Intro to Monetary Policy with Heterogeneity

Edmund Crawley

Heterogeneous Agent + New Keynesian

- Large literature on Heterogeneous Agents
- Large literature on Representative Agent New Keynesian Models (RANK)

Heterogeneous Agent + New Keynesian

- Large literature on Heterogeneous Agents
- Large literature on Representative Agent New Keynesian Models (RANK)

Up until recently very little overlap

- Belief heterogeneity didn't matter for monetary policy
- Computational difficulties

Heterogeneous Agent + New Keynesian

- Large literature on Heterogeneous Agents
- Large literature on Representative Agent New Keynesian Models (RANK)

Up until recently very little overlap

- Belief heterogeneity didn't matter for monetary policy
- Computational difficulties

New HANK literature shows these to be false

Heterogeneous Agent + New Keynesian

RANK model (Representative Agent NK)

- Monetary policy transmission through Intertemporal Substitution
- MPCs around 3%

Heterogeneous Agent + New Keynesian

RANK model (Representative Agent NK)

- Monetary policy transmission through Intertemporal Substitution
- MPCs around 3%

TANK model (Two Agent NK)

- High MPCs by construction
- Doesn't match micro behavior - but good enough for macro? Debortoli and Gali (2018)

Heterogeneous Agent + New Keynesian

RANK model (Representative Agent NK)

- Monetary policy transmission through Intertemporal Substitution
- MPCs around 3%

TANK model (Two Agent NK)

- High MPCs by construction
- Doesn't match micro behavior - but good enough for macro? Debortoli and Gali (2018)

HANK model (Heterogeneous Agent NK)

- Can have high MPCs (ex-ante heterogeneity in β, or illiquid asset)
- Matches micro behavior. Can model uncertainty shocks.

Outline for Today

- Empirical Framework and Evidence (Auclert (2017))
- Two Agent New Keynsian Models (TANK)
- Solution methods for HANK (Bayer and Luetticke (2018))

Some Motivation from Denmark

Some Motivation from Denmark

Medium MPX
≈ 0.5

High MPX
≈ 0.8

Low MPX
≈ 0.25

MPX: Marginal Propensity to eXpend (includes durables)

Some Motivation from Denmark

Medium MPX	High MPX	Low MPX
≈ 0.5	≈ 0.8	≈ 0.25

$\swarrow$ Decrease spending a *lot*

$\searrow$ Increase spending a *little*

Some Motivation from Denmark

Medium MPX ≈ 0.5

High MPX ≈ 0.8

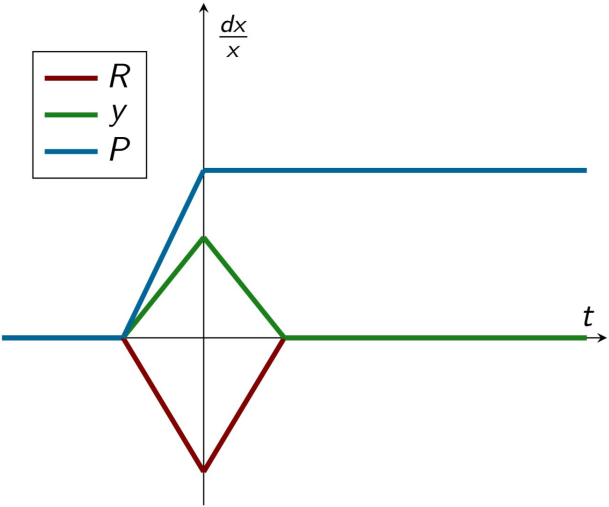
Low MPX ≈ 0.25

1yr rate $\uparrow$ 1%

Aggregate Spending $\downarrow$ 26 basis points

Through this redistribution channel *alone*

Auclert's Experiment



Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

} Representative Agent Channels

Dominates in Rep. Agent NK models

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

} Representative Agent Channels

Large in Spender-Saver, or TANK models

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

} Representative Agent Channels

- Fisher (Inflationary debt relief)
- Earnings Heterogeneity
- Interest Rate Exposure

} Redistribution Channels

Auclert's Decomposition

How does Monetary Policy Effect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

} Representative Agent Channels

- Fisher (Inflationary debt relief)
- Earnings Heterogeneity
- Interest Rate Exposure

} Redistribution Channels

How can we *empirically* measure the size of these channels?

