

Monetary Policy According to HANK

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Questions/Motivation

- ▶ Holy grail questions:
 - ▶ *What constitute* the (conventional, r) *monetary policy* (MP) *transmission mechanism*?
 - ▶ How *big* are they?
 - ▶ What dominates what—i.e., what is net effect of mechanism?
- ▶ Purpose:
 - ▶ Accurate accounting of components crucial for “successful” conduct of monetary policy
- ▶ This paper:
 - ▶ Focus on household *consumption* demand channel(s): direct vs indirect effects

Empirical evidence

- ▶ Macro evidence:
 - ▶ consumption not so sensitive to changes in interest, controlling for income
- ▶ Micro (SCF) evidence:
 - ▶ 25-33% of households have close to **zero** liquid wealth (e.g., bank balances) and face high borrowing costs
 - ⇒ high *individual* MPCs, low interest sensitivity (depends on h/hold balance sheet composition of liquid/illiquid assets)
 - ▶ *aggregated* quarterly MPC of about 0.25
- ▶ A *causal question* needing a causal structure:
 - ▶ Focus on household *consumption* demand channel(s): direct vs indirect effects

Model taxonomy

- ▶ **Representative Agent New Keynesian**
 - ▶ Sticky nominal price (Rotemberg) + Permanent-income consumer
- ▶ **Heterogeneous Agent New Keynesian ... *Por que no tres?***
 - ▶ Sticky nominal price (Rotemberg)
 - ▶ Uninsurable idiosyncratic income risk (Bewley → Huggett/Aiyari/İmhoroglu)
 - ▶ Borrowing constraints
 - ▶ Incomplete asset market(s)
 - ▶ Multiple assets with liquidity premia (Kaplan-Violante)
 - ▶ Costly portfolio rebalancing

- ▶ Uninsurable idiosyncratic income risk + Asset classes deliver:
 - ▶ large fraction of poor *and* wealthy hand-to-mouth (HTM) consumers
 - ▶ these agents have high MPCs, low interest sensitivities
 - ▶ c.f. permanent-income-hypothesis (PIH) consumer
- ▶ If monetary policy widens spread in asset returns, agents rebalance portfolios towards high-yield asset
- ▶ Macro 2 lessons:
 - ▶ Kinked individual budget constraints break Ricardian equivalence
 - ▶ Room for fiscal policy (FP) influence in GE

Forces at work (calibrated models)

Partial equilibrium decompositions:

- ▶ Focus on household **consumption** demand channel(s)

$$\text{Direct}(\Delta r) + \text{Indirect}(\Delta Y) \longrightarrow \Delta C$$

- ▶ **Direct:** intertemporal substitution effects
- ▶ **Indirect:** Income effects
- ▶ **RANK** (direct $\sim 99\%$, indirect $\sim 1\%$)
- ▶ **HANK** (direct $< 20\%$, indirect $> 80\%$)

General equilibrium overall effect?

- ▶ **RANK** independent of FP (Ricardian equivalence)
- ▶ **HANK** FP also matters for C (non-Ricardian) and for slope of Phillips curve (PC).

Monetary transmission

Implications:

- ▶ **RANK** — just focus on directly influencing r and let intertemporal substitution “do the work” (Euler-IS curve)
 - ▶ small, persistent or large, transient MP cuts are the same if cumulative cut is equal.
- ▶ **HANK** — size, composition and timing of policy matters.
 - ▶ transient but large MP cuts more effective in boosting C
 - ▶ passive (debt as shock absorber) FP provides PC tradeoff that is friendlier to MP.

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Section I:

- ▶ RANK in continuous time (Werning, 2015)
- ▶ Consider extreme case of fixed prices—MP as if controlling real r_t
- ▶ Suffices to focus on Euler-IS equation:

$$\frac{\dot{C}_t}{C_t} = \frac{1}{\gamma}(r_t - \rho)$$

and a time-path for MP:

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

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Proposition 1

- Direct (r_t) and indirect (Y_t) effects on C are linearly decomposable

$$d \log C_0 = -\frac{1}{\gamma} \int_0^\infty e^{-\rho t} dr_t dt - \frac{\rho}{\gamma} \int_t^\infty dr_s ds dt$$

- Simplifies to

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

- More risk averse (higher γ), smaller response.

