_0}{\partial r_t^b} dr_t^b dt}_{\text{direct effect}} + \underbrace{\int_0^\infty \left(\frac{\partial C_0}{\partial w_t} dw_t + \frac{\partial C_0}{\partial r_t^a} dr_t^a + \frac{\partial C_0}{\partial \tau_t} d\tau_t + \frac{\partial C_0}{\partial T_t} dT_t \right) dt}_{\text{indirect effects}} .$$

Transmission of Monetary Policy

- **Direct Effect**:
  - $\downarrow r^b \rightarrow$ intertemporal substitution + negative income effect (HH with low liquid assets have high MPC).

- **Indirect Effects**:
  - $\uparrow w \rightarrow$ increase in consumption raises labor demand and further raise wages.
  - $\uparrow r^a \rightarrow$ higher capital demand raises r^a, households re-balance their portfolios and change consumption;
  - fiscal policy $\rightarrow \downarrow r^b$ lower interest rate payments on debt and higher tax revenue.
  - loose gov. budget constraint $\rightarrow$ adjustment of a fiscal instrument. Which and when matters (non-Ricardian equivalence). In the baseline adjustment is T_t.

Calibration

Earnings Process: Estimated using SMM.

TABLE 3—EARNINGS PROCESS ESTIMATION FIT

Moment	Data	Model
Variance: annual log earns	0.70	0.70
Variance: 1-year change	0.23	0.23
Variance: 5-year change	0.46	0.46
Kurtosis: 1-year change	17.8	16.5
Kurtosis: 5-year change	11.6	12.1
Frac. 1-year change $<$ 10%	0.54	0.56
Frac. 1-year change $<$ 20%	0.71	0.67
Frac. 1-year change $<$ 50%	0.86	0.85

TABLE 4—EARNINGS PROCESS PARAMETER ESTIMATES

	Parameter	Component $j = 1$	Component $j = 2$
Arrival rate	λ_j	0.080	0.007
Mean reversion	β_j	0.761	0.009
Standard deviation of innovations	σ_j	1.74	1.53

Note: Rates expressed as quarterly values.

Calibration: External Parameters

Table 6—List of Calibrated Parameter Values

	Description	Value	Target/source
Preferences			
ζ	Death rate	1/180	Avg. lifespan 45 years
$1/\gamma$	Intertemporal elasticity of subst.	1	
$1/\nu$	Frisch elasticity of labor supply	1	
φ	Disutility of labor	2.2	Avg. hours worked equal to 1/2
ρ	Discount rate (p.a.)	5.1%	Internally calibrated
Production			
ε	Demand elasticity	10	Profit share of 10 percent
θ	Price adjustment cost	100	Slope of Phillips curve, $\varepsilon/\theta = 0.1$
α	Capital share	0.33	
$\bar{\delta}$	Steady-state depreciation rate (p.a.)	7%	
Government			
τ	Proportional labor tax	0.30	
T	Lump-sum transfer (rel. GDP)	0.06	40% hh with net govt. transfer
Monetary Policy			
ϕ	Taylor rule coefficient	1.25	
$\bar{r}^b$	Steady-state real liquid return (p.a.)	2%	
Unsecured borrowing			
r^{borr}	Borrowing rate (p.a.)	8%	Internally calibrated
$\underline{b}$	Borrowing limit	$16,500	1 × quarterly labor income

Calibration: Household Wealth

- Data from SCF:
  - **liquid**: Consumer debt, deposits, bonds (0.26 of GDP);
  - **illiquid**: Housing, durables, corporate and private equity (2.92 of GDP).
- Matching moments: choose $(\rho,\ \kappa,\ \chi_0,\ \chi_1,\ \chi_2)$ to match the moments:
  - Mean of liquid and illiquid wealth distribution;
  - Fraction of poor and wealthy hand-to-mouth (HH with liquid wealth between -1000 and 1000 USD).
  - Fraction of HH with negative liquid wealth.
- Two-asset structure helps to match the distribution.