Income Channels

Income for household i changes dY_i, then

$$dC_i = \text{MPC}_i dY_i$$

Income Channels

Income for household i changes dY_i, then

$$dC_i = \text{MPC}_i dY_i$$

Aggregate:

$$dC = \mathbb{E}_i \left(\text{MPC}_i dY_i \right)$$

Income Channels

Income for household i changes dY_i, then

$$dC_i = \text{MPC}_i dY_i$$

Aggregate:

$$dC = \mathbb{E}_i \left(\text{MPC}_i dY_i \right)$$

Split into *Aggregate Income* and *Earnings Heterogeneity* channels

$$AggInc = \mathbb{E}_i \left(\text{MPC}_i Y_i \right) \frac{dY}{Y}$$

$$EarnHet = \mathbb{E}_i \left(\text{MPC}_i dY_i \right) - \mathbb{E}_i \left(\text{MPC}_i Y_i \right) \frac{dY}{Y}$$

Fisher Channel

Key assumption:
Households treat redistribution like an income shock

Fisher Channel

Key assumption:
Households treat redistribution like an income shock

Experiment

One time price level increase

Hold constant income and real interest rate

Dimension of Redistribution: **Net Nominal Position**

$$dC_i = MPC_i NNP_i \frac{dP}{P}$$

Fisher Channel

Key assumption:
Households treat redistribution like an income shock

Experiment

- One time price level increase
- Hold constant income and real interest rate

Dimension of Redistribution: **Net Nominal Position**

$$dC_i = MPC_i NNP_i \frac{dP}{P}$$

Aggregate:

$$dC = \mathbb{E}_i \left(MPC_i NNP_i \right) \frac{dP}{P}$$

Interest Rate Exposure Channel

Experiment

Short term real interest rate $\uparrow$ 1% for 1 year

Hold constant income and inflation

Dimension of Redistribution: **Unhedged Interest Rate Exposure**

URE Definition: Net savings made at this year's interest rate

$$URE_i = Y_i - C_i + A_i - L_i$$

Where

- Y_i = Total after tax income
- C_i = Total Expenditure, including interest payments
- A_i = Maturing assets
- L_i = Maturing liabilities

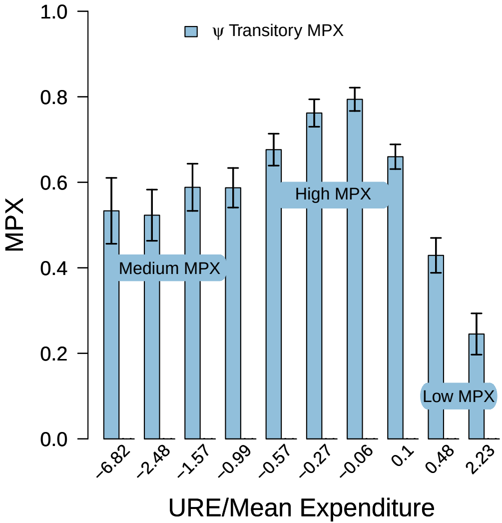
$$dC_i = MPC_i URE_i \frac{dR}{R}$$

Interest Rate Exposure Channel

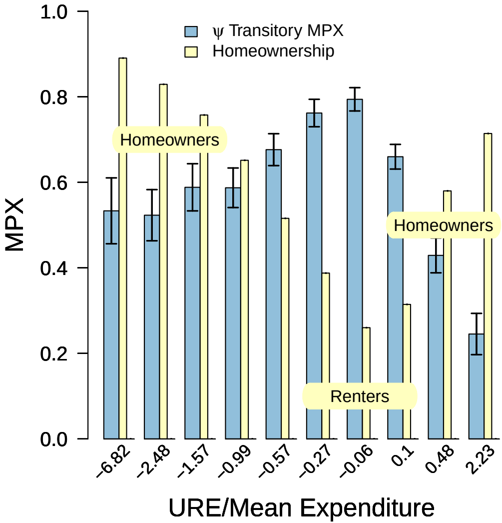
Aggregate to find size of channel:

$$
\begin{aligned}
dC_i &= \quad MPC_i URE_i \quad \frac{dR}{R} \\
\implies dC &= \mathbb{E}_I\left(MPC_i URE_i\right)\frac{dR}{R}
\end{aligned}
$$

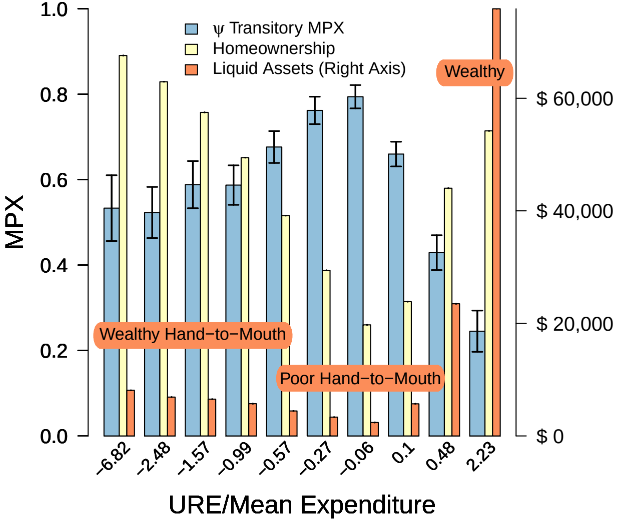
Evidence from Denmark



Evidence from Denmark



Evidence from Denmark



Intertemporal Substitution Channel

$$dC = \mathbb{E}_i \left(\sigma_i (1 - \mathrm{MPC}_i) C_i \right) \frac{dR}{R}$$

All Five Transmission Channels

$$\frac{dC}{C} = \overbrace{\mathcal{M}\frac{dY}{Y}}^{\text{Aggregate Income Channel}} \overbrace{+\gamma\mathcal{E}_Y\frac{dY}{Y}}^{\text{Earnings Heterogeity Channel}} \overbrace{-\mathcal{E}_P\frac{dP}{P}}^{\text{Fisher Channel}}$$

$$\underbrace{+\mathcal{E}_R\frac{dR}{R}}_{\text{Interest Rate Exposure Channel}} \underbrace{-\sigma\mathcal{S}\frac{dR}{R}}_{\text{Intertemporal Substitution Channel}}$$

$\mathcal{M}$	0.52
$\mathcal{E}_Y$	-0.03
$\mathcal{E}_P$	-0.75
$\mathcal{E}_R$	-0.26
$\mathcal{S}$	0.49

All Five Transmission Channels

$$\frac{dC}{C} = \overbrace{\mathcal{M}\frac{dY}{Y}}^{\text{Aggregate Income Channel}} \overbrace{+\gamma\mathcal{E}_Y\frac{dY}{Y}}^{\text{Earnings Heterogeity Channel}} \overbrace{-\mathcal{E}_P\frac{dP}{P}}^{\text{Fisher Channel}} \underbrace{+\mathcal{E}_R\frac{dR}{R}}_{\text{Interest Rate Exposure Channel}} \underbrace{-\sigma\mathcal{S}\frac{dR}{R}}_{\text{Intertemporal Substitution Channel}}$$

$\mathcal{M}$	0.52
$\mathcal{E}_Y$	-0.03
$\mathcal{E}_P$	-0.75
$\mathcal{E}_R$	-0.26
$\mathcal{S}$	0.49

Compare $\mathcal{E}_R$ to σS:

$\sigma \approx 0.1$ Best, Cloyne, Ilzetzki, and Kleven (2018)

$\sigma S \approx 0.05$

Two Agent New Keynesian Models (TANK)

- Simplest Model with Redistribution Channels
- Widely used by Policy Institutions (esp. for Fiscal Policy)
- Many insights carry over to HANK models

Two Agent New Keynesian Models (TANK)

- Simplest Model with Redistribution Channels
- Widely used by Policy Institutions (esp. for Fiscal Policy)
- Many insights carry over to HANK models

Two Agents: Ricardian and Keynesian
Fixed Capital (owned by Ricardian's)
Keynesians can borrow up to Ω of their steady state income as short term nominal bonds $\rightarrow$ Not a common feature of these models
Standard New Keynesian Phillips curve

TANK Setup: Ricardian Households

Ricardian Housholds maximize:

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t\left(\frac{\left(C_t^R\right)^{1-\sigma}}{1-\sigma}-\frac{\left(N_t^R\right)^{1+\psi}}{1+\psi}\right)$$

subject to budget constraint

$$P_tC_t^R+I_t^{-1}B_{t+1}=N_t^RW_t+P_tD_t+B_t$$

TANK Setup: Ricardian Households

Ricardian Housholds maximize:

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t\left(\frac{\left(C_t^R\right)^{1-\sigma}}{1-\sigma}-\frac{\left(N_t^R\right)^{1+\psi}}{1+\psi}\right)$$

subject to budget constraint

$$P_t C_t^R + I_t^{-1} B_{t+1} = N_t^R W_t + P_t D_t + B_t$$

They choose consumption by their Euler Equation:

$$\left(C_t^R\right)^{-\sigma} = \beta\mathbb{E}\left(I_t\frac{P_t}{P_{t+1}}\left(C_{t+1}^R\right)^{-\sigma}\right)$$

TANK Setup: Keynesian Households

Each period Keynesian Housholds maximize:

$$\frac{\left(C_t^K\right)^{1-\sigma}}{1-\sigma} - \frac{\left(N_t^K\right)^{1+\psi}}{1+\psi}$$

subject to their budget constraint:

$$C_t^K \leq N_t^K \frac{W_t}{P_t} + \left(I_t^{-1} \frac{\mathbb{E}_t P_{t+1}}{P_t} - \frac{\mathbb{E}_{t-1} P_t}{P_t}\right) \Omega \bar{N}_K \overline{W/P} \qquad (1)$$

Household Aggregation and Wage Schedule

With the Keynesian proportion of households equal to λ, total consumption is:

$$C_t = \lambda C_t^K + (1 - \lambda) C_t^R$$

Hours are equally rationed between both types of household such that:

$$N_t = N_t^K = N_t^R$$

The real wage is set according to the demand schedule:

$$\frac{W_t}{P_t} = \mathcal{M}^{\omega} (C_t)^{\sigma} (N_t)^{\psi}$$

Final Goods Firms

The final goods firm produces a final consumption good, Y_t, from intermediated inputs, $X_t(j)$ for $j \in [0,1]$ using the technology:

$$Y_t = \left(\int_0^1 X_t(j)^{1-\frac{1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

Profit maximization yields the demand schedule $X_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon}$ where P_t is the price of the final good. Competition also imposes a zero profit condition that yields $P_t = \left(\int_0^1 P_t^{1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}}$.

