Economics 704a Lecture 12: Heterogenous Agents and Monetary Transmission

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Spring 2024

Heterogenous Agent New Keynesian Models

- Last two lectures are on new approaches to monetary transmission.
  - In the New Keynesian model, all about intertemporal substitution by representative consumer.
  - But is this really how monetary policy works?
- Today: A crash course on Heterogenous Agent New Keynesian (HANK) models.
  - This is one of the hottest areas in macroeconomics in the last 5 years!
  - Combining HA and NK gives new results that were not in HA or NK on their own.
  - Lots of ways in which theme of HANK models is being taken – will only scratch the surface today.
- Significant chunk of my 2nd year course is on HANK!
  - Bonus lecture on course website on household balance sheets and HANK.

HANK Outline

1. The Conventional Channel
   - 1.1 Intertemporal Substitution
   - 1.2 Permanent Income Hypothesis
2. Does The Permanent Income Hypothesis Hold?
   - 2.1 Evidence
   - 2.2 Models
   - 2.3 New Evidence on Idiosyncratic Income Risk
   - 2.4 Wealth Distribution
3. Kaplan and Violante (2014): The Wealthy Hand to Mouth
4. Kaplan, Moll and Violante (2018): "Monetary Policy According to HANK"
   - 4.1 Hand-to-Mouth Consumers in a New Keynesian Model
   - 4.2 The Full HANK Model

Conventional Channel

- How does monetary policy affect the real economy in the New Keynesian model?
- Intertemporal substitution along an Euler equation:

$$C_t^{-\gamma} = \beta E_t \left\{ Q_t \frac{P_t}{P_{t+1}} C_{t+1}^{-\gamma} \right\} = \beta E_t \left\{ R_t C_{t+1}^{-\gamma} \right\}$$

  or log linearized:

$$\hat{c}_t = -\sigma \left(\hat{i}_t - E_t \left\{ \hat{\pi}_{t+1} \right\} \right) + E_t \left\{ \hat{c}_{t+1} \right\}$$

- This is fundamentally about substitution effects:
  - Real interest rate is price of consumption today vs. tomorrow.
  - As real interest rate changes, households change savings.
  - This affects aggregate demand today.
- Where is the wealth effect?

Where is the Wealth Effect?

- It's there, but it's tiny!
  - Because of the permanent income hypothesis.
    - Only changes in permanent income lead to substantial consumption responses.
  - Temporary change in interest rates does change in present value of lifetime income.
  - But small and distributed over the remainder of the agent's life, leading to a minuscule change in consumption today.
    - Key feature of PIH: Low MPC of $\frac{r}{1+r}$.
- By contrast, the change in consumption resulting from intertemporal substitution is substantial.
- Kaplan, Moll, and Violante (2018) show that in a broad class of NK models, the direct effects through intertemporal substitution account for well over 80% of C response.

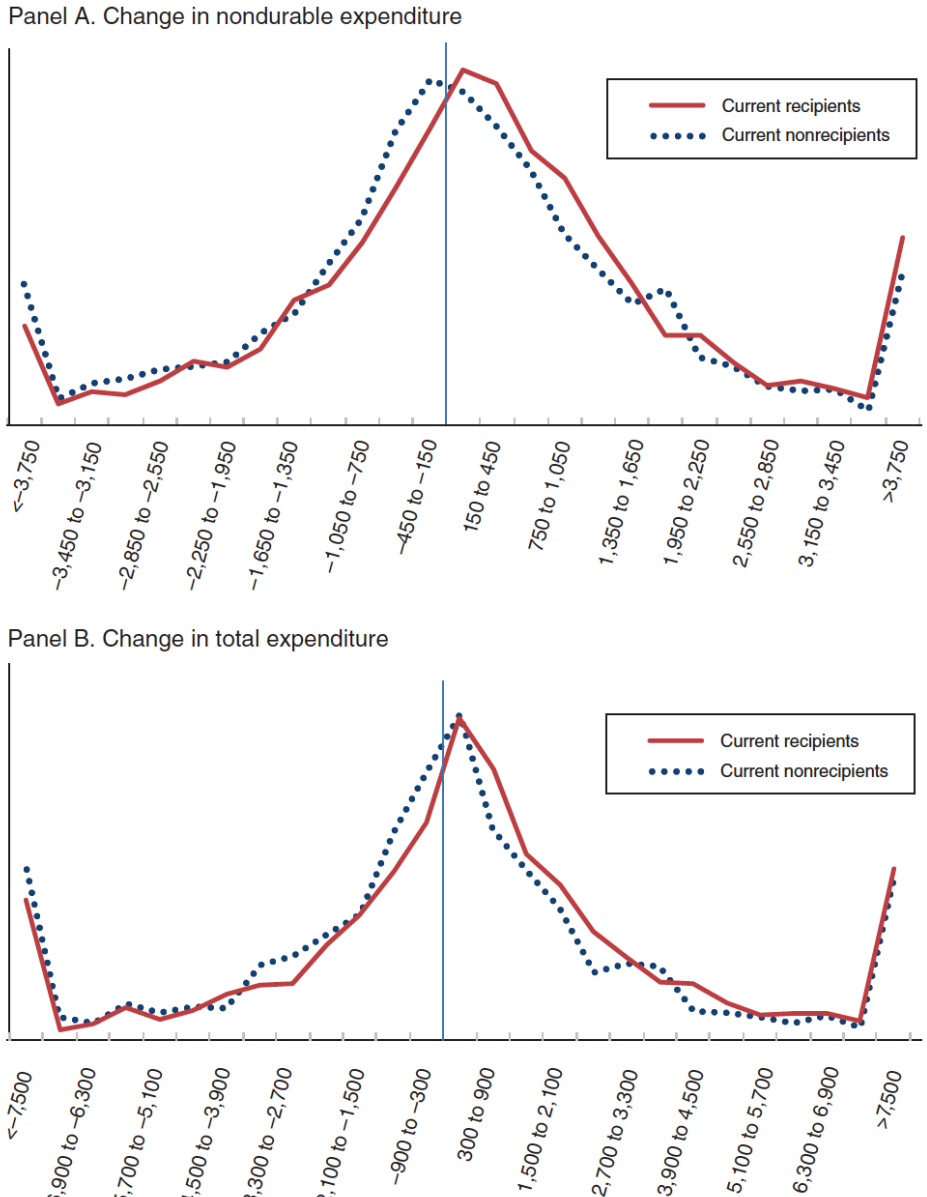
Evidence on the PIH

- Big literature testing PIH.
  - Hall (1978): With quadratic preferences, Euler implies consumption follows random walk.
    - All current info is incorporated into consumption plan, so only news changes consumption.
    - Finds supporting evidence.
  - However, subsequent Euler equation literature generally finds expected income growth has substantial effect on consumption, violating PIH (e.g., Campbell and Mankiw, 1989).
    - Also small sensitivity to interest rates.
  - Also response to permanent shocks larger than transitory, but still less than full, consistent with precautionary savings.
- Good Survey: Jappelli and Pistaferri (2010).
- Recent literature looks at marginal propensity to consume out of transitory income using quasi-experimental variation.
  - Generally but not uniformly find higher average MPCs than predicted by PIH.

Parker et al. (2006, 2013): Timing of Tax Rebates

- Parker et al. (2006, 2013) study 2001 and 2008 tax rebates, respectively.
  - 2001: \$300-600
  - 2008: \$300-600 for individuals, \$600-\$1,200 for couples plus \$300 per child.
  - Both times: Random timing of rebate based on SSN.
- Johnson et al. use quasi-experimental variation from random timing of rebate to estimate MPCs.
  - Focus on nondurables to test PIH, because durables are form of perpetual consumption.
- Findings:
  - 2001: 20-40% MPC on nondurables. Later literature with improved econometrics settles at 25%.
  - 2008: 12-30% MPC on nondurables, 50-90% overall (more durable spending than 2001).

Parker et al. (2013): Timing of Tax Rebates



Parker et al. (2006, 2013): Timing of Tax Rebates

ESTIMATES OF THE 2001 REBATE COEFFICIENT ($\hat{\beta}_2$)[a]

	Nondurables
JPS 2006, 2SLS ($N = 13{,}066$)	0.375 (0.136)
Trim top & bottom 0.5%, 2SLS ($N = 12{,}935$)	0.237 (0.093)
Trim top & bottom 1.5%, 2SLS ($N = 12{,}679$)	0.219 (0.079)
MS 2011, IVQR ($N = 13{,}066$)	0.244 (0.057)

Source: Kaplan and Violante (2014)

Hsieh (2003): Alaska Permanent Fund

- Hsieh studies large and anticipated payouts of oil revenues in Alaska Permanent Fund.
  - Varies from $300 to $2,000 per person.
  - Highly publicized, always in October.
  - Uses variation in size of payout over time and by family size.
- Finds no consumption response to APF payments.

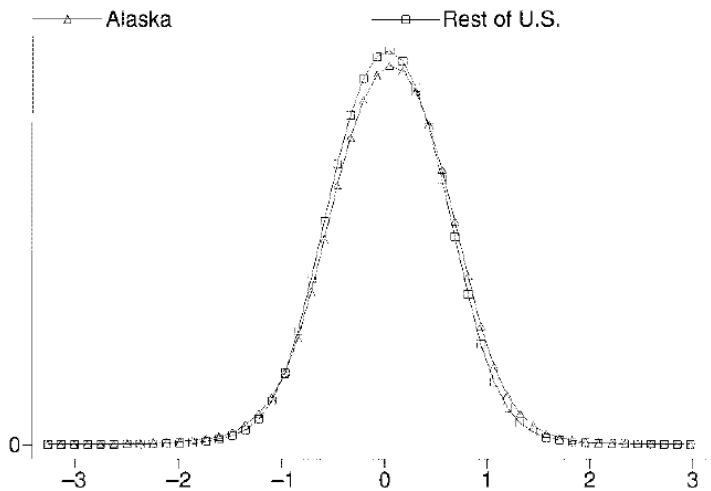


FIGURE 2. DISTRIBUTION OF LOG(CONSUMPTION $q4$/CONSUMPTION $q3$)

- But Kueng (2018) shows using better data and overcoming measurement error gives 25% MPC.

