# A Tail of Labor Supply and a Tale of Monetary Policy

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# Motivation

- *Policies to support labor supply are not the domain of the Fed: Our tools work principally on demand.* J. Powell 30/11/2022

- HANK:
  1. Heterogeneity in the inter-temporal substitution between C & S (**Euler equation**)

     Income effect > Substitution effect

  2. Not much heterogeneity in the intra-temporal substitution between C & L (**Labor Supply equation**).
     - **No income effect** on labor supply.
     - **Sticky wages** → labor is demand determined!

     Same in RANK

- We study the interaction between **monetary policy** (MP) and **labor supply** decisions at the individual level.

  Do people use their labor supply in response to MP shocks?
  And does this differ across the income distribution?

# What we do 1/2

## A Tail of labor supply

1 Novel evidence using survey data for US:

- **Strong countercyclicality** of labor supply for **individuals** on the **left tail** of the income distribution following a MP shock. → int. ≠ ext. margin
  - $R \Uparrow \rightarrow \Uparrow$ hours of the left tail.
  - Aggregate hours and wages across the whole distribution $\Downarrow$.
- Hours at the left tail also exhibit a **larger elasticity**.
- The tail of labor supply is also **quantitatively relevant**.
- Different explanations:
  - No savings buffer (Supply/Income effect)
  - Higher debt repayments (Supply/Income effect)
  - Sectoral (Demand)
  - Opposite of labor hoarding (Demand)

# What we do 2/2

## A Tale of Monetary Policy

2 Implications for **the tale of the monetary policy transmission mechanism**:

- Two-agent New Keynesian (**TANK**) set up with **heterogeneous income effects on labor supply**.
- Heterogeneity in the income effect affects the elasticity of HtM consumption to aggregate income. [Bilbiie (2020), Auclert (2019), Patterson (2021)]
- ⇒ Novel channel of transmission of inequality on MP generated by **HtM substitution of leisure for consumption** following an MP hike.
  - Labor supply as insurance/work effort to smooth consumption
  - Standard Keynesian Cross argument abstracts from this

*MP amplification of aggregate demand due to inequality is muted.*

# Literature

- **MP Heterogeneity**: Coibion et al. (2017); Mumtaz and Theophilopoulou (2017); Auclert (2019); Cloyne et al. (2020); Andersen et al. (2021); Holm et al. (2021); Amberg et al. (2022).
- **MP and Labor mkt**: Kehoe et al. (2020); Amir-Ahmadi et al. (2021); Broer et al. (2022); Hubert and Savignac (2022); Graves et al. (2023).
- **HANK/TANK**: Bilbiie (2008); Athreya et al. (2017); Debortoli and Galí (2017); Kaplan et al. (2018); Auclert (2019); Patterson (2021); Bilbiie (2021); Bilbiie et al. (2022a); Bilbiie et al. (2022b); Gerke et al. (2024).
- **Income effect on Labor Supply**: Mastrogiacomo et al. (2017); Cesarini et al. (2017); Golosov et al. (2021).
- **Labor supply as insurance**: Parker et al. (2005); Pijoan-Mas (2006); Blundell et al. (2016); Ellieroth and Michaud (2024).

