Monetary Policy and Heterogeneity: An Analytical Framework

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Motivation

- 2008 **Great Expansion**—*stabilization* policies (mon&fisc)
  - + inequality-redistribution (i.a. Bernanke, Yellen, Draghi)
- Micro data in macro + solving HA models
  - Krusell Smith, Den Haan, Reiter; Mean-Field Games (Lasry Lions), **Many** others
- *Overwhelming* evidence:
  - aggregate Euler eqn?: Hall 88 Cambell Mankiw to Yogo, Vissing-Jorgensen, Canzoneri Cumby Diba, Bilbiie Straub
  - high fraction with zero net worth: Wolff, SCF (Bricker et al)
- **Important** recent *empirical work*
  - consumption—income: Johnson, Parker, Souleles; Misra Surico; Surico Trezzi
  - liquidity constraints & MPC, *wealthy hand-to-mouth*: Kaplan Violante; Cloyne Ferreira Surico; Gorea Midrigan

HA

NK

$$\frac{\text{HA}_{\text{NK}}}{_{\text{HA}}\text{NK}}$$

	Quantitative	Analytical
TANK		Bilbiie **2008** *JET* (2004) ↓
HANK		↓ χ

Key channel: $\chi \gtrless 1$ ~ Cyclical Inequality

Core: *individual income elasticity to aggregate* (cycle), as determined by **profits** & their (re)distribution link

This Paper: a-HANK

1. representation of **several** quantitative-HANK channels

   (prequel: **The New Keynesian Cross** (*JME*): **one** channel)

2. "analytical" **fits purpose:** *closed-form, full-blown NK*

Using a-HANK: Closed-form

1. **Determinacy** with IR rules and **No-Puzzle** *(iff)* conditions.
   - *HANK Taylor Principle* & Sargent-Wallace
2. **Catch-22:**

   no-Puzzles $\chi < 1$ ↯ Amplif. (multipliers) $\chi > 1$

3. **Solutions** (ways out):
   - add (*better be!*) distinct HANK channel: **cyclical risk**
   - *Wicksellian rule* (price-level targeting) in HANK
4. **Optimal policy** (closed-form)
5. **Liquidity Traps**: Redo 1-4

Literature: TANK 2000s

- Campbell Mankiw 90s: estimate elasticity of intertemporal substitution from aggregate Euler
- Bilbiie 08, **analytical:** aggregate demand and *monetary policy; profits and redistribution; optimal* monetary policy
- Galí Lopez-Salido Vallés 07, **quantitative**: physical capital or not; fiscal multipliers, determinacy, numerical; Mankiw 00: fiscal policy in TA-RBC; Bilbiie Straub 04 fiscal multipliers TANK analytical+dist. tax; Bilbiie Meier Muller 08: estimated fiscal TANK; Colciago; Ascari, Colciago and Rossi (sticky wages); Eser; Farhi Werning 16: currency unions
- different (related) TA (*borrower-saver*): Iacoviello 05; Eggertsson Krugman; Curdia Woodford; Nistico; Monacelli Perotti; Bilbiie Monacelli Perotti;
- Bilbiie Straub: estimated TANK (Bayesian and GMM)
- Debortoli Galí 17: compare TANK with HANK

Literature: HANK 2010s

- Monetary policy: *Kaplan, Moll, Violante (KMV): monetary policy transmission, direct-indirect effects, liquid assets*; *McKay Nakamura Steinsson (MNS)*: FG power; Guerrieri Lorenzoni: deep LT-deleveraging recessions; Auclert; Auclert Rognlie: transmission channel; Bayer Luetticke Pham-Dao Tjaden; Luetticke: liquidity, portfolio composition;
- Endogenous unemployment implications: Ravn Sterk; Den Haan Rendahl Riegler; Gornemann Kuester Nakajima; McKay Reis; Challe Matheron Ragot Rubio
- Fiscal: Oh Reis; Hagedorn Manovskii Mitman; Ferrière Navarro; Auclert Rognlie Straub
- **Analytical HANKs**: Acharya Dogra (isolate cyclical-risk channel); Broer, Hansen, Krusell, Oberg (virtues of sticky wages); Ravn Sterk (add analytical SAM, transmission and puzzles); Werning (cyclical risk&liquidity); Bilbiie Ragot (endogenous liquidity–money); **this**

Literature: NK Analysis

- **Determinacy: RA(NK)** Benhabib Farmer; Leeper; Woodford; Cochrane; Benhabib Schmitt-Grohé Uribe; Dupor; Lubik Schorfheide; etc.; **TANK**: Galí Lopez-Salido Vallés (quant.); Bilbiie (analytical); Ascari et al;
- **FG puzzle** (Del Negro, Giannoni, Patterson): ~~perfect information/rational expectations~~: sticky info (Kiley; Carlstrom et al); eductive stability Garcia-Schmidt Woodford (+6=Farhi-Werning); dispersed information Wiederholt; Andrade et al; sparsity (Gabaix); imperfect common knowledge (Angeletos Lian); ; fiscalist: Cochrane (FTPL+long-term debt); OLG: Del Negro, Giannoni, Patterson; peg interest on reserves: Diba Loisel; wealth-in-utility: Canzoneri Diba, Michaillat Saez; heterogeneity+**incomplete markets**: MNS, KMV; Ravn Sterk; *Acharya Dogra*; Hagedorn
- **Optimal policy in TANKs** (Bilbiie 08, Ascari et al; Nistico; Curdia Woodford) and **HANKs**: Bhandari Evans Golosov Sargent; Challe; McKay Reis; Nuno Thomas; Bilbiie Ragot

Analytical (a-)HANK Model (Ingredients)