Intermediate Goods Firms

Technology:

$$X_t(j) = AK_t(j)^{\alpha} N_t(j)^{1-\alpha}$$

Calvo Fairy: Adjust price with probability $1 - \theta$

Leads to standard New Keynesian Phillips curve:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} \left(\sigma + \frac{\psi + \alpha}{1-\alpha} \right) \tilde{y}_t$$

Monetary Policy and Equilibrium

Taylor Rule

$$i_t = \phi_\pi \pi_t + \nu_t$$

Monetary Policy and Equilibrium

Taylor Rule

$$i_t = \phi_\pi \pi_t + \nu_t$$

Equilibrium conditions:

$$Y_t = C_t$$

and the total capital and labor used must equal that available:

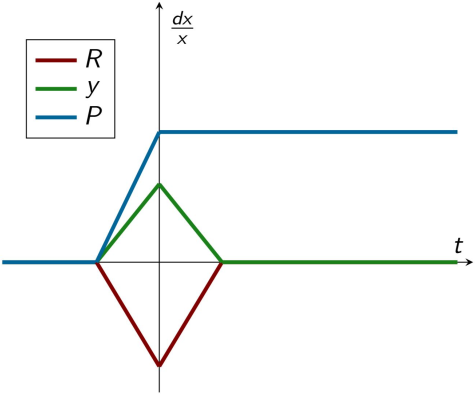
$$\int_0^1 K_t(j)dj = \bar{K}$$
$$\int_0^1 N_t(j)dj = N_t$$

Calibration

Baseline Calibration

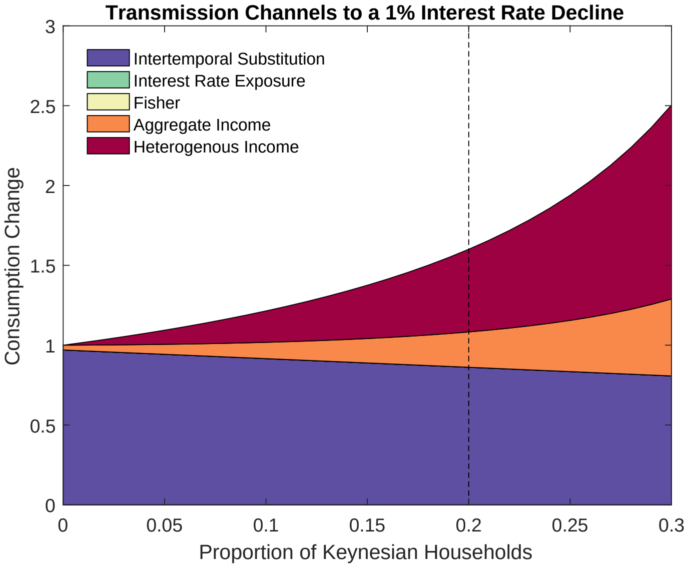
σ	1.0	Inverse EIS
ψ	1.0	Inverse Frisch Elasticity
ϕ_π	1.5	Taylor Rule Coefficient
θ	0.667	Calvo stickiness parameter
β	1.0	Discount Factor
α	0.33	Capital Share
ε	6.0	Elasticity of sub. between goods
λ	0.2	Share of Keynesian Households
Ω	0.0	Keynesian Debt as Share of Income
δ	0.1	Depreciation (capital model only)

Model Fits Auclert's Transitory Framework

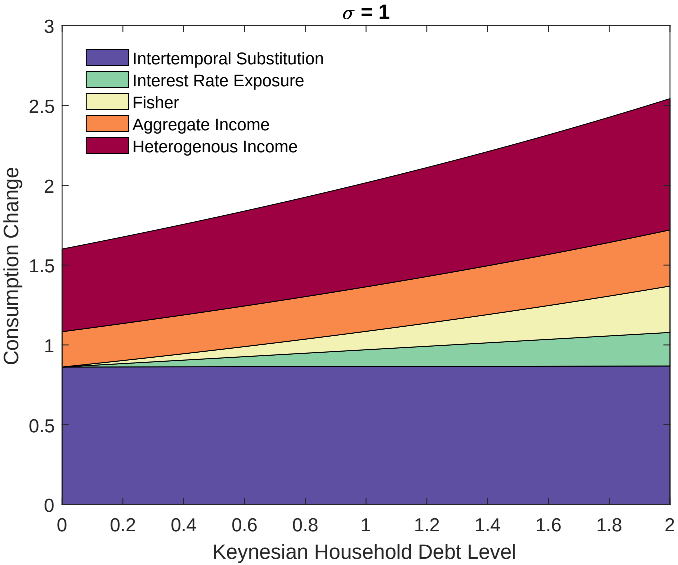


Why? No *predetermined* variables

Model with no Debt ($\Omega = 0$)