Hsieh (2003): Alaska Permanent Fund

- But same households show excess sensitivity to tax rebates.
  - Suggests size, nature of payment matters.

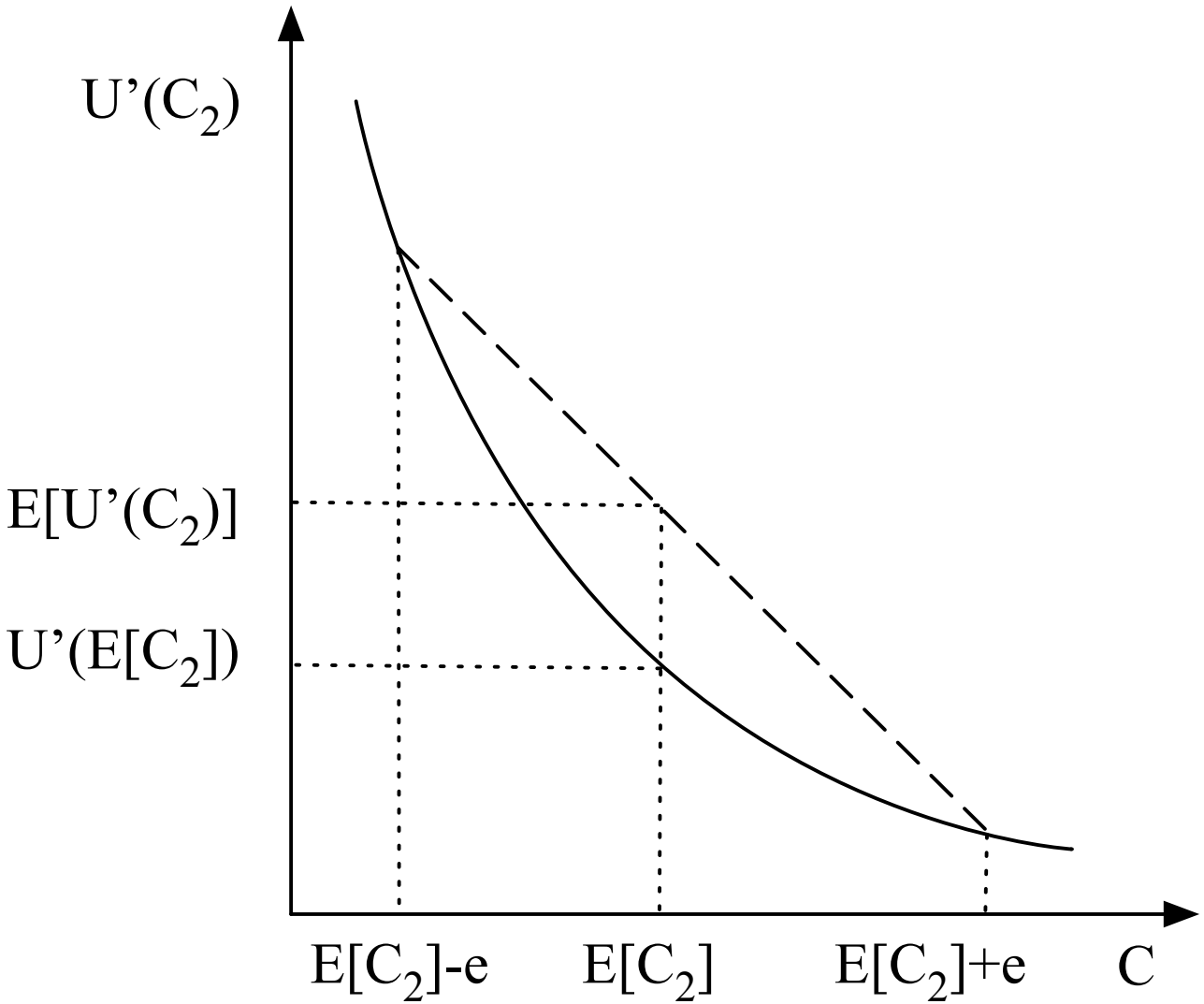
	dlog(*Nondurable consumption*)	
	$\log(C_{II}/C_{I})$	$\log(C_{IV}/C_{III})$
$\frac{PFD_t \times Family\ Size_h}{Family\ Income_h}$	—	0.0032
		(0.0562)
$\frac{Income\ tax\ refund_h}{Family\ Income_h}$	0.2831	—
	(0.1140)	
Number of observations	369	369

Precautionary Savings and Liquidity Constraints

- What explains high MPC?
- Two ingredients added to PIH model:

1. Precautionary Savings:
   - Increased weight on bad future states with high MU leads to precautionary savings.
   - $U''' > 0$ so Jensen implies $E\{U'(C)\} > U'(E\{C\})$. To offset, rise in RHS of Euler, savings must rise.
2. Liquidity Constraints
   - If on constraint, hand to mouth consumer.
   - Constraint binds and Euler does not.