Calibration: Household Wealth

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

Calibration: Household Wealth

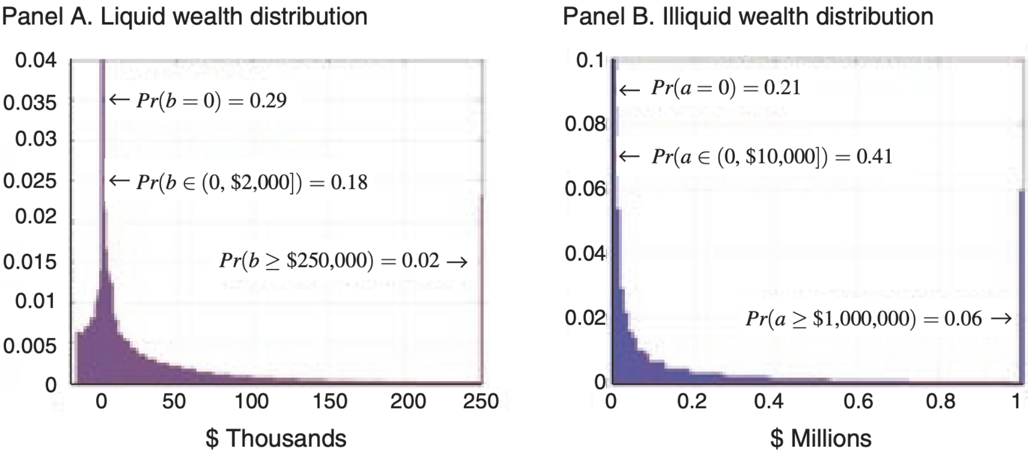
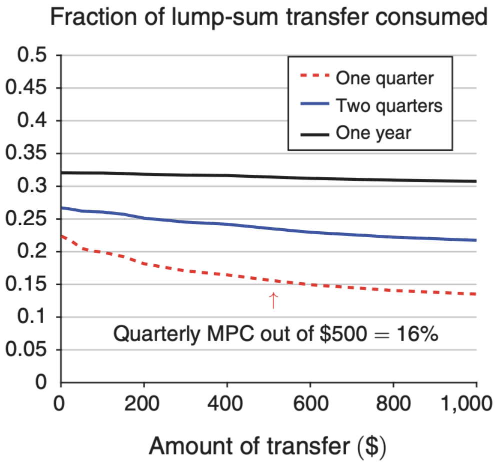


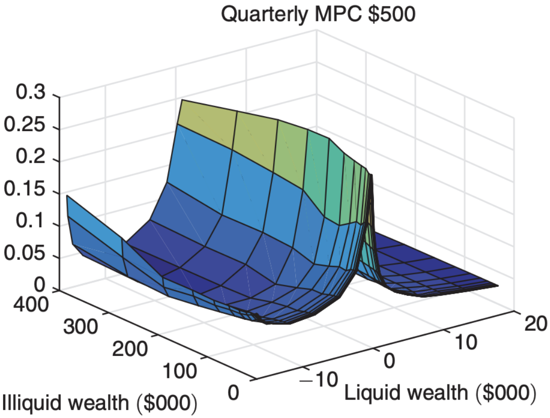
FIGURE 1. DISTRIBUTIONS OF LIQUID AND ILLIQUID WEALTH

Substantial Heterogeneity in MPC

Panel A. $\int MPC_{\tau}^{x}(a,b,z)\,d\mu$ by τ, x



Panel B. $MPC_{1}^{\$500}(a,b,z)$



Quantitative Results

- **Shock**: $\epsilon_0 = -0.25$. $i_t = \overline{r}^b + \phi\pi_t + \epsilon_t$.

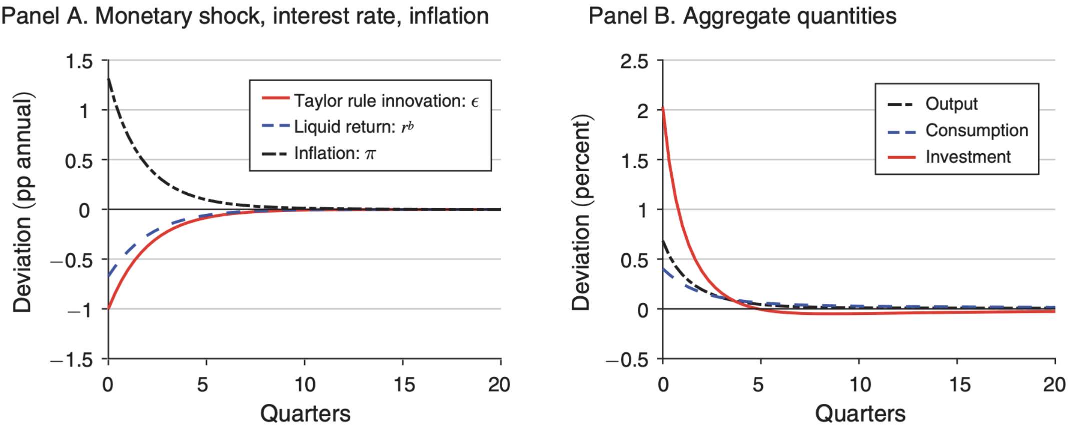


FIGURE 3. IMPULSE RESPONSES TO A MONETARY POLICY SHOCK
(*A Surprise, Mean-Reverting Innovation to the Taylor Rule*)