RANK to TANK

More general setups ...

- If government debt is nonzero, so exists tax sequence T_t to balance intertemporal GBC. Even so, decomposition

$$\frac{d \log C_0}{dr_0} = \frac{1}{\gamma \eta} \left[\underbrace{\frac{\eta}{\rho + \eta} \left(1 - \rho \gamma \frac{B_0}{\bar{Y}} \right)}_{\text{direct, } r} + \underbrace{\frac{\rho}{\rho + \eta}}_{\text{indirect, } Y} + \underbrace{\frac{\eta}{\rho + \eta} \left(\rho \gamma \frac{B_0}{\bar{Y}} \right)}_{\text{indirect, } T} \right]$$

largely driven by direct channel (for plausible debt-to-GDP ratios).

- **TANK**: Ad-hoc share of rule-of-thumb or hand-to-mouth consumers? Similar conclusion.
- How about even more detail? Table 1, p708.

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Aggregate supply - Rotemberg's NKPC

Rotemberg's NKPC:

$$\pi_t = \underbrace{\frac{1}{\left(r_t^a - \frac{\dot{Y}}{Y}\right)}}_{\text{discounting}} \left[\underbrace{\dot{\pi}_t}_{\text{Future inflation}} + \frac{\varepsilon}{\theta} \underbrace{(m_t - m^*)}_{\text{real MC dev.}} \right],$$

- ▶ $1/m^* = \varepsilon/(\varepsilon - 1)$ Ramsey optimal, flex-price monopolistic markup
- ▶ $m_t = \left(\frac{r_t^k}{\alpha}\right)^\alpha \left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}$ real marginal cost of production

π_t s.t. marginal cost of instantaneous price change = PV of future price-change marginal profits:

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

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Heterogeneous demand - Bewley households

Preference representation:

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

- ▶ ζ Poisson death rate (intensity)
- ▶ Controls: c, ℓ, a, b, d

Constraints on liquid (b) and illiquid (a) asset demands,

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

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

$$b_t \geq -\underline{b}, \quad , a_t \geq 0$$

Costly portfolio adjustment (d):

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

- ▶ V-shaped part: implies states where agents would optimally do nothing
- ▶ Convex part: never optimal to withdraw/deposit infinite quantities

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Policy makers

Monetary authority:

- ▶ (Henderson-McKibbin-)Taylor rule:

$$i_t = \bar{r}^b + \phi \pi_t + \epsilon_t, \quad \phi > 1$$

- ▶ Return on government bonds (Fisher relation):

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

Fiscal authority:

- ▶ Exogenous G_t , imposes taxes $(\tau_t, T_t) > 0$ issues liquid bonds B_t^g (assumed to be a consol) s.t.

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

HANK - Stationary Equilibrium

Individual household's asset balance sheet

Share price q , PV of firm profits Π , equity s , capital k

- ▶ Illiquid asset/claims:

$$a_t = k_t + q_t s_t$$

- ▶ Portfolio dynamics:

$$\dot{k}_t + q_t \dot{s}_t = (r_t^k - \delta)k_t + \Pi_t s_t + d_t$$

where $r_t^k - \delta = r_t^a$.

- ▶ No-arbitrage: returns on equity and capital must equalize

$$\frac{\Pi_t - \dot{q}_t}{q_t} = r_t^a$$

HANK - Stationary Equilibrium

Market clearing

- ▶ Liquid asset—total household bonds equals outstanding government debt

$$\int b d\mu_t = -B_t^g$$

- ▶ Illiquid asset

$$\int a d\mu_t = K_t + q_t \cdot 1$$

Dixit-Stiglitz firms live in $[0, 1]$.

- ▶ Labor:

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

- ▶ Goods

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

Lesson 1

Monetary transmission

Decomposing initial consumption response:

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

- ▶ Direct: Intertemporal (as in RANK's total effect) + income effects (wealth no long in zero supply plus hetero wealth)
- ▶ Indirect: First two would be standard income effect. Latter two is new! Fiscal policy channel (non-Ricardian h/holds)

Decomposition by numerical simulation:

- ▶ See Table 7 under calibrated model and alternative scenarios.
- ▶ Insight: Indirect effects (w and T) $> 80\%$

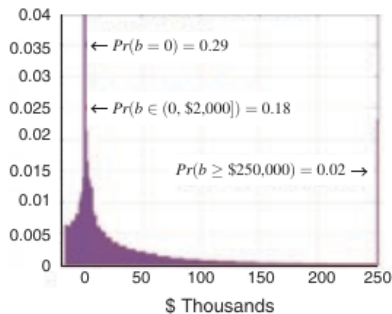
Lesson 2

Why indirect effects dominate?