Precautionary Savings Intuition

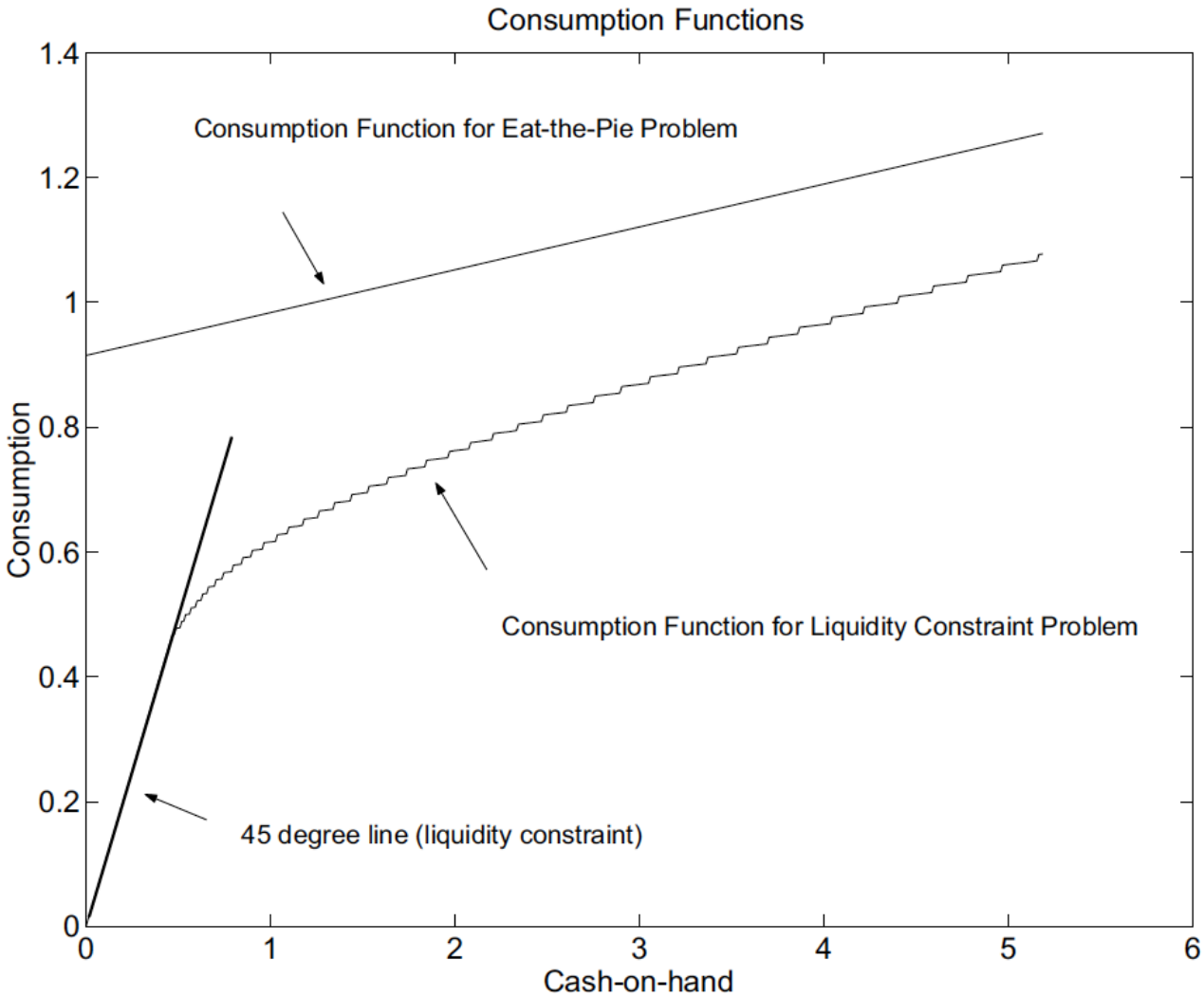


Buffer Stock Model

1. Liquidity constraint and uncertainty.
2. Consumers are impatient: $\rho > r$.

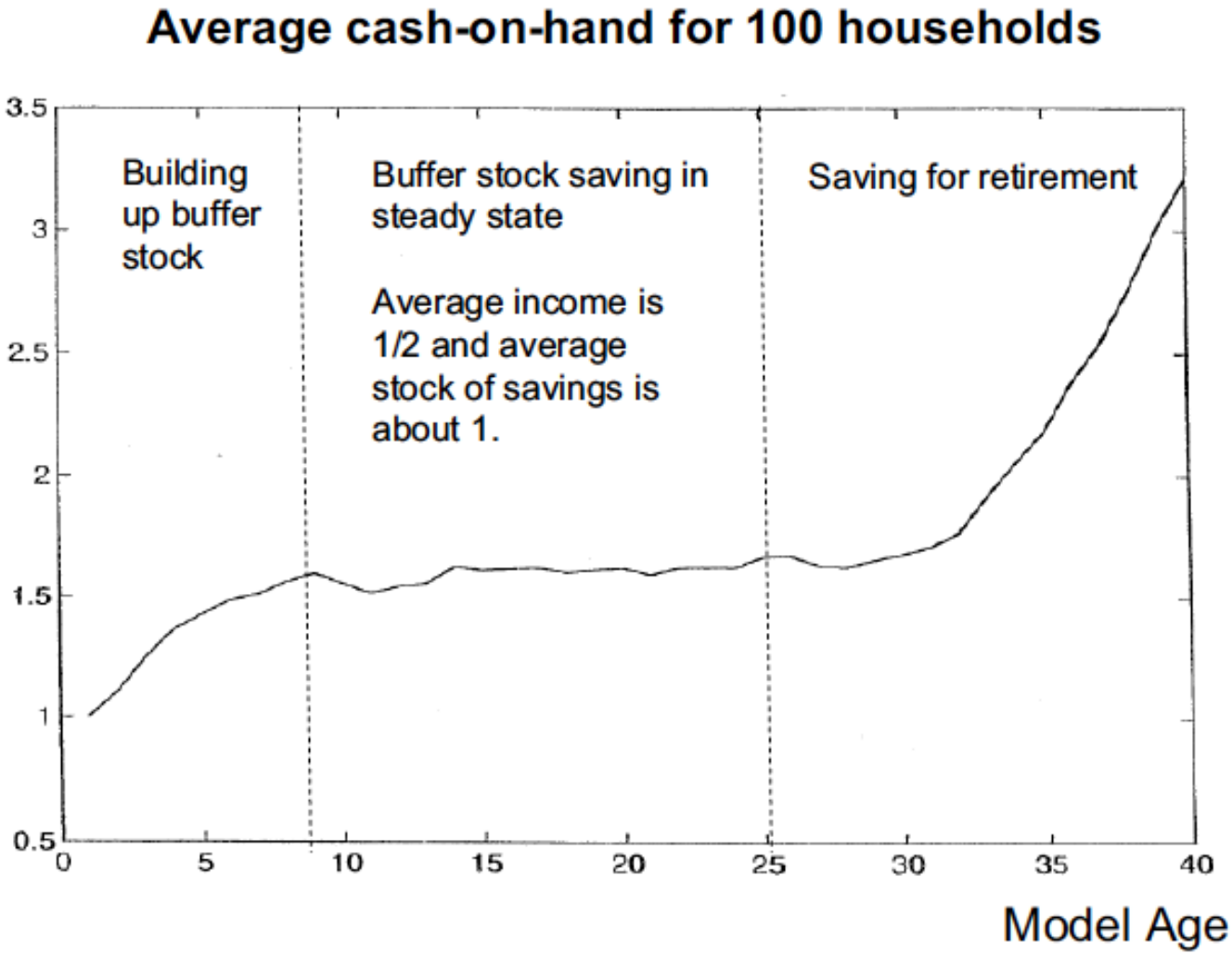
- Implies consumers are worried about large shocks that cause them to hit liquidity constraint in the future.
  - Liquidity constraint convexities marginal utility further, as MU very high with bad shocks.
- Predictions
  - Households accumulate stock of assets to buffer transitory income shocks.
  - At low asset levels, look hand to mouth because strong precautionary motives to build buffer stock.
  - At high asset levels, look permanent income because have buffer stock, so precautionary motives fade.

Buffer Stock Consumption Function



Source: David Laibson Lecture Notes

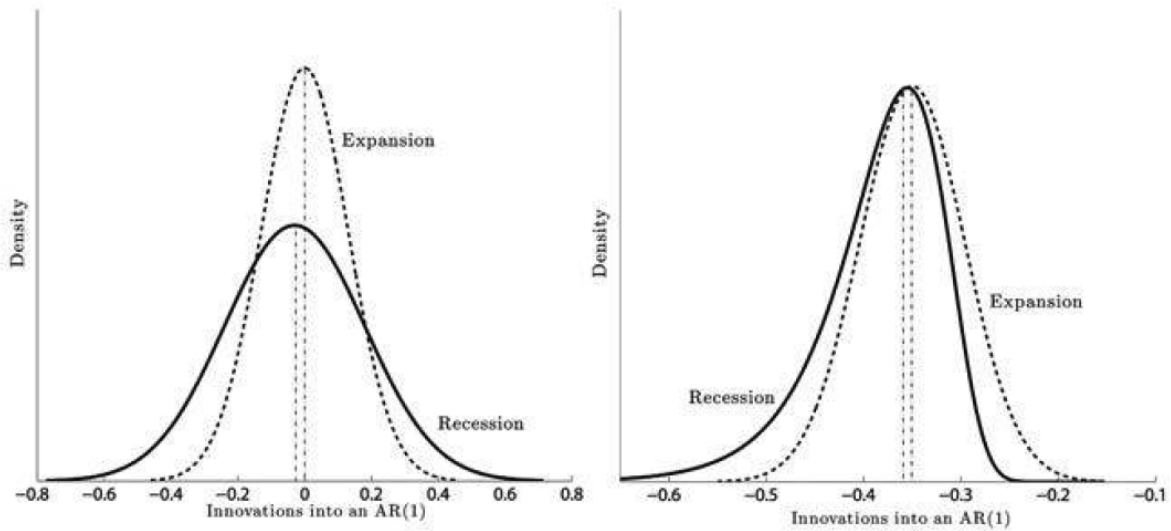
Buffer Stock Assets Over Lifecycle



Source: David Laibson Lecture Notes

New Evidence on Idiosyncratic Income Risk

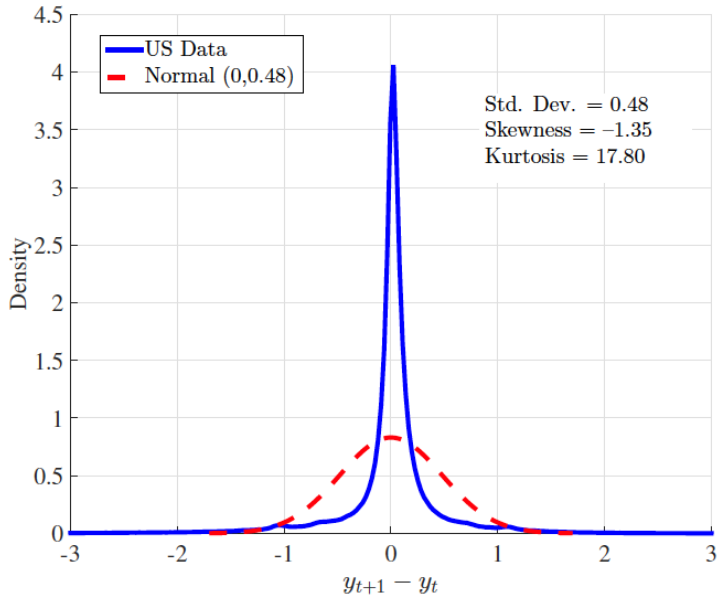
- Guvenen et al. (2014, 2021) use massive administrative dataset from Social Security Administration to provide new facts about idiosyncratic income risk.
  - Facts strengthen precautionary motives.
- Fact 1: Idiosyncratic shock variance is is not countercyclical (left). Instead, countercyclical left skewness (right):



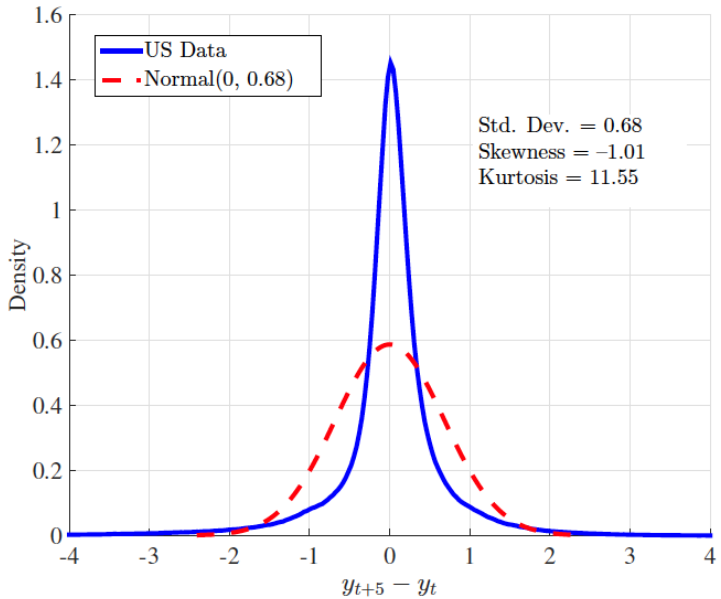
New Evidence on Idiosyncratic Income Risk

- Fact 2: Idiosyncratic shocks have high kurtosis.
  - In a given year, most experience small shocks, but small number experience large shocks.

One-year change



Five-year change



- Fact 3: For high income, positive shocks are transitory while negative shocks are persistent. Opposite true for low income.

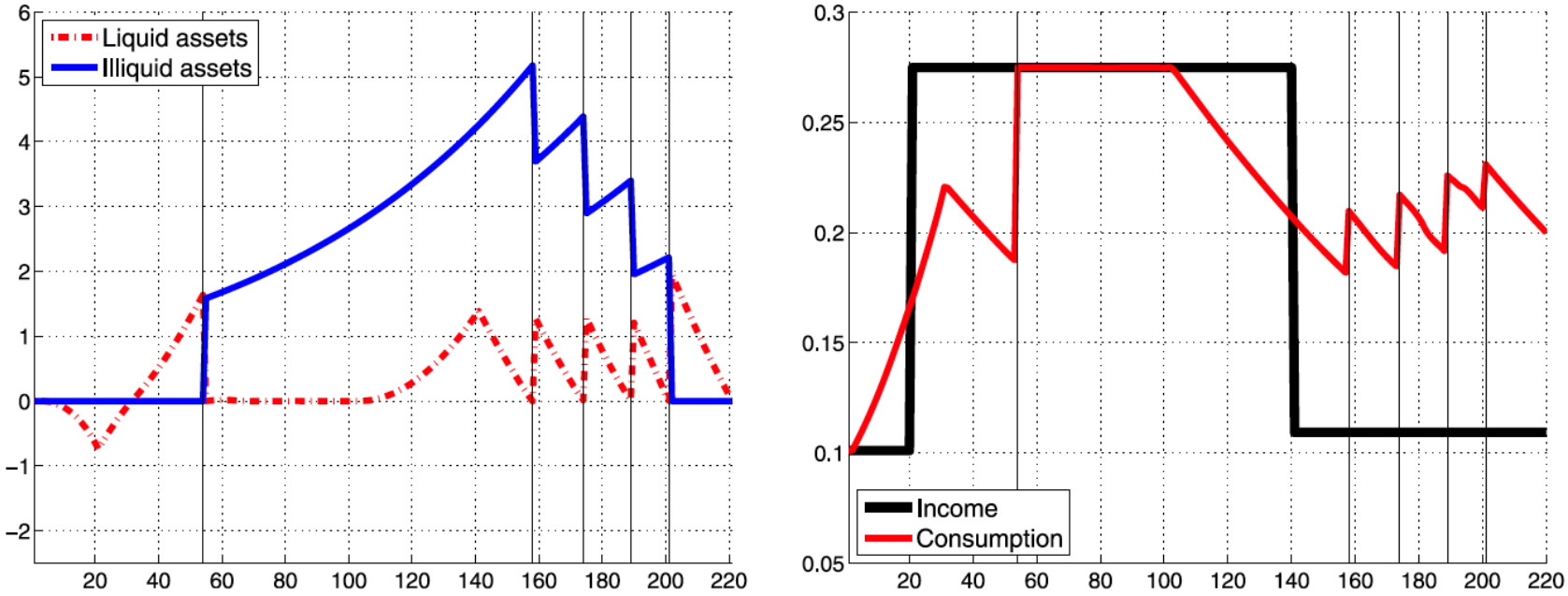
Wealth Distribution and Hand to Mouth Consumers