- **Two states**: constrained hand-to-mouth H and unconstrained "savers" S
  - switch *exogenously* (idiosyncratic uncertainty).
- Insurance:
  - *full within* type (after idiosyncratic uncertainty revealed)
  - *limited across* types.
- **Two assets** and *liquidity*:
  - bonds are **liquid** (*can* be used to self-insure, before idiosyncratic uncertainty is revealed)
  - stocks are **illiquid** (cannot ——„——).
- Bond trading
  - equilibrium liquidity
  - or **not (***most analytical* HANK): "**Bondless** limit"

Self-insurance and Asset Market

- separable $U^j(C^j, N^j)$; $\sigma^{-1} \equiv -U^j_{CC}C^j/U^j_C$; $\varphi \equiv U^j_{NN}N^j/U^j_N$
- shocks S$\leftrightarrows$H, $\mathrm{p}(S|S) = s$; $\mathrm{p}(H|H) = h$; H mass:

$$\lambda = \frac{1-s}{2-s-h}$$

- S$\xrightarrow{1-s}$H bonds liquid, stock illiquid (*temporarily)*
  - **self-insurance** w/ bonds (priced even when *not traded):*

$$\left(C^S_t\right)^{-\frac{1}{\sigma}} = \beta E_t\left\{(1+r_t)\left[s\left(C^S_{t+1}\right)^{-\frac{1}{\sigma}} + (1-s)\left(C^H_{t+1}\right)^{-\frac{1}{\sigma}}\right]\right\}$$

- H Euler with inequality (constrained); with no liquidity:

$$C^H_t = Y^H_t$$

  - "wealthy" H

HA-1: Income Processes

- Autocorrelation (> 0 if $s \geq 1 - h$)

$$corr\left(Y_{t+1}^{j}, Y_{t}^{j}\right) = s + h - 1 = 1 - \frac{1-s}{\lambda};$$

- **Conditional variance** ($\sim$ *income risk*)**:**

$$var\left(Y_{t+1}^{S} | Y_{t}^{S}\right) = s\left(1-s\right)\left(Y_{t+1}^{S} - Y_{t+1}^{H}\right)^{2}.$$

- **Conditional skewness** and **kurtosis**:

$$skew\left(Y_{t+1}^{S} | Y_{t}^{S}\right) = \frac{1-2s}{\sqrt{s\left(1-s\right)}};$$

$$kurt\left(Y_{t+1}^{S} | Y_{t}^{S}\right) = \frac{1}{s\left(1-s\right)} - 3$$

  (Basically Rouwenhorst with 2 states.)

- **Benchmark:** approximate model $\sim$ long-run symmetric steady-state $Y^{S} = Y^{H}$
  $\rightarrow$ **risk acyclical**

Rest = TANK (Bilbiie 2008 version)

- Core distinction: hold *assets* (→**profits**) or not chi
  - H (λ fraction) consume all **their** income
    $c_t^H = w_t + n_t^H + \frac{\tau^D}{\lambda} d_t$
- Equilibrium (2 lines of algebra):

$$
\begin{aligned}
c_t^H &= \chi y_t \\
\textbf{key} &: \quad \chi \equiv 1 + \underbrace{\varphi}_{\text{labor mkt.}} \times \underbrace{\left(1 - \frac{\tau^D}{\lambda}\right)}_{\text{fiscal redistrib.}} \gtrless 1 \\
c_t^S &= \frac{1 - \lambda \chi}{1 - \lambda} y_t
\end{aligned}
$$

Extra income effect $w \uparrow \rightarrow d \downarrow$ *keystone*: **profits** (#45-60)[1]

Cyclical Inequality: $y_t^S - y_t^H \equiv (1 - \chi) \frac{1}{1 - \lambda} y_t$

[1] Cyclicality? 1. conditional; 2. *data?; 3.* entry, variety, markups, profits: 15 years of Bilbiie Ghironi Melitz)

Analytical HANK: Aggregate Euler-IS

- Aggregate, replace $c_t^j \longrightarrow c_t^S = sE_t c_{t+1}^S + (1-s) E_t c_{t+1}^H - \sigma r_t$

$$c_t = \underbrace{\left[1 + (\chi - 1)\frac{1-s}{1-\lambda\chi}\right]}_{\equiv \delta} E_t c_{t+1} - \sigma \underbrace{\frac{1-\lambda}{1-\lambda\chi}}_{\text{TANK}} r_t$$

"Discounting" $\delta < 1$ iff PI $\chi < 1$
"**Compounding**" $\delta > 1$ iff CI $\chi > 1$

- *complementarity* $\frac{\partial^2 \delta}{\partial \lambda \partial (1-s)} \sim \chi - 1 \lesseqgtr 0$

- **Exact same χ-channel** as TANK, but *intertemporal*
- **Acyclical** idiosyncratic income risk (approx$\sim Y^H = Y^S$)

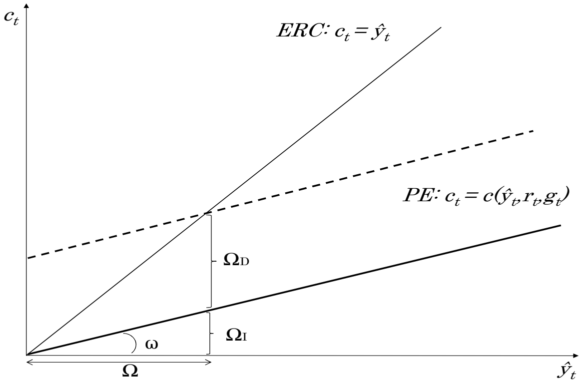
HA-2: The New Keynesian Cross

$$\text{PE: } c_t = \left[1 - \beta\left(1 - \lambda\chi\right)\right] y_t - \left(1 - \lambda\right)\beta\sigma r_t + \beta\delta\left(1 - \lambda\chi\right) E_t c_{t+1}$$