# Data

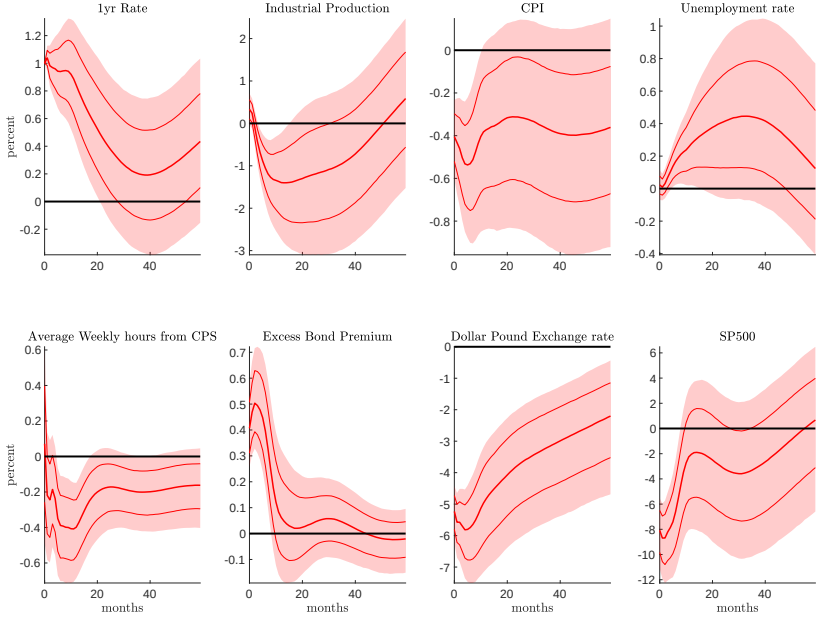
- **Individual survey data** for US (CPS-ORG) working age population to study decisions by percentile of gross **earnings**.
- Individuals are assigned to each month of the year by their date of interview (see Cloyne and Surico (2016)) and sorted into multiple bins by gross earning.
- We look at actual **hours worked** in all jobs and **hourly wages**. ▸ details ▸ aggregate
- Repeat this for each year in the sample to get a monthly time-series for each group.
- This is a pseudo-panel → we cannot track individuals over time.
- We also use the longitudinally matched version of CPS to do so.

# Empirical Model

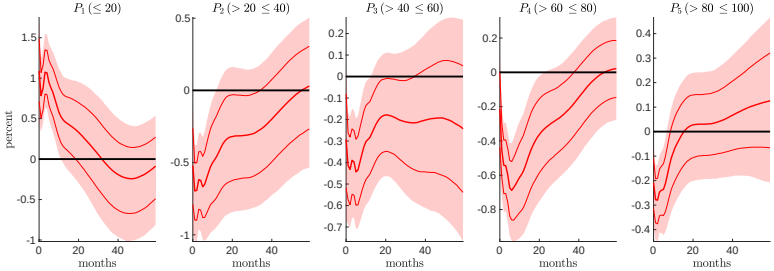
- **FAVAR with IV identification** (in levels). details
- $X_t$ (Macro-Financial plus Survey): real activity, employment, inflation, money, credit, spreads and asset prices.
  - 149 series, 1985m1 to 2019m12.
- $m_t$ (instrument): intraday variation of interest rates to MP announcements
  - Bauer and Swanson (2023), Gertler and Karadi (2015), Miranda-Agrippino and Ricco (2021)
- Why FAVAR? structural vs idiosyncratic shocks (and ME) [De Giorgi and Gambetti (2017)]; information deficiency [Forni and Gambetti (2014)]; shocks deformation [Canova and Ferroni (2022)].

# US Monetary Policy Shock

more

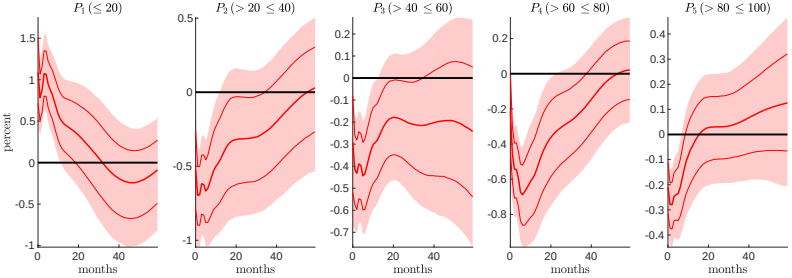


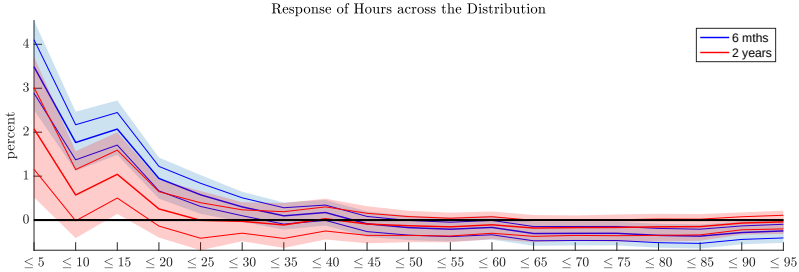
# The Left Tail of US Labor Supply



# The Left Tail of US Labor Supply

▸ wages ▸ Unempl.