Quantitative Results

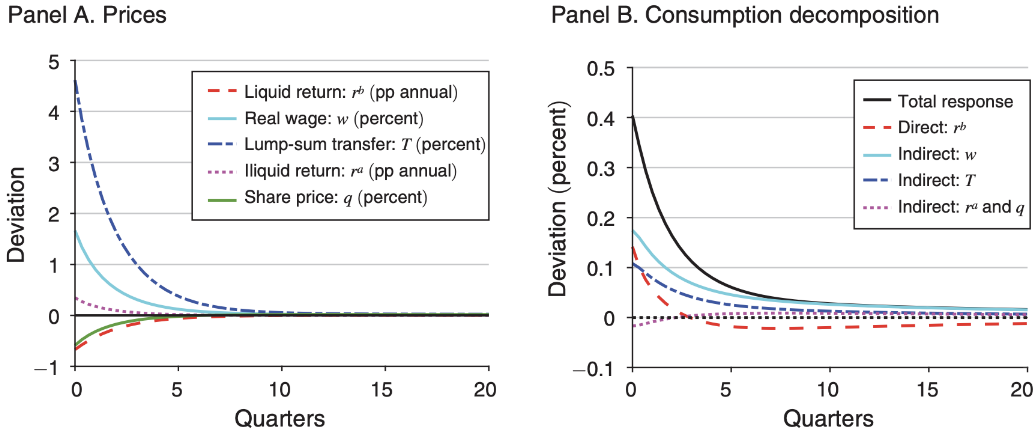


FIGURE 4. DIRECT AND INDIRECT EFFECTS OF MONETARY POLICY IN HANK

Quantitative Results

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.

Quantitative Results

- **HANK**: direct effect: 19%, indirect effect: 81%.
  - Elasticity of C w.r.t r is around -2.93
- Stark contrast with **RANK**, where direct effect is $> 90\%$ (and TANK $> 50\%$).
  - Elasticity of C w.r.t r is around -2.0
- Large income effects from w_t and T_t; robust to all specifications;
- Portfolio rebalancing decreases consumption (mostly from non hand-to-mouth HHs).

The Distribution of Monetary Transmission

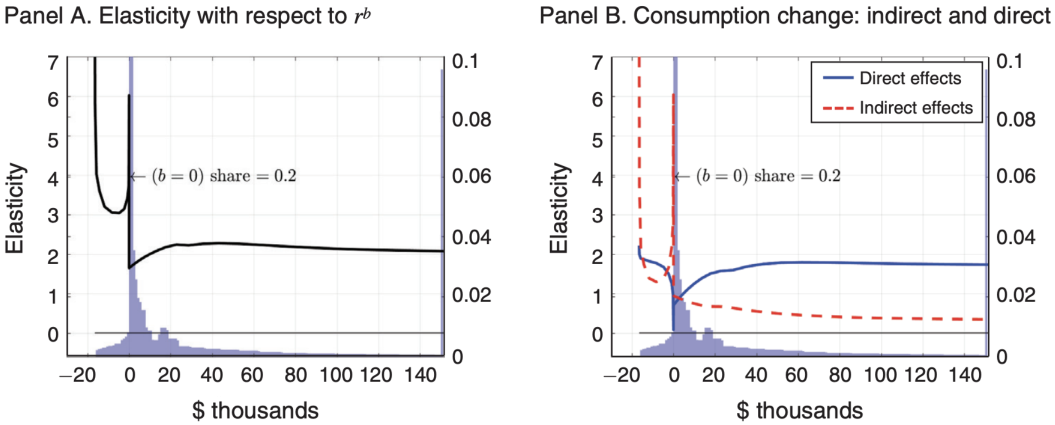


FIGURE 5. CONSUMPTION RESPONSES BY LIQUID WEALTH POSITION

Quantitative Results

- Substantial heterogeneity on the response of monetary policy.

- **Hand-to-mouth HHs** (around 20% of the total consumption)
  - Elasticity of 6;
  - Respond mostly to indirect effects (changes in w_t and T_t);

- **Other HHs** (around 80% of the total consumption)
  - Elasticity of 2;
  - Respond mostly to direct effects (intertemporal substitution);

- Back of the envelope calculation of total elasticity: $6 \times 0.2 + 2 \times 0.8 = 2.8$.