	Total effect Ω ("multiplier")	Indirect-effect share ω ("aggregate MPC")
TANK	$\frac{\sigma}{1-p}\frac{1-\lambda}{1-\lambda\chi}$	$\frac{1-\beta(1-\lambda\chi)}{1-\beta p(1-\lambda\chi)}$
a-HANK	$\frac{\sigma}{1-\delta p}\frac{1-\lambda}{1-\lambda\chi}$	$\frac{1-\beta(1-\lambda\chi)}{1-\delta\beta p(1-\lambda\chi)}$

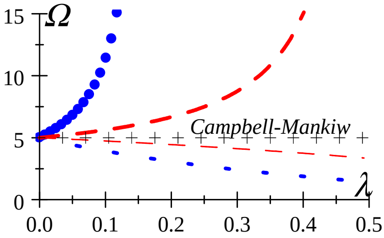
The New Kenesian Cross

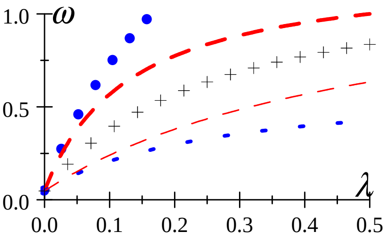
$$c_t = \omega \hat{y}_t - (1-\omega)\,\Omega r_t + (1-\omega)\,(M-1)\,g_t$$



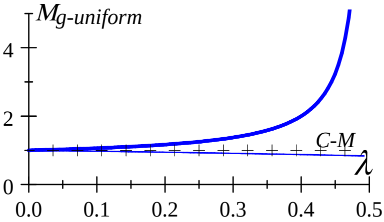
$$\text{aggreg. MPC } \omega \equiv \lambda \times 1 \times \chi + (1-\lambda) \times (1-\beta) \times \frac{1-\lambda\chi}{1-\lambda}$$

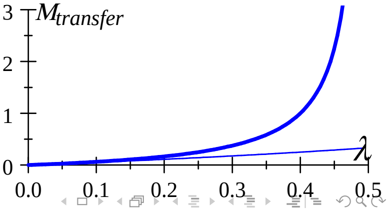
The New Kenesian Cross (in a-HANK)





Calibrate **KMV** $\Omega/\Omega_{rank} = 1.5, \omega = .8$: $\chi = 1.42; \lambda = .37; 1 - s = .04$





Calibrating Simple to Match Complicated

Table 1: Approximating HANK

HANK: Equilibrium objects					Implied parameters		
	$\frac{\Omega}{\Omega^*}$	ω	$\frac{\Omega_1^F}{\Omega^*}$	$\frac{\Omega_{20}^F}{\Omega^*}$	χ	λ	$1-s$
Kaplan et al	1.5	.8	—	—	1.48	.41	0 (TANK)
					1.48	**.37**	**.04**
McKay et al	—	—	.8	.4	—	—	0 (TANK)
					.3	.21	.04

Paper: other HANKs (Goremann et al, Debortoli Gali, Hagedorn et al, Auclert et al)

HA-3: iMPCs in a-HANK (w/ liquidity)

- Auclert Rognlie Straub; Hagedorn Manovskii Mitman
  - *fiscal policy*
- most compelling critique of **TANK** ... **not of a-HANK!**
- better still: χ helps match data (Fagereng Holm Natvik)

HA-3: iMPCs in a-HANK (w/ liquidity)

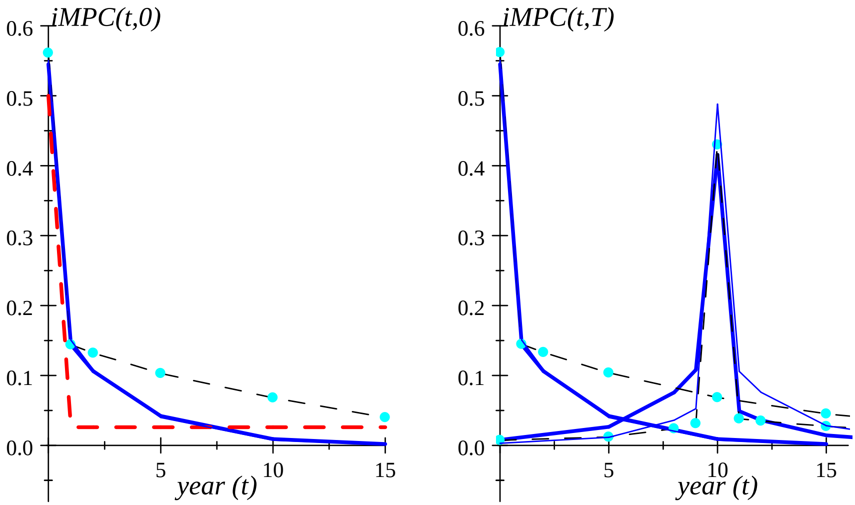
- Proposition: iMPCs $\frac{dc_t}{d\hat{y}_T}$

$$
\begin{aligned}
< \quad & T: \frac{1-\lambda\chi}{s}\frac{\delta-\beta x_b}{1-\beta x_b^2}\left(\beta x_b\right)^{T-t}\left(1-x_b+x_b\left(1-\beta x_b\right)\left(\beta x_b^2\right)^t\right) \\
= \quad & \text{T:}1-\frac{1-\lambda\chi}{s}\beta x_b-\left(\delta-\beta x_b\right)x_b\frac{1-\lambda\chi}{s}\left(1-\beta x_b\right)\frac{1-\left(\beta x_b^2\right)^T}{1-\beta x_b^2} \\
> \quad & T: \frac{1-\lambda\chi}{s}\frac{1-\beta x_b}{1-\beta x_b^2}x_b^{t-T}\left(1-x_b\delta+x_b\left(\delta-\beta x_b\right)\left(\beta x_b^2\right)^T\right)
\end{aligned}
$$