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

Largely due to wealth redistribution effects

Panel A. Liquid wealth distribution



Panel B. Illiquid wealth distribution

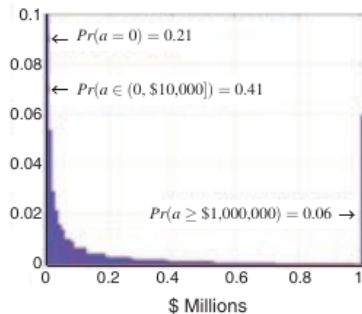


FIGURE 1. DISTRIBUTIONS OF LIQUID AND ILLIQUID WEALTH

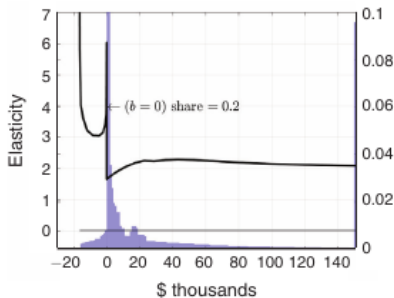
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Wealth effects — fix your stare around $b = 0$!

Panel A. Elasticity with respect to r^b



Panel B. Consumption change: indirect and direct

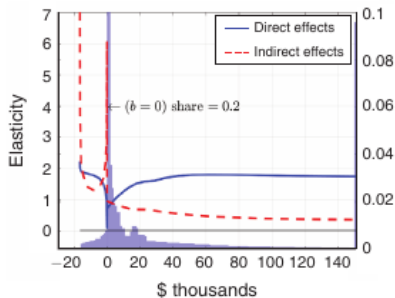


FIGURE 5. CONSUMPTION RESPONSES BY LIQUID WEALTH POSITION

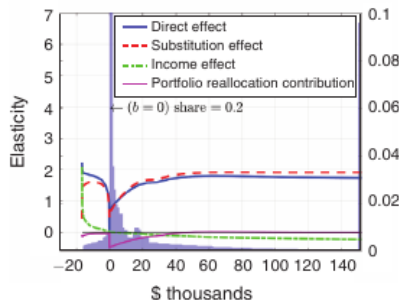
Lesson 2

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

Wealth effects (decomposed)— fix your stare around $b = 0$!

Panel A. Breakdown of direct effect



Panel B. Breakdown of indirect effect

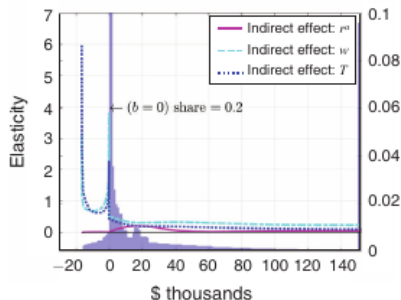


FIGURE 6. CONSUMPTION RESPONSES BY LIQUID WEALTH POSITION

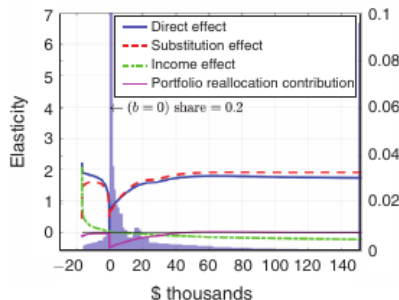
Lesson 2

Why indirect effects dominate?