- Calibrated buffer stock models do not generate a large fraction of hand-to-mouth consumers.
  - About 10% based on data on asset holdings.
  - Perhaps a bit higher with income processes based on Guvenen et al.'s facts.
  - Aggregate MPC below Johnson et al. (2006, 2013).
- Intuition:
  - Accumulate buffer stock fairly quickly.
  - Implies young and people who have recently had shock should be had to mouth, but few others.
  - Most people are far too wealthy to be on portion of buffer stock consumption function that is hand to mouth.

Kaplan and Violante (2014): Wealthy Hand to Mouth

- Kaplan and Violante (2014) introduce life cycle savings model that can explain Johnson et al. (2006, 2013) facts.
- Idea: Two types of assets
  - Liquid asset with low return.
  - Illiquid asset with high return, fixed cost to adjust.
    - Represents housing and retirement savings.
- Generates Large Number of "Wealthy Hand to Mouth" Agents.
  - Few liquid assets even though large amount of illiquid assets.
  - When hit with small income shock, appear hand to mouth
    - To smooth shock need to pay transaction cost or hold large liquid buffer stock and forgo high return.
    - Better off consuming additional income at slight utility loss than smoothing shock.
- In Survey of Consumer Finances, 10% poor hand-to-mouth and 7-26% wealthy hand to mouth.
  - Depends on how define illiquid assets.

Kaplan and Violante (2014): Wealthy Hand to Mouth



(a) Life-cycle asset accumulation

(b) Life-cycle income and consumption path

FIGURE 2.—Example of life-cycle of a wealthy hand-to-mouth agent in the model.

- Large shock ⇒ tap illiquid asset ⇒ smooth consumption.
- Small shock ⇒ do not tap illiquid asset ⇒ hand to mouth.
- Potential explanation for Hsieh (2003)?

Monetary Policy According to HANK

- Heterogeneous agent New Keynesian model with two key new ingredients.
  1. Two assets: Low-return liquid and high-return illiquid.
     - Convex costs with additional fixed cost of nonzero change.
  2. High kurtosis of idiosyncratic income shocks as in Guvenen et al. (2021) makes precautionary motives stronger, increases number of hand to mouth and savings incentives for wealthy.
- Also has capital, but not crucial for intuition.
- Solve impulse response to one-time deterministic shock using continuous time heterogenous agents methods.
  - Beyond scope of this lecture.
  - Two infinite-dimensional state variables!

Monetary Policy According to HANK

- Direct effects through intertemporal substitution are small, indirect effects through wealth are large.
  - Back to the future: High MPC similar to "Old" Keynesians.
- Consequences:
  1. Monetary policy works through Central Bank's ability to move labor demand and put money in household pockets.
     - Anything that weakens pass-through to household labor income limits monetary transmission.
     - Works through fiscal redistribution, labor demand created by investment boom, and amplified direct effects.
  2. Because of failure of Ricardian equivalence, potency of monetary policy intertwined with fiscal response.
     - Monetary policy relaxes government budget constraint.
     - Timing and distribution of government distributional response is crucial (assume lump-sum rebated immediately in baseline).
  3. Strength depends on household asset distributions and precisely who gets income generated by shifts in labor demand.

Hand to Mouth Consumers in a New Keynesian Model

- Can see intuition clearly in vanilla NK model with fraction of rule of thumb households.
  - Simplified version of Gali, Lopez-Salido, and Valles (2007) with monetary shocks.
  - What Kaplan, Moll, and Violante (2018) call a "TANK" or "spender-saver" model.
- Production side is identical to standard NK model:

$$\hat{\pi}_t = \kappa \hat{y}_t + \beta E_t \left\{ \hat{\pi}_{t+1} \right\}$$

  - For simplicity, no A_t shocks so $Y_t = N_t$.
- Two types of households:
  - λ are rule of thumb (superscript r).
  - $1 - \lambda$ are optimizing (superscript o).
    - For simplicity, own all firm, get all Seignorage revenues.
  - For simplicity ignore money.

Spender-Saver NK: Optimizing Households

$$\max_{C_t^o, N_t^o, B_t^o, M_t^o} E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left(\frac{\left(C_{t+s}^o\right)^{1-\gamma}}{1-\gamma} - \chi \frac{\left(N_{t+s}^o\right)^{1+\varphi}}{1+\varphi} \right) \right\}$$

$$\text{s.t. } C_t^o = \frac{W_t}{P_t} N_t^o - \frac{B_t^o - Q_{t-1} B_{t-1}^o}{P_t} + TR_t^o + PR_t^o - T_t^o$$

- FOCs:

$$\begin{aligned} \frac{W_t}{P_t} &= \chi \left(N_t^o\right)^{\varphi} \left(C_t^o\right)^{\gamma} \\ 1 &= \beta E_t \left\{ Q_t \frac{P_t}{P_{t+1}} \frac{\left(C_{t+1}^o\right)^{-\gamma}}{\left(C_t^o\right)^{-\gamma}} \right\} = E_t \left\{ \Lambda_{t,t+1} R_{t+1} \right\} \end{aligned}$$

Spender-Saver NK: Rule of Thumb Households

$$\max_{N_t} E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left(\frac{\left(C_{t+s}^r\right)^{1-\gamma}}{1-\gamma} - \chi \frac{\left(N_{t+s}^r\right)^{1+\varphi}}{1+\varphi} \right) \right\}$$

$$\text{s.t. } P_t C_t^r = W_t N_t^r - P_t T_t^r$$

- FOC:

$$\frac{W_t}{P_t} = \chi \left(N_t^o\right)^{\varphi} \left(C_t^r\right)^{\gamma}$$

- Consumption:

$$C_t^r = \frac{W_t}{P_t} N_t^r - T_t^r$$

Spender-Saver NK: Household Aggregation

- Household aggregation:

$$\begin{aligned} C_t &= \lambda C_t^r + (1-\lambda) C_t^o \\ N_t &= \lambda N_t^r + (1-\lambda) N_t^o \end{aligned}$$

- To simplify aggregation, assume that in steady state $C^r = C^o = C \Rightarrow N^r = N^o = N$.
  Can obtain using T^r and T^o.
- Log-linearized consumption equations:

$$\begin{aligned} \hat{c}_t^o &= -\sigma \left(\hat{i}_t - E_t \left\{ \hat{\pi}_{t+1} \right\} \right) + E_t \left\{ \hat{c}_{t+1}^o \right\} \\ \hat{c}_t^r &= \frac{WN}{PC} \left(\hat{w}_t - \hat{p}_t + \hat{n}_t^r \right) - \frac{Y}{C} \hat{t}_t^r \end{aligned}$$

Spender-Saver NK: Dynamic IS Curve

- Lots of algebra (see course website) gives:

$$c_t = E_t\{c_{t+1}\} - \tilde{\sigma}\left(\hat{i}_t - E_t\{\hat{\pi}_{t+1}\}\right) - \Theta_n E_t\{\Delta\hat{n}_{t+1}\} + \Theta_\tau E_t\left\{\Delta\hat{t}^r_{t+1}\right\}$$

where $\gamma_c = C/Y$, $t_t = \frac{T_t - T}{Y}$, $\Delta\hat{n}_{t+1} = E_t\{n_{t+1}\} - n_t$, $\Delta\hat{t}^r_{t+1} = E_t\left\{t^r_{t+1}\right\} - t^r_t$ and:

No GHH (Wealth Effect)	GHH (No Wealth Effect)
$\tilde{\sigma} = \sigma(1-\lambda)\Gamma(\mu\varphi\gamma_c + \gamma)$	$\tilde{\sigma} = \sigma(1-\lambda)$
$\Theta_n = \lambda\Gamma\varphi(1+\varphi)$	$\Theta_n = \lambda\Gamma\varphi(1+\varphi)$
$\Theta_\tau = \lambda\mu\varphi\Gamma$	$\Theta_\tau = \lambda\mu\varphi\Gamma$
$\Gamma = (\mu\varphi\gamma_c + \gamma - \lambda\gamma(1+\varphi))^{-1}$	$\Gamma = (\mu\varphi\gamma_c)^{-1}$

Spender-Saver NK: Dynamic IS Curve

$$c_t = E_t\{c_{t+1}\} - \tilde{\sigma}\left(\hat{i}_t - E_t\{\hat{\pi}_{t+1}\}\right) - \Theta_n E_t\{\Delta\hat{n}_t\} + \Theta_\tau E_t\left\{\Delta\hat{t}_t^{\,r}\right\}$$

- New direct channels:
  1. Consumption is increasing in $\hat{n}_t$ ($\downarrow$ in $\Delta\hat{n}_{t+1}$).
     - Increase in employment creates positive wealth effect for spenders as hours and wages rise.
  2. Consumption is decreasing in $\hat{t}_t^r$ ($\uparrow$ in $\Delta\hat{t}_{t+1}^r$).
     - Increase in T creates negative wealth effect for spenders.
     - Timing and distribution of fiscal response is crucial.
- Intertemporal substitution channel weakened:
  1. $1-\lambda$ of optimizers.
  2. But wealth effects strengthen this and weaken income effects.