  $x_b\left(s,\lambda\right)<1$ the stable root of asset-accumulation equation

- increasing with χ when $t<T$, decreasing when $t\geq T>0$ (given $dc_0/d\hat{y}_0$).

iMPCs in a-HANK



$\chi = 1$ (dot-dash); TANK (red dash); $\chi > 1$ thick and < 1 thin

Recap: a-HANK as HANK projection

1. Idiosyncratic uncertainty, income processes
   - persistence, risk, skewness, kurtosis, etc.
2. NK Cross:
   - *cyclical inequality* χ, Euler discounting/compounding δ
3. iK Cross:
   - iMPCs (with liquidity)

Remainder: zero-liquidity limit (*passive-Ricardian* FP, zero SS debt)

The Analytical-HANK 3-Equation Model

$$
\begin{aligned}
c_t &= \delta E_t c_{t+1} - \sigma \frac{1-\lambda}{1-\lambda\chi}\left(i_t - E_t \pi_{t+1} - \rho_t\right) \\
&: \quad (\text{with } \delta \equiv 1 + (\chi - 1)\frac{1-s}{1-\lambda\chi}) \\
\pi_t &= \kappa c_t + \beta E_t \pi_{t+1} \\
i_t &= \rho_t + i_t^* + \phi \pi_t
\end{aligned}
$$

- (*here* $\pi_t = \kappa c_t$ simple closed forms, paper NKPC)
- Boil down to **one (!) equation** $\lambda, \chi, \delta \longrightarrow \mathcal{V}$["new"]

The Analytical-HANK 3-Equation Model

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The HANK Taylor Priciple

$$c_t = \nu E_t c_{t+1} + shocks$$

$$News\text{ on AD} \quad : \quad \nu \equiv \frac{\delta + \kappa\sigma \frac{1-\lambda}{1-\lambda\chi}}{1 + \phi\kappa\sigma \frac{1-\lambda}{1-\lambda\chi}}$$

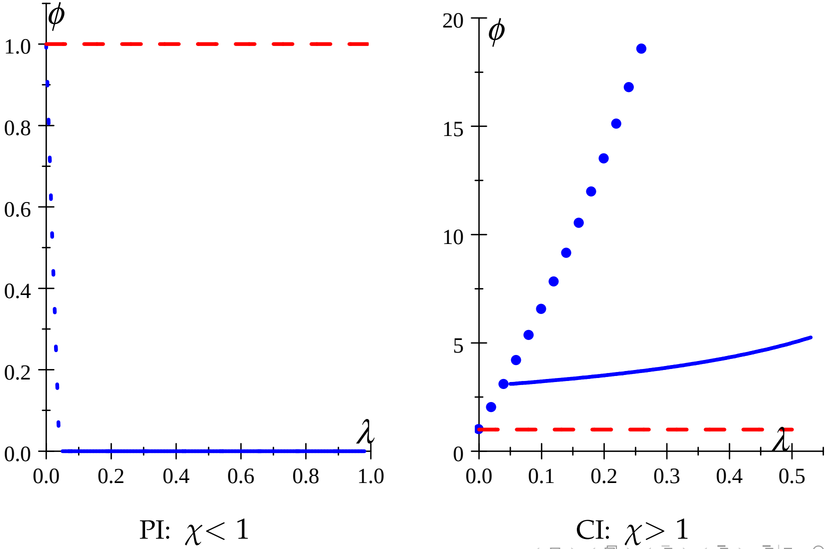
- $\exists!$ REE (local determinacy) with $\lambda < \chi^{-1}$:

$$\nu < 1 \Leftrightarrow \phi > 1 + \frac{\delta - 1}{\kappa\sigma \frac{1-\lambda}{1-\lambda\chi}}.$$

- **Taylor principle** $\phi > 1$ *sufficient* if:

$$\delta \leq 1 \longrightarrow \chi \leq 1$$

The HANK Taylor Priciple



HANK and Sargent-Wallace

- Determinacy with **peg** $\phi = 0$

$$c_t = \nu_0 E_t c_{t+1} + \text{shocks}$$

news on AD under **peg**

$$\nu_0 = \delta + \kappa\sigma \frac{1-\lambda}{1-\lambda\chi} < 1$$

HANK Cures FG Puzzle IFF:

HANK AD-Discounting >> RANK AS-Compounding

$$\nu_0 = \delta + \kappa\sigma\frac{1-\lambda}{1-\lambda\chi} < 1$$

- $\delta < 1$ necessary *not sufficient* (complementarity):

$$1 - s > 0 \text{ and } \chi < 1 - \sigma\kappa\frac{1-\lambda}{1-s} < 1$$

Proof

$$c_t = \nu_0 E_t c_{t+1} - \sigma\frac{1-\lambda}{1-\lambda\chi} i_t^* = \nu_0^{\bar{T}} E_t c_{t+\bar{T}} - \sigma\frac{1-\lambda}{1-\lambda\chi} E_t \sum_{j=0}^{\bar{T}-1} \nu_0^j i_{t+j}^*$$

$$\text{FG: cut at time } t+T, \ \frac{\partial c_t}{\partial\left(-i_{t+T}^*\right)} = \sigma\frac{1-\lambda}{1-\lambda\chi}\nu_0^T$$

Amplification without Puzzles: Catch-22?

- **HANK multiplier** (balanced-budget uniform $t_t = g_t$):[2]

$$\frac{\partial c_t}{\partial g_t} \sim \underbrace{\zeta\left(\chi-1\right)\frac{\lambda\left(1-\mu_g\right)+\left(1-s\right)\mu_g}{1-\lambda\chi}}_{\text{TANK + HANK AD}} - \underbrace{\kappa\zeta\sigma\frac{1-\lambda}{1-\lambda\chi}\left(\phi-\mu_g\right)}_{\text{RANK AS}}$$

(times $\frac{1}{1-\nu\mu_g}\left(1+\phi\kappa\sigma\frac{1-\lambda}{1-\lambda\chi}\right)^{-1}$)

- *The New Keynesian Cross* gets going *iff* cross

$$\chi > 1$$

Underlies amplification-HANKs (Kaplan Moll Violante, etc.)