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

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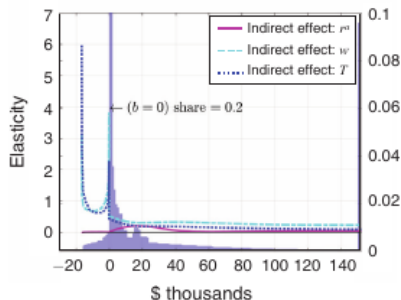
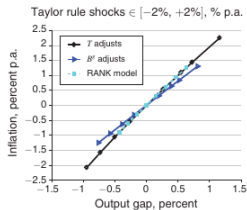


FIGURE 6. CONSUMPTION RESPONSES BY LIQUID WEALTH POSITION

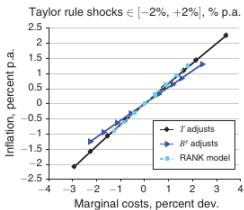
Lesson 3

Fiscal policy matters for MP conduct

Panel A. Inflation-output gap



Panel B. Inflation-marginal cost



Panel C. Marginal cost-output

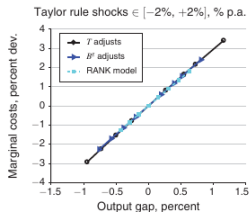


FIGURE 9. ANALYSIS OF INFLATION-ACTIVITY TRADE-OFF

Reflections

- ▶ Good example of careful model setup, clear exposition of economic mechanism and connections to micro data on consumption/MPC distribution
- ▶ Model inherits from two textbook models we are familiar with plus a more recent quantitative hack:
 - ▶ NK sticky price
 - ▶ Bewley exogenously incomplete markets
 - ▶ costly portfolio rebalancing
- ▶ Interesting twist to insight of "standard" macro-MP model: Heterogeneity, MP and FP coordination matters
 - ▶ Wealth effects matter much more than just the aggregate IS curve

Reflections

- ▶ Questions/comments
 - ▶ If identifying possible channels of MP transmission is important, why stop at black-box descriptions of financial markets: $\chi(\cdot)$, \underline{b} ?
 - ▶ Model has sticky prices but no price dispersion. What if we have both endogenously—not by assumption of menu cost $\Theta(\cdot)$?
- ▶ What if these “mechanical devices” also depend on policy? Would we get even more surprising insights? Or are they of higher (lesser) order of importance?
- ▶ What is a “standard” model? Do we remain in close orbit around what is effectively a neoclassical planet?

Stationary equilibrium as PDE

Consider a stripped down version of HANK into its Bewley-Huggett component:

$$\max_c \left\{ \begin{array}{l} \mathbb{E}_0 \int_0^\infty e^{-\rho t} u(c_t) dt : \\ \dot{a}_t = z_t + r_t a_t - c_t \\ \dot{z}_t = \mu(z_t) dt + \sigma(z_t) dW_t \\ a_t \geq \underline{a} \end{array} \right\}$$

Equilibrium must satisfy market clearing

$$\int a g_t(a, z) da dz = 0$$

(Achdou *et al*, 2014, Phil. Trans. R. Soc. A)

Stationary equilibrium as PDE

A *dynamic (stationary) equilibrium* is pair of *time-dependent* (independent) value and density functions $(a, z) \mapsto (v, g)(a, z, t)$ and a real rate r solving:

$$\partial_t v + \frac{1}{2} \sigma^2(z) \partial_{zz} v + \mu(z) \partial_z v + (z + r(t)a) \partial_a v + H(\partial_a v) - \rho v = 0 \quad (1)$$

$$\partial_t g - \frac{1}{2} \partial_{zz} [\sigma^2(z)g] + \partial_z [\mu(z)g] + \partial_a [(z + r(t)a)g] + \partial_a [\partial_p H(\partial_a v)g] = 0 \quad (2)$$

$$\int ag(a, z, t) da dz = 0 \quad (3)$$

$$\int g(a, z, t) da dz = 1, g \geq 0 \quad (4)$$

where $H(p) = \max_{c \geq 0} \{-pc + u(c)\}$ and some boundary value conditions.

1. $v \leftarrow$ Hamilton-Bellman-Jacobi equation
2. $g \leftarrow$ Fokker-Planck equation s.t. (3) and (4)

Solution

- ▶ Time-dependent solution on $(\underline{a}, \infty) \times (\underline{z}, \bar{z}) \times (0, T)$ and imposes $T \rightarrow \infty$, and $v(a, z, T) = v_\infty(a, z)$.
- ▶ In practice, solution is done using a finite-difference method (“upwind”).
- ▶ In theory, there are some sticking points:
 - ▶ Stationary equilibrium of this coupled PDE: uniqueness unknown.
 - ▶ Dynamic equilibrium of this coupled PDE: existence and uniqueness unknown.