Spender-Saver NK: Fiscal Policy

- Government Budget Constraint:

$$P_t T_t + B_t = Q_{t-1} B_{t-1} + P_t G_t$$

  where $T_t = \lambda T_t^r + (1-\lambda) T_t^o$.

- Assume government keeps debt the same and spending the same and lump-sum tax adjusts to maintain budget constraint.
  - Rebate is equal across population, so $\hat{t}_t = \hat{t}_t^o = \hat{t}_t^r$.
- Letting $\gamma_b = \frac{B}{PG+B}$,

$$\hat{t}_t = \frac{\gamma_b}{1-\gamma_b} \hat{i}_t$$

  - Decline in i_t relaxes gov't BC as cost of borrowing falls, reducing taxes.
  - Results in increased transfers to consumers given assumptions.
  - Monetary policy weaker if instead B_{t+1} rises.

Spender-Saver NK: Fiscal Policy

- Monetary policy follows Taylor Rule:

$$i_t = \rho + \phi_\pi \pi_t + v_t$$

where $v_t = \rho_v v_{t-1} + \varepsilon_t$.

- Market clearing:

$$\begin{aligned} Y_t &= C_t + G_t \\ \hat{y}_t &= \gamma_c \hat{c}_t \end{aligned}$$

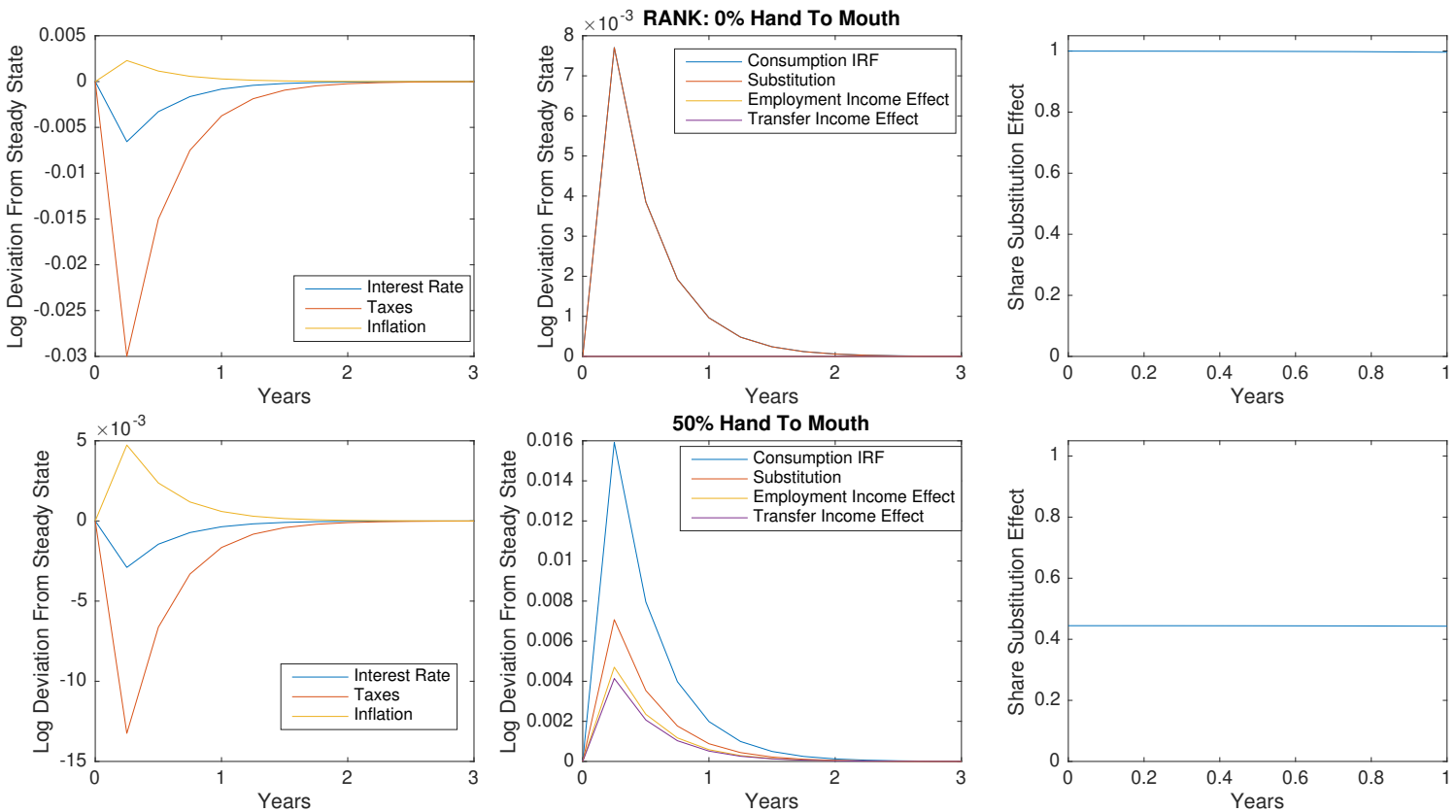
Spender-Saver NK: Equilibrium System

$$
\begin{aligned}
\hat{c}_t &= E_t\left\{\hat{c}_{t+1}\right\} - \tilde{\sigma}\left(\hat{i}_t - E_t\left\{\hat{\pi}_{t+1}\right\}\right) \\
&\quad -\Theta_n E_t\left\{n_{t+1} - n_t\right\} + \Theta_\tau E_t\left\{\hat{t}_{t+1} - \hat{t}_t\right\} \\
\hat{\pi}_t &= \kappa \hat{y}_t + \beta E_t\left\{\hat{\pi}_{t+1}\right\} \\
\hat{y}_t &= \hat{n}_t \\
\hat{y}_t &= \gamma_c \hat{c}_t \\
\hat{t}_t &= \frac{\gamma_b}{1-\gamma_b}\hat{i}_t \\
\hat{i}_t &= \phi_\pi \hat{\pi}_t + \hat{v}_t \\
\hat{v}_t &= \rho_v \hat{v}_{t-1} + \varepsilon_t
\end{aligned}
$$

- Will consider GHH and non-GHH as well as $\lambda = .5$ and $\lambda = 0$, both of which alter $\tilde{\sigma}$, Θ_n, and Θ_τ.

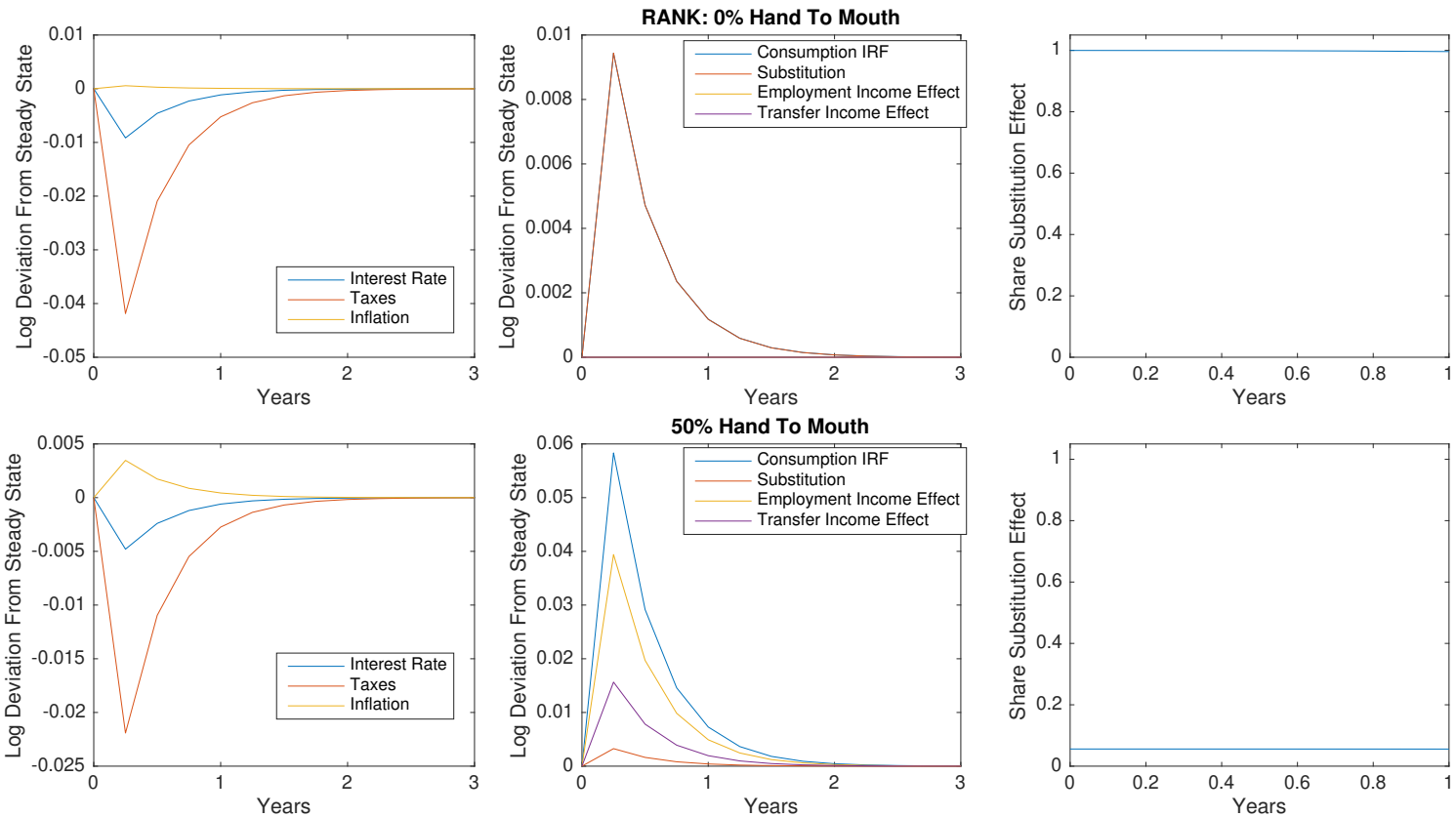
Spender-Saver NK IRFs: With Wealth Effects

- Overall effect of monetary policy twice as strong due to Keynesian multiplier with MPC=1 consumers.