- $\rightarrow$ **Catch-22**

[2] Income effect $\zeta \equiv \left(1+\varphi^{-1}\sigma^{-1}\right)^{-1}$

Cyclical Risk: a Different Channel

- (Ravn Sterk; Challe et al; Werning; **Acharya Dogra**)

$-s'(Y_{t+1}) \gtrless 0 \;\rightarrow\;$ pro-(counter-)cyclical *risk* (NB: λ invariant)

- Aggregate Euler-IS ($\Gamma = Y^S / Y^H \geq 1$):

$$c_t = (\delta + \eta) E_t c_{t+1} - \sigma \frac{1-\lambda}{1-\lambda\chi} r_t$$

$$\eta \equiv \frac{s_Y Y}{1-s}\left(1 - \Gamma^{-1/\sigma}\right)(1-\tilde{s})\,\sigma \frac{1-\lambda}{1-\lambda\chi}$$

- **Similar** equilibrium implications:
  - pro-*(counter-)*cyclical→discounting (*compounding*)
- *Different* economic mechanism ("precautionary saving")
  - earlier on risk and aggregate Euler with incompleteness: *Krueger and Lustig* 2010

Solution to Catch-22? Cyclical Inequality vs Risk

- Yes and No
- No-Catch-22 (Amplification without Puzzles) iff

$$\begin{aligned} \text{Countercyclical Inequality} &: \quad \chi \geq 1 \\ \text{Procyclical (enough) Risk} &: \quad \eta < 1 - \delta < 0 \end{aligned}$$

- Flip side: *everything worse* if **risk countercyclical too**
  - **Policy options?**

HANK: Virtues of a Wicksellian Rule

- **Proposition**: Even with **Amplification ++** (both inequality and risk countercyclical):[3]

  $i_t = i_t^* + \phi_p p_t$ with $\phi_p > 0$ (Woodford & Giannoni in RANK)

  1. $\exists!$ REE (local **determinacy**) with $\lambda < \chi^{-1}$
  2. no FG puzzle

- Intuition: **PID control**–bygones are *not* bygones;

Hagedorn, other ways out

[3]Corrolary: *also* in **RANK**!

Optimal Policy in a-HANK

- Aggregate welfare 2^{nd} order, Ramsey problem becomes (Woodford 2003 RANK, Bilbiie 2008 TANK):
  - approx. around *first-best*, *perfect-insurance* y

$$\min_{\{c_t,\pi_t\}} \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \alpha y_t^2 + \pi_t^2 \right\},$$

$$\alpha \equiv \frac{\sigma^{-1}+\varphi}{\psi} \left[\underbrace{1}_{\text{RANK}} + \underbrace{\varphi^{-1}\sigma^{-1}\frac{\lambda}{1-\lambda}(\chi-1)^2}_{\text{HANK-inequality}} \right]$$

- more H $\rightarrow$ *less π stabilization*
  - key: **profits**, π like a distortionary tax
  - *more π volatility* under optimal policy (discretion, commitment)
  - makes large difference in: ...

Liquidity Traps with a-HANK

- use Bilbiie 2016 (*Optimal Forward Guidance*, AEJ-Macro) simple closed-form, FG "state"
  - **first** *closed-form* **optimal policy** in RANK-LT ($\sim$Ramsey) + "simple rule FG" (how long should CB $i = 0$)
- Extend Eggertsson-Woodford to *three states*: P(L$\to$F)= $(1-z)\,q$, P(F$\to$F)= q; E(FG duration)=$1/\,(1-q)$

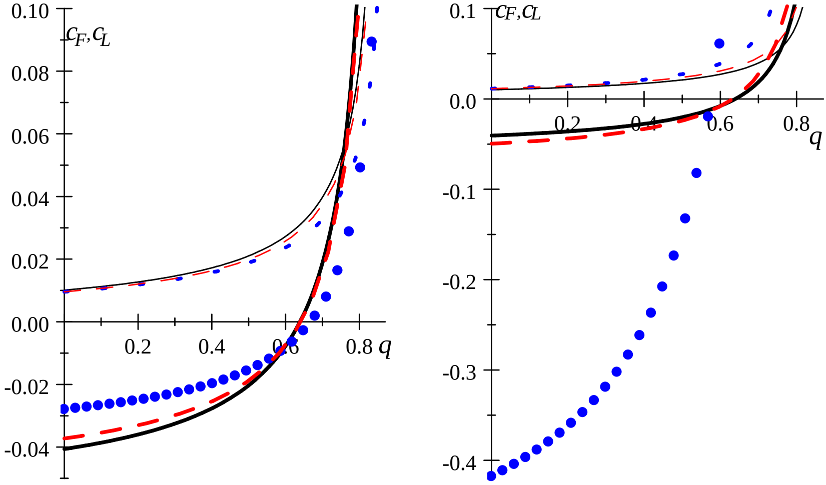
$$E_t c_{t+1} = z c_L + (1-z)\,q c_F + (1-z)\,(1-q)\,0$$

- Equilibrium $dc_F/dq > 0; dc_L/dq > 0$

$$\begin{aligned} c_F &= \frac{1}{1-q\nu_0}\sigma\frac{1-\lambda}{1-\lambda\chi}\rho \\ c_L &= \frac{1-z}{1-z\nu_0}\frac{q\nu_0}{1-q\nu_0}\sigma\frac{1-\lambda}{1-\lambda\chi}\rho + \frac{\sigma}{1-z\nu_0}\frac{1-\lambda}{1-\lambda\chi}\rho_L \end{aligned}$$