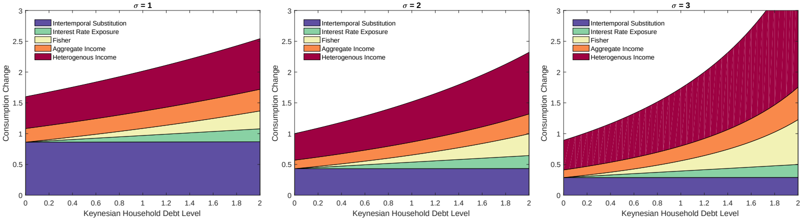


Adding Debt



σ = 1
Intertemporal Substitution
Interest Rate Exposure
Fisher
Aggregate Income
Heterogenous Income
Consumption Change
Keynesian Household Debt Level
0
0.5
1
1.5
2
2.5
3
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

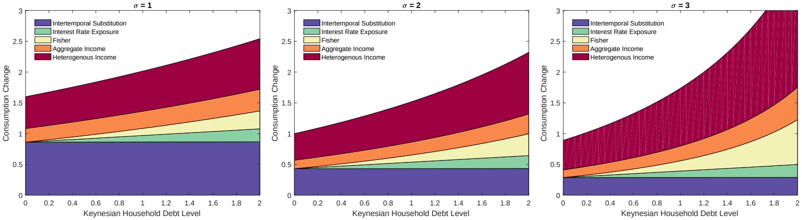
Elasticity of Intertemporal Subs.



Intertemporal Substitution and Interest Rate Exposure act as initial 'kick'

Three other channels amplify this

Elasticity of Intertemporal Subs.



Intertemporal Substitution and Interest Rate Exposure act as initial 'kick'

Three other channels amplify this

We should be weary of HANK models and empirically verify

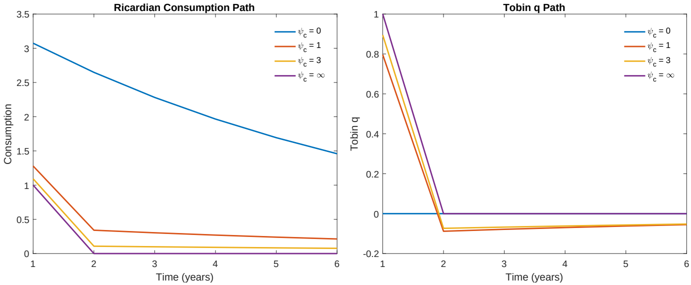
Some Time Series Evidence

I have presented cross-sectional evidence

Some time series evidence:

- Wong (2016)
- Cloyne, Ferreira, and Surico (2016)

How does Investment Change Things?



Depends on Adjustment Costs ψ_c

Extra 'kick' from firm investment

Solving HANK Models is more involved

The entire distribution of wealth is a *predetermined* variable

We need new solution methods

- Reiter (2009)
- Winberry (forthcoming QE)
- Ahn, Kaplan, Moll, Winberry, and Wolf (2017)
- Bayer and Luetticke (2018)

Bayer Luetikke code available in HARK...

Greenwood, Hercowitz and Huffman Preferences

Many HANK models use GHH preferences

$$U(c, n) = u(c - \nu(n))$$

Removes wealth effects from labor decision

Greenwood, Hercowitz and Huffman Preferences

Many HANK models use GHH preferences

$$U(c, n) = u(c - \nu(n))$$

Removes wealth effects from labor decision

BUT these preferences have a strong link between consumption and hours worked

Extra transmission channel:

$$\text{GHHchannel} = \mathbb{E}\left((1 - MPC_i)h_i\right)\frac{\bar{N}}{\psi}d\omega$$