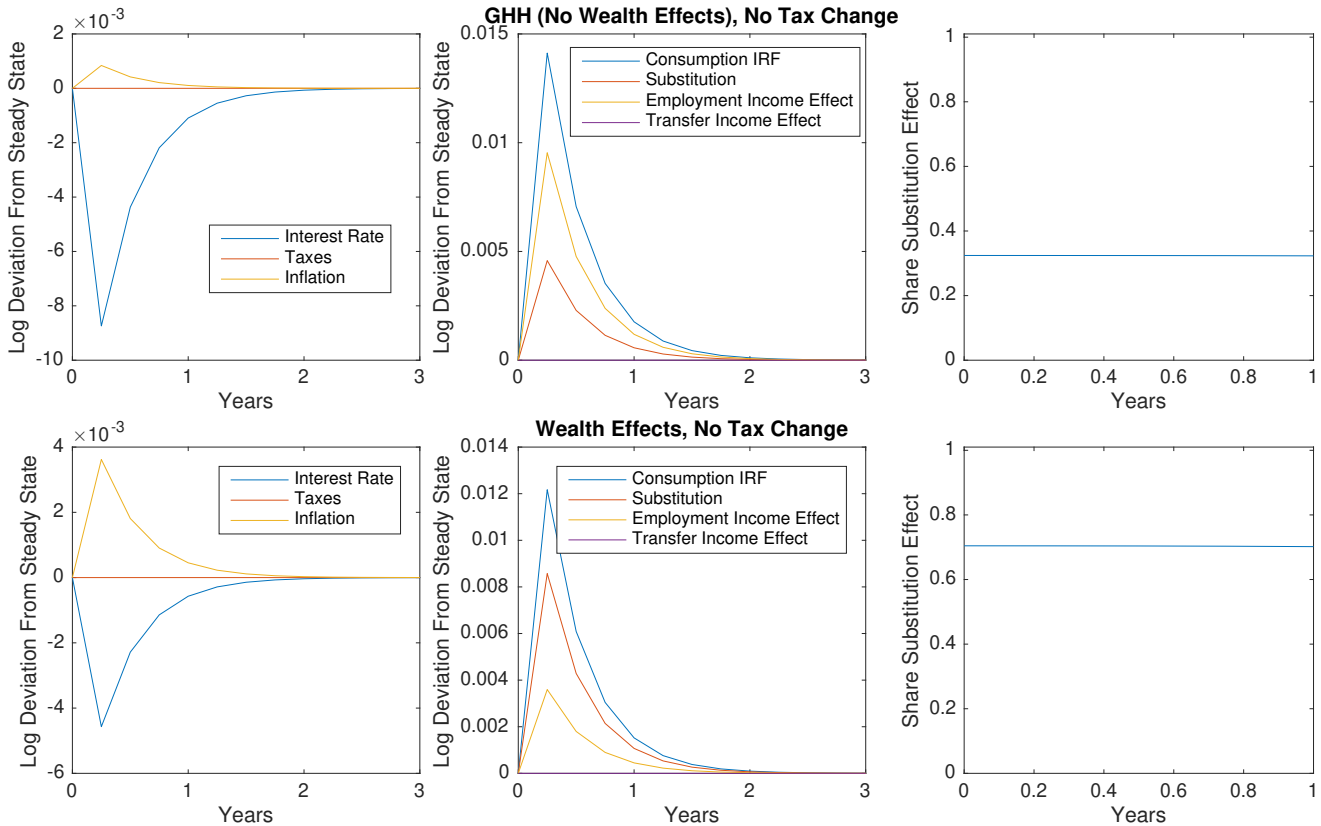
Spender-Saver NK IRFs: No Wealth Effects (GHH Prefs)

- Without wealth effects reducing labor supply as get richer, monetary policy *6x* as strong.
- Spender-Saver: 95% through "GE" income effects.



Spender-Saver NK IRFs: No Tax Change (B Adjusts)

- Without fiscal rebates generating Keynesian multipliers, much weaker.
- Very sensitive model with MPC=1 consumers.

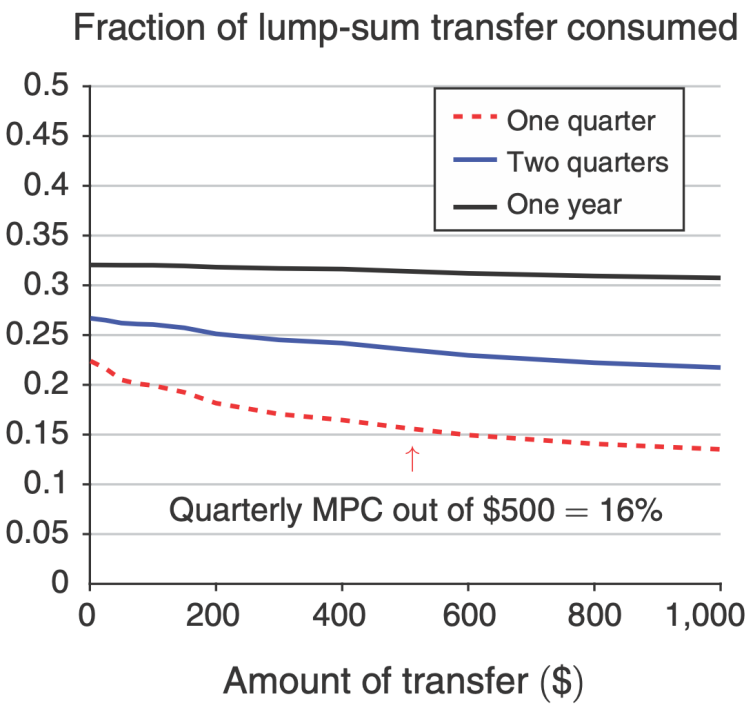


Monetary Policy According to HANK

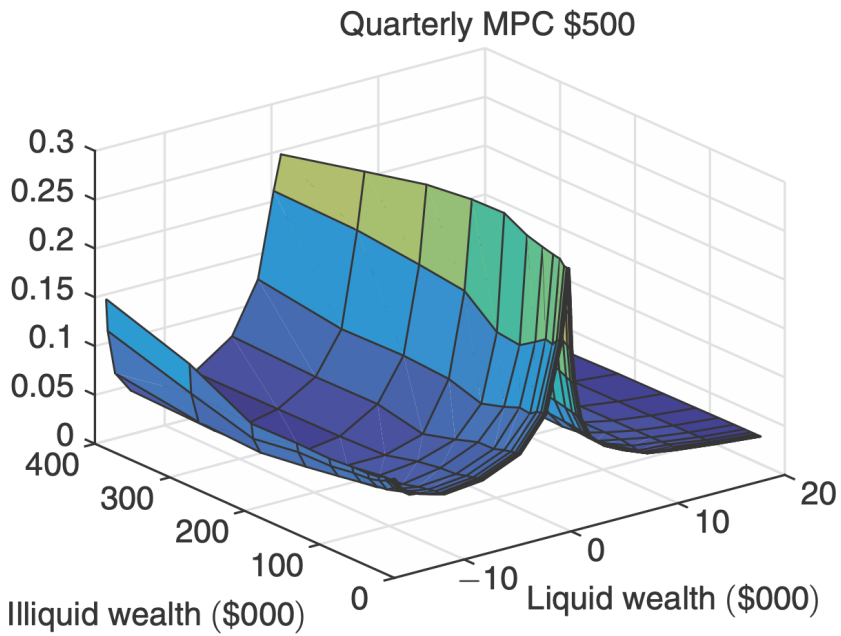
- Now to full Kaplan et al. (2018) calibrated model.
- Benefits mainly quantitative:
  Our paper adds an empirically realistic model of the consumption side of the economy by exploiting state-of-the art ideas for modeling household consumption and the joint distribution of income and wealth.
- Diff from TANK: "In our model even high liquid wealth households do not increase consumption much in response to an interest rate cut because the risk of receiving negative income shocks and binding liquidity constraints in the future truncates their effective time horizon."
  - Direct effects weakened.
  - Also they find TANK weaker, but that is because they calibrate to 30% spenders (consistent with micro data) rather than 50% (consistent with macro).