FG: Dampening and Amplification

c_L (thick) and c_F (thin): RANK, TANK and iid-HANK



PI: $\chi < 1$ CI: $\chi > 1$

FG Power and Puzzle

- **FG power**:

$$\mathcal{P}_{FG} \equiv \frac{dc_L}{dq} = \left(\frac{1}{1-q\nu_0}\right)^2 \frac{(1-z)\,\nu_0\sigma\frac{1-\lambda}{1-\lambda\chi}}{1-z\nu_0}\rho.$$

  - $\chi > 1$: $\partial\mathcal{P}_{FG}/\partial\lambda > 0$; $\partial\mathcal{P}_{FG}/\partial(1-s) > 0$

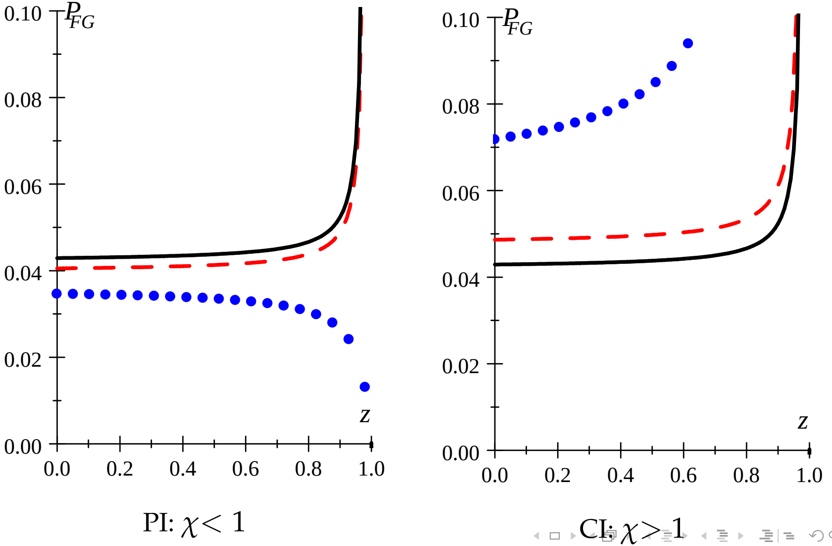
- *Corollary*:

$$\textbf{FG puzzle: } \frac{\partial\mathcal{P}_{FG}}{\partial z} \geq 0 \text{ ruled out } \textit{iff}$$

$$\nu_0 < 1.$$

FG Puzzle: Resolution or Aggravation?

RANK, TANK and iid-HANK; $q = 0.5$ $\lambda = 0.1$



Optimal Policy in LT (and the Dark Side of FG Power)

- E(PDV(Welfare)) w/ Markov chain:

$$W = \frac{1}{1-\beta z}\frac{1}{2}\left[c_L^2 + \omega\left(q\right)c_F^2\right],$$

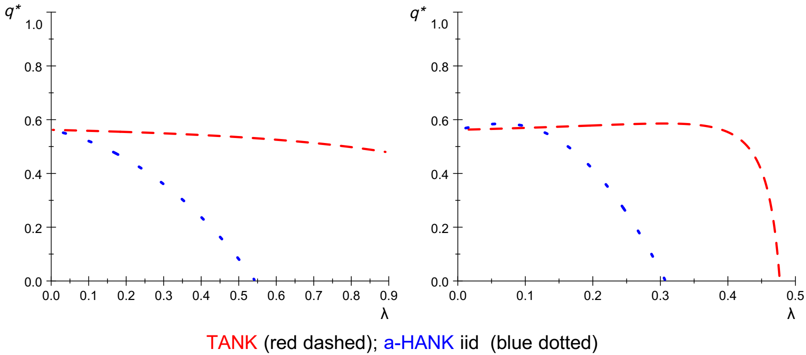
  - $\omega\left(q\right) = \frac{1-\beta z+\beta(1-z)q}{1-\beta q}$, $\omega'\left(q\right) > 0$: the longer in F, the larger the total welfare cost.

- $\min_q W$ s.t. equilibrium c_F and c_L

$$c_L\frac{dc_L}{dq} + \omega\left(q\right)c_F\frac{dc_F}{dq} + \frac{1}{2}\frac{d\omega\left(q\right)}{dq}c_F^2 = 0$$

- simple case: closed-form q^* (paper)

Optimal FG duration



$q^* (\lambda)$: $\chi < 1$ (left) and $\chi > 1$ (right)

Convergence

HANK

↓↑

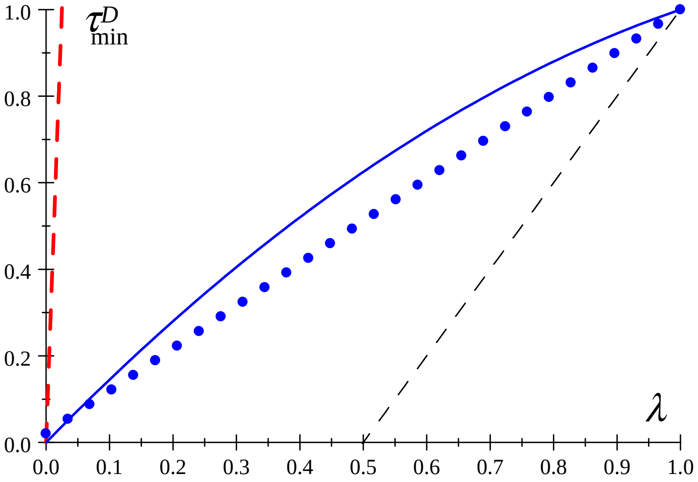
HANK

Convergence

- *Paramount* policy inputs: χ, $(\lambda, 1-s, \eta) = ?$
  - **inequality (χ)**: Heathcote Perri Violante HPV-2010
  - worryingly, **countercyclical**: Patterson (2019)
  - ... *risk too*! Storesletten et al; Guvenen et al
- $\longrightarrow$**Urgency**

1. *Estimate* quantitative model with all channels (disentangle)
2. **Optimal** policy (recent numerical advances)

No-Puzzle Threshold Redistribution



Redistribution threshold $\tau^D_{\min}$ in TANK $1 - s \to 0$ (dash); $1 - s = 0.04$ (solid); iid HANK $1 - s = \lambda$ (dots).