The Distribution of Monetary Transmission

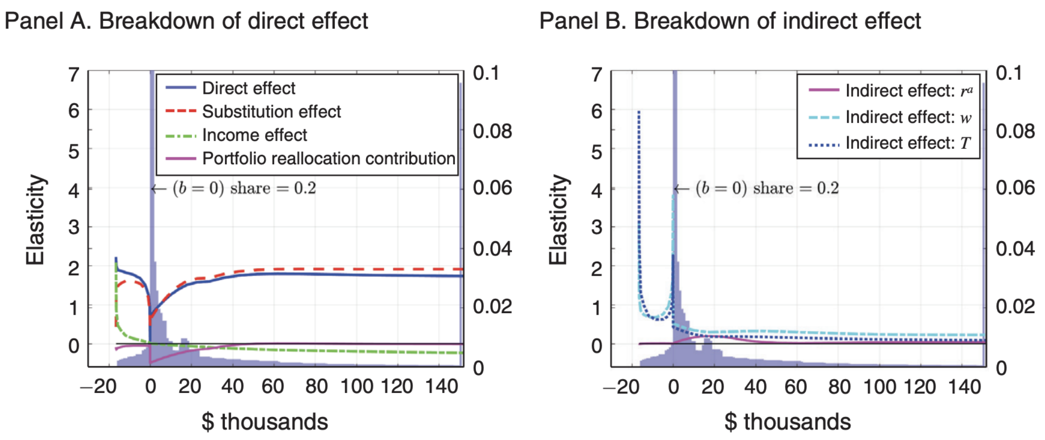


FIGURE 6. CONSUMPTION RESPONSES BY LIQUID WEALTH POSITION

Quantitative Results

- **Why are the direct effect is small?**
  - Intertemporal substitution is weaker: even though some agents have low MPCs, they might have higher in the future;
  - Instead of intertemporally substitute consumption; moderately rich households rebalance their portfolios toward the illiquid asset.

- **Why are the indirect effects are large?**
  - Presence of hand-to-mouth (wealthy or not) are key;
  - Redistribution of T_t to HHs is very important;
  - Negative effects of r^a and q are small.

The Role of Fiscal Policy

- $\downarrow r^b$: debt service is cheaper. What the government does with that money?

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

- $\uparrow T$: hand-to-mouth households increase consumption.

- $\uparrow G$: effect on output is higher (before only H-t-M were consuming), but the effect on consumption is lower (through wages).

- $\downarrow \tau$: less redistributive than T, but has positive effect on labor supply.

- $\uparrow B^g$: decreases debt now and transfer the money back to households in the future (T). Low effect on aggregate demand now, which substantially decreases indirect effects.

The Role of Fiscal Policy

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.

Size vs Persistence of Monetary Shocks

- **RANK**:

$$C_0 = \overline{C} \exp\Big(-\frac{1}{\gamma} \underbrace{\int_0^\infty (r_s - \rho) ds}_{R_0\text{: cumulative deviation from natural rate}} \Big)$$

it does not matter if monetary policy is less or more persistent, as long the overall size of R_0 is the same.

- **HANK**:
  - Persistence does matter for hand-to-mouth HHs. Their consumption jump when they receive a transitory income shock;
  - Consumption jumps more to a large but transitory interest rate cut than to a mild but persistent;
  - Fiscal policy also matters: cut in interest rates now means that the relaxation of the government budget constraint happens today.

Inflation-Activity Trade-Off

- Trade-off between **inflation** and **output** is largely determined by the New-Keynesian side of the model:
  - (New-Keynesian) Phillips Curve;
  - Taylor rule.

- Since they are similar across models, it does not differ too much between RANK and HANK.

- The extent of the trade-off in HANK depends also on the type of fiscal adjustment.

Conclusion

- **HANK:** Brings back the MPC to the core of the monetary policy.
  - Indirect effects such as wages and transitory effects matter;
  - Secondary role for intertemporal substitution;
  - Share of HHs hand-to-mouth are important;
  - Fiscal policy adjustment matters.
- Possible new insights for unconventional monetary policy?
  - Less power to forward guidance?
  - Role of quantitative easing?
- Optimal monetary policy?

Where to go now?

- **Further Inspection on Transmission of MP**: Auclert (2019, AER), Alves et al (2021, JMCB).
- **Analytic Models**: Acharya and Dogra (2020, ECTA), Bilbiie (2021, WP).
- **Forward Guidance and Quantitative Easing**: McKay, Nakamura, and Steinsson (2016, AER); Cui and Sterk (Forthcoming, JME).
- **Fiscal Policy**: Auclert, Rognlie and Straub (2018, WP), Hagedorn, Manovskii, and Mitman (2019, WP)
- **Open Economy**: Auclert et al (2021, WP).
- **Household Portfolio**: Luetticke (2021, AEJ: Macro), Melcangi and Sterk (2019, WP).
- **Labor Market Frictions**: Ravn and Sterk (2021, JEEA).