MPC Heterogeneity in HANK

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



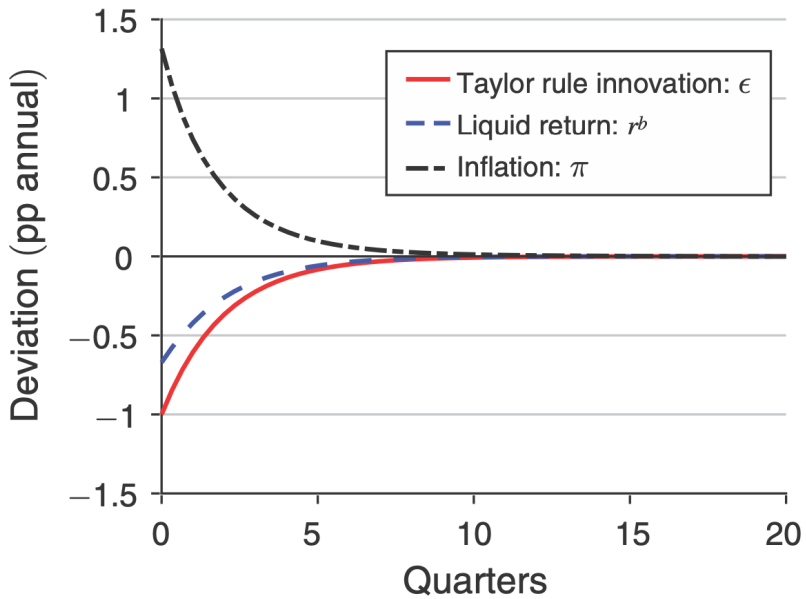
Panel B. $MPC_{1}^{\$500}(a,b,z)$



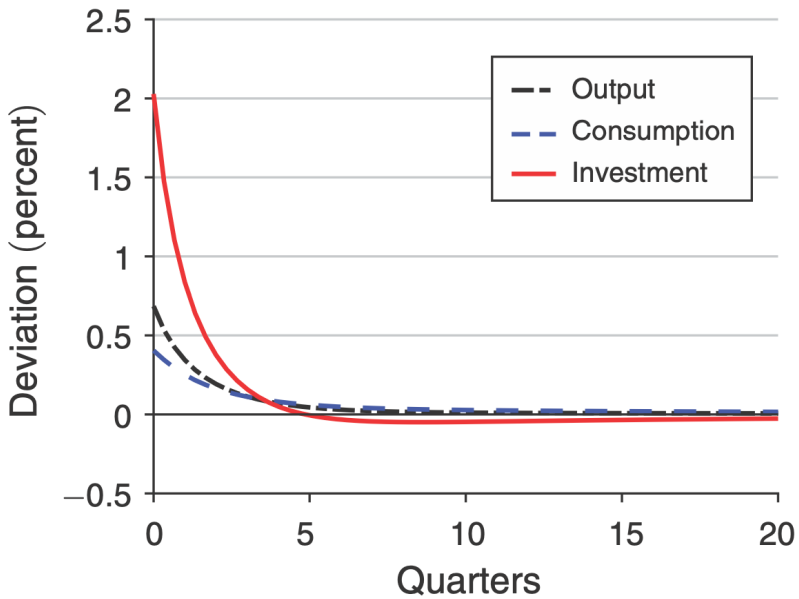
HANK: Impulse Response to Monetary Shock

- Impulse response to decline in interest rates.
  - Lump sum transfers adjust to keep budget balanced in baseline.
  - Slightly stronger transmission than RANK in this case.

Panel A. Monetary shock, interest rate, inflation

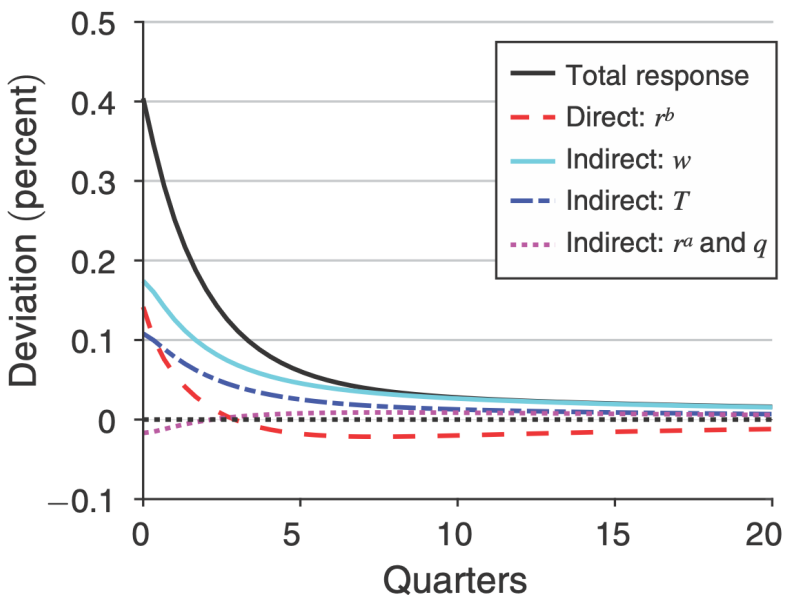


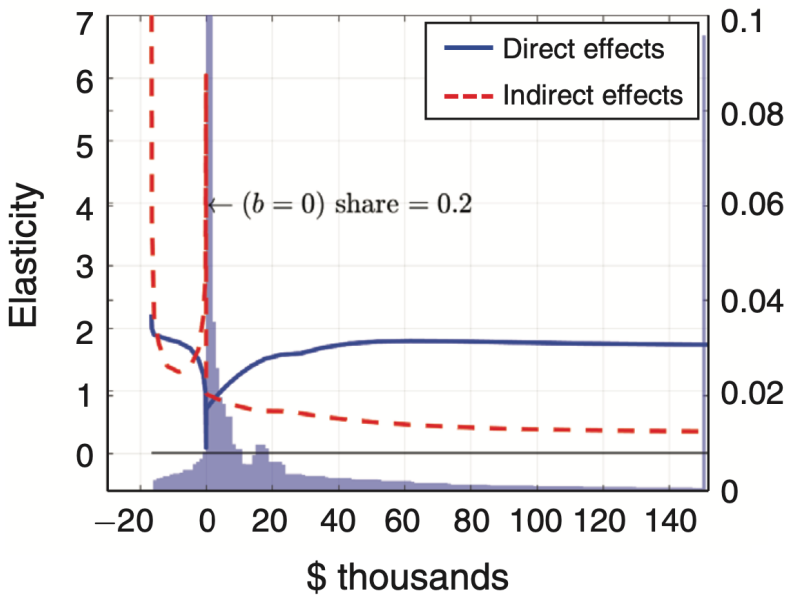
Panel B. Aggregate quantities



HANK: Decomposition of Mon Policy

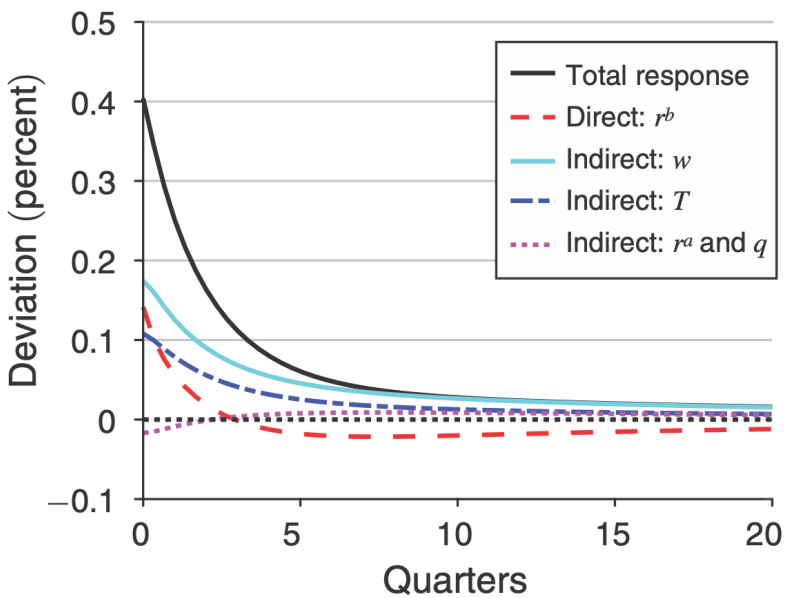
- Direct effects $\approx$ 20% of overall response. $\approx$ 80% indirect.
  - Even stronger with GHH, as in our spender-saver example.

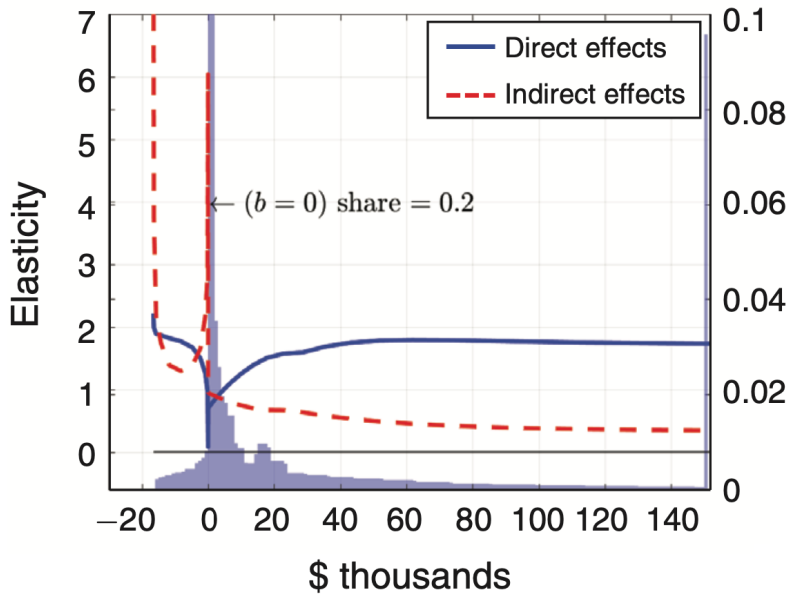




HANK: Decomposition of Mon Policy

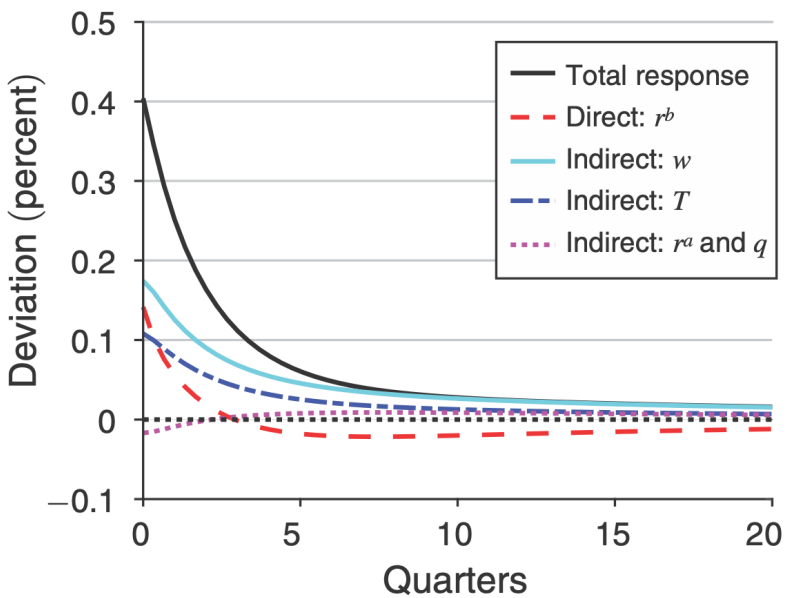
- Why is direct effect weak?
  - Many households with low liquid assets not on Euler.
  - Even for richer households, potential for binding constraint in future pulls off Euler.