What (else) determines χ?

- *Fiscal redistribution:*

$$\chi \equiv 1 + \varphi \left(1 - \frac{\tau^D}{\lambda}\right)$$

  - "proper" progressive taxation: (Ferrière Navarro; Heathcote Storesletten Violante);
  - crucial ingredient in **all** HANK: here spelled out transparently

- *Sticky wages* (HANK: Broer et al; TANK: Ascari et al), f fixed

$$\chi = (1 + \varphi) \frac{1 - f}{1 - \lambda f} \lesseqgtr 1$$

Other ways out

- other ~~puzzles~~ with $\chi > 1$
  - add orthogonal ingredients: deviations from RE, PI, PCC; wealth in U, interest on reserves, etc.
  - **HA**: Hagedorn (2018): a. positive B demand (BIU, HA), b. *choose nominal B*, c. and d. commit to nominal T and to i$\rightarrow P$
- "Amplification" with $\chi < 1$
  - note: "indirect effect" always there; multipliers with transfers (progressivity increase)
  - wicksellian

J. Heathcote et al. / Review of Economic Dynamics 13 (2010) 15–51

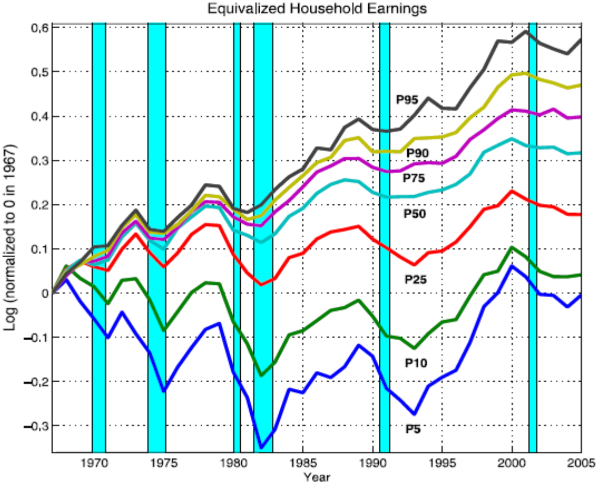


Fig. 9. Percentiles of the household earnings distribution (CPS). Shaded areas are NBER recessions.

Source: Heathcote, Perri, Violante 2010

Back to TANK Concl

Bilbiie (2008 JET) 4 contributions in nutshell

1. TANK analytical⟶income (profits') distribution key for AD&MP

Interest rate changes modify the intertemporal consumption and labor supply profile of *asset holders*, agents who smooth consumption by trading in asset markets. This affects the real wage and hence the demand of agents who have no asset holdings but merely consume their wage income. Variations in the real wage (marginal cost) lead to variations in profits and hence in the dividend income of asset holders. These variations can either reinforce (if participation is not 'too' limited) or *overturn* the initial impact of interest rates on aggregate demand. The latter case occurs if the share of non-asset holders is high enough and/or and the elasticity of labor supply is low enough, for the potential variations in profit income offset the interest rate effects on the demand of asset holders. This is the main mechanism identified by this paper to change dramatically the effects of monetary policy as compared to a standard full-participation case whereby aggregate demand is completely driven by asset holders.

If participation is restricted below a certain threshold, the predictions are **strengthened**: as the share of non-asset holders increases, the link between interest rates and aggregate demand becomes stronger, and monetary policy is more effective; we label this case '*standard aggregate demand logic*', (SADL). However, when participation is restricted beyond a given threshold,

2. aggregate Euler-IS; key $c_j = \varepsilon(\lambda) * y$ (intuition Section 3.1) TANK

Straightforward algebraic manipulation of the equilibrium conditions in Table 1 allows the derivation of aggregate dynamics, similar to the standard, full-participation New Keynesian benchmark. We start by deriving the aggregate Euler equation, or 'IS' curve. To that end, we need to express consumption of asset holders (the only agents whose consumption obeys an Euler equation) in terms of aggregate consumption/output. Since hours of non-asset holders are constant $n_{H,t} = 0$,[13] their consumption tracks real wage, $c_{H,t} = w_t$. Total labor supply (from the labor market clearing condition) is $n_t = [1-\lambda]\, n_{S,t}$. Using these last two expressions, asset holders' labor supply equation, the production function and the goods market clearing condition into the definition of total consumption we find:

$$c_{S,t} = \delta y_t + (1+\mu)(1-\delta)\, a_t, \quad \text{where } \delta \equiv 1 - \varphi \frac{\lambda}{1-\lambda} \frac{1}{1+\mu}. \tag{7}$$

Substituting (7) into the Euler equation of asset holders we find the *aggregate Euler equation*, or 'IS curve':

$$y_t = E_t y_{t+1} - \delta^{-1} [r_t - E_t \pi_{t+1}] + (1+\mu)\left(1-\delta^{-1}\right)[a_t - E_t a_{t+1}]. \tag{8}$$

Direct inspection of (8) suggests the impact that LAMP has on the dynamics of a standard business cycle model through modifying the elasticity of aggregate demand to real interest rates

$$w_t = \chi y_t - \varphi a_t, \quad \text{where } \chi \equiv 1 + \varphi/(1+\mu) \geqslant 1 \geqslant \delta.$$

3.1. *Intuition and the labor market*

How can an increase in interest rates become expansionary when asset market participation is restricted enough? To answer this question, it is useful to conduct a simple mental experiment whereby the monetary authority pursues a one-time discretionary increase in the interest rate ε_t, otherwise pursuing a policy that fully accommodates inflationary expectations, namely $r_t = E_t \pi_{t+1} + \varepsilon_t$. In the standard, full-participation economy, an increase in interest rates leads to a fall in aggregate demand today. Asset holders are also willing to work more at a given real wage (labor supply shifts rightward), but labor demand shifts left because of sticky prices (not all the fall in demand can be accommodated via cutting prices). The new equilibrium is one with lower output, consumption, hours and real wage. Suppose now that we are in an economy with limited participation, but $\lambda < \lambda^*$ either because participation is not restricted 'enough' or labor supply is not inelastic enough. The fall in real wage brought about by the intertemporal substitution of asset holders now means a further fall in demand, since non-asset holders merely consume their wage income. This generates a further shift in labor demand, so the new equilibrium is one with even lower (compared to the full-participation one) output, consumption, hours and real wage.

This effect could at first sight seem monotonic over the whole domain of λ: the more restricted asset market participation, the stronger the contractionary effect on demand and hence on labor demand, and hence the more effective monetary policy. In order to understand why this is not the case, it is helpful to consider the additional distributional dimension introduced by limited asset market participation. The further demand effect that occurs because of non-asset holders has an effect on profits: both marginal cost (wage) and sales (output and hours) fall. The relative

size of these reductions (and the final effect on profits) depends on the relative mass of non-asset holders and on labor supply elasticity. In particular, if labor supply is inelastic enough

Note that such a wage–hours locus implies that the model generates a higher partial elasticity of hours to the real wage, and more so more negative δ is. Importantly, despite the potential decrease, in general equilibrium *actual* profits may not fall, precisely due to the negative income effect making asset holders willing to work more; for as a result of this effect hours will increase by more and marginal cost by less, preventing actual profits from falling. In fact, for certain combinations of parameters, shocks or policies our model would *not imply countercyclical profits* in equilibrium (or at least implies more procyclical profits than a standard full-participation model with countercyclical markups). This is an important point, since it is widely believed that profits are procyclical.[23] It is also important to note that the negative income effect does not mean that

[23] See Section 7 of the working paper version [7] for a detailed discussion.

Bilbiie (2008 JET) 4 contributions in nutshell - cont'd

3. fiscal redistribution key for AD amplification of MP; AD elasticity:

$$c_{S,t} = \delta_\tau y_t, \quad \text{where } \delta_\tau = \frac{1}{1-\tau^D}\left[1 - \tau^D \frac{\mu}{1+\mu} + \frac{\tau^D - \lambda}{1-\lambda}\frac{\varphi}{1+\mu}\right].$$

4.3. Redistribution restores Keynesian logic

The mechanism of all the previous results relies on the interaction between labor and asset markets, namely income effects on labor supply of asset holders from the return on shares. This hints to an obvious way to restore Keynesian logic relying on a specific fiscal policy rule that shuts off this channel: tax dividend income and redistribute proceedings as transfers to non-asset holders. We focus on the IADL case whereby in the absence of fiscal policy $\delta < 0$. To make this point, consider the following simplified fiscal rule: profits are taxed at rate τ_t^D and the budget is balanced period-by-period, with total tax income $\tau_t^D D_t$ being distributed lump-sum to all non-asset holders. We focus on the case where profits are zero in steady state. The balanced-budget rule then is $\tau_t^D D_t = \lambda L_{H,t}$ which around the steady state (both profits and transfers are shares of

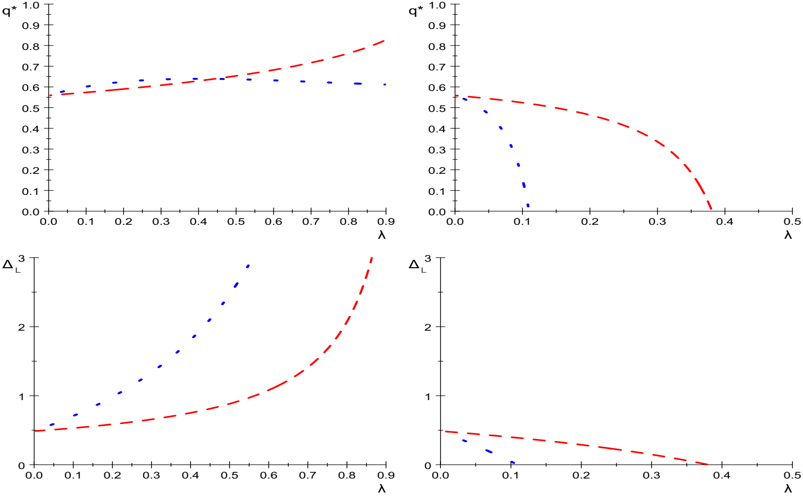
4. optimal policy in TANK Intro TANK

Proposition 4. *If the steady state of the model in Section 3 is* ***efficient*** *the aggregate welfare function can be approximated by (ignoring terms independent of policy and terms of order higher than 2):*

$$\mathbf{U}_t = -\frac{U_C C}{2}\frac{\varepsilon}{\psi} E_t \sum_{i=t}^{\infty}\left\{\alpha x_{t+i}^2 + \pi_{t+i}^2\right\}, \tag{18}$$

$$\alpha = \frac{\varphi+\gamma}{1-\lambda}\left[1 - \lambda(1-\gamma)(1+\varphi)\right]\frac{\psi}{\varepsilon}.$$

Caveat: given shock or given recession? (Nakata et al)



TANK (red dashed) - a-HANK iid (blue dotted)

$q^*(\lambda)$: fixed recession, Δ_L adjusts endogenously