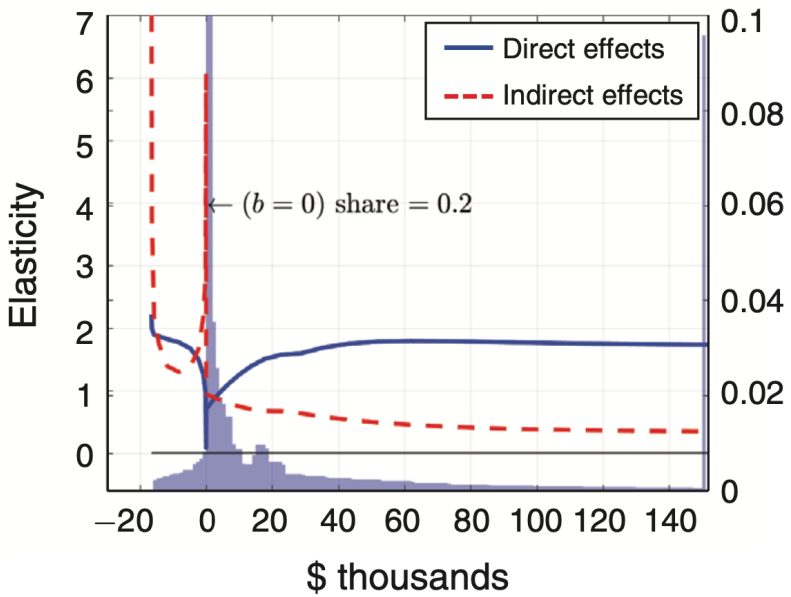




HANK: Decomposition of Mon Policy

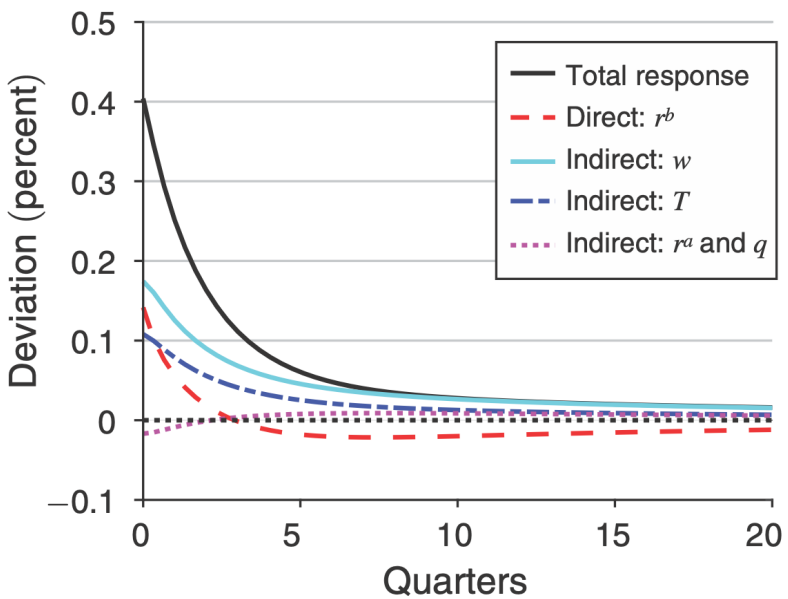
- What about indirect effects? There are three:
  - Portfolio rebalancing weak

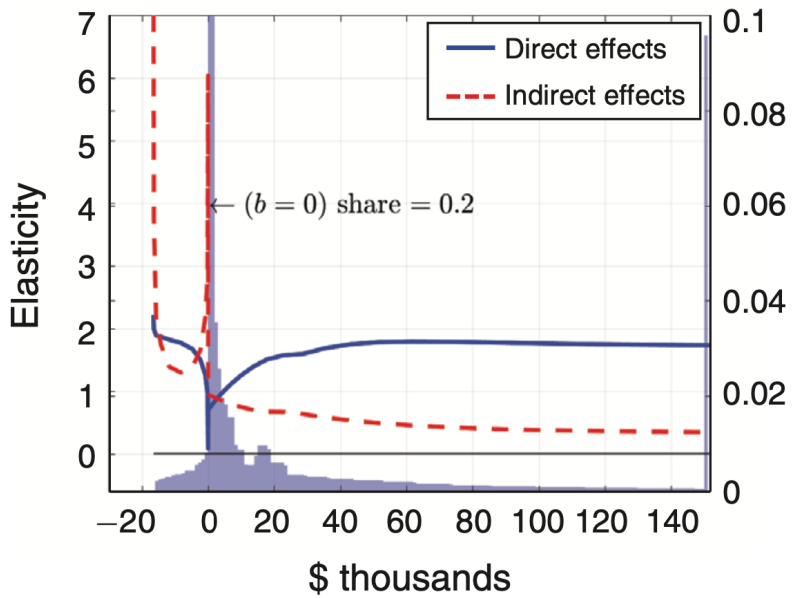




HANK: Decomposition of Mon Policy

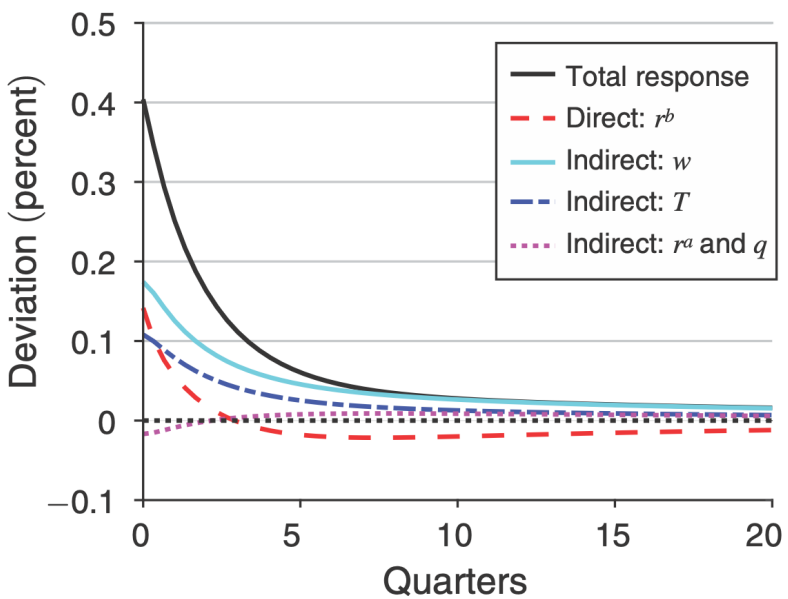
- Increase in income through labor demand which increases wages is largest component of impulse response.
  - Direct elasticity similar to spender-saver.

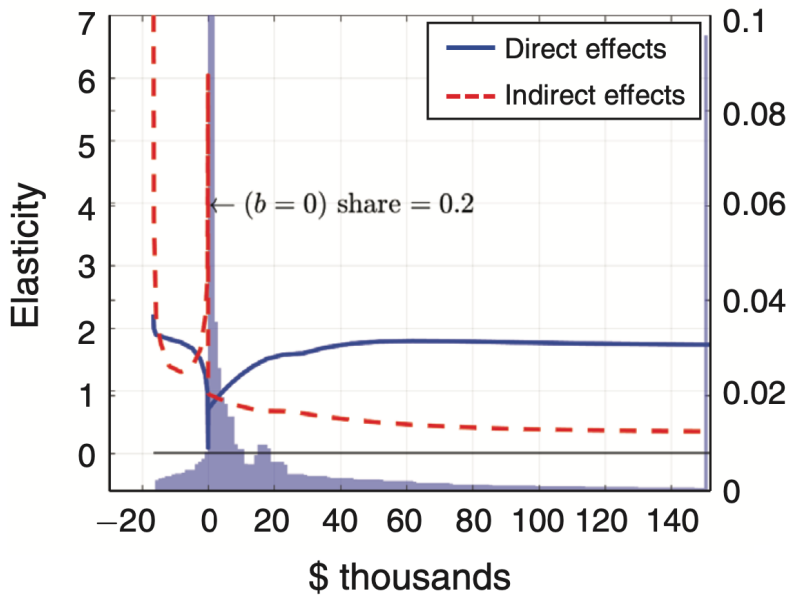




HANK: Decomposition of Mon Policy

- Wealth effect through relaxed government budget constraint increasing transfers plays important role.
  - Highlights interaction with fiscal policy.





HANK: Interaction with Fiscal Policy

- Transmission of monetary policy is similar of T or G adjusts, but weaker if government debt / budget deficit adjusts because pass-through to labor demand or transfers is weakened.

TABLE 8—IMPORTANCE OF FISCAL RESPONSE TO MONETARY SHOCK

	T adjusts (1)	G adjusts (2)	τ adjusts (3)	B^g adjusts (4)
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

- Strength relies on short-term bonds, less potent with long-term debt (Aculert et al, 2021).

Implications for Optimal Policy

1. Policy instrument is less direct and relies more on equilibrium feedbacks.
   - More for for CB to think about. Investment, labor markets, financial markets, etc.
2. Transitory vs. Persistent Rate Cuts:
   - In RANK, transitory and large and persistent but small rate cuts have same effect.
   - In HANK a transitory but large cut can be more effective: larger reduction in interest payments $\Rightarrow$ more fiscal stimulus.
3. Inflation-Output Tradeoff Depends on Fiscal Response:
   - Phillips curve pinned down by NK side in RANK and HANK, which are the same, so similar slope.
   - Fiscal response matters for slope. More passive fiscal response $\Rightarrow$ less non-neutrality $\Rightarrow$ more favorable CB trade-off.

HANK and Monetary Transmission: Take Aways

- New way of thinking about monetary policy.
  - Somewhat "Old Keynesian": Spending response by high MPC individuals matters due to Keynesian multiplier.
    - Reminiscent of "Keynesian Cross."
  - More caveats in monetary policy since depends on GE effects.
    - Interaction with fiscal and asset distribution.
    - Potential for monetary transmission to be time-varying in interesting ways.
    - Lots of open space in this literature. Potentially very exciting.
  - Bigger role for fiscal policy?
- Huge literature has developed around this; today only scratching surface with one seminal paper.
- Next class: More on heterogeneity, this time focusing on household finance and housing.