# The Left Tail of US Labor Supply - Composition effect

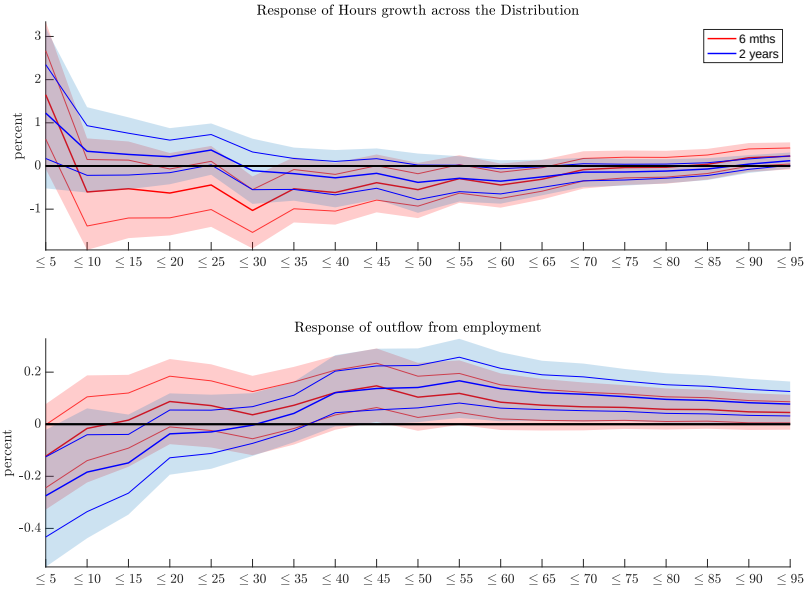
- The left tail response could be driven by composition effects in the group of low- and moderate-income individuals.

  people working part time or fewer than 40 hours per week could be laid off during a monetary policy tightening cycle; thus, the average hours worked in this group could increase mechanically because these individuals drop off the sample.

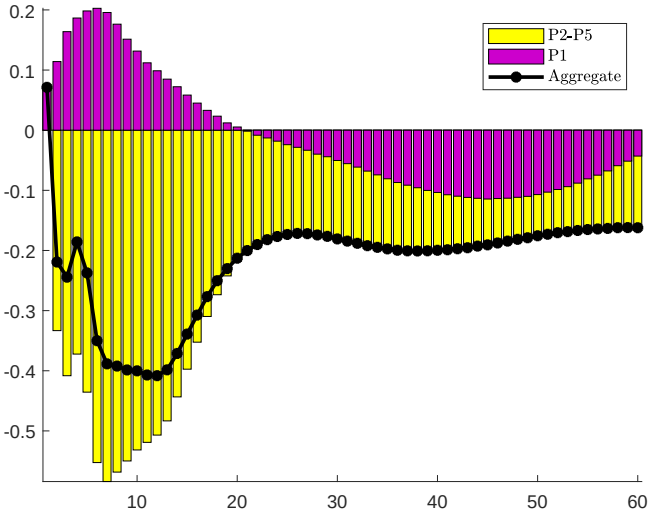
- CPS panel: we construct:
  - change in hours between month $t$ and $t + 12$ at the individual level
  - outflow of workers from employment in $t - 12$ to either unemployment or out of the labor force in $t$.

# The Left Tail of US Labor Supply - Composition effect

intensive margin



# The Left Tail of US Labor Supply - Decomposition



# Robustness

- CES survey + UK data.
- Alternative monetary policy shock ▸ identification
- Response by ▸ industry
- Response by ▸ education
- ▸ Variance contribution (%) of total hours

# A Tale of Monetary Policy

- Rationalize the empirical results and quantify their implications for the **monetary policy transmission mechanism**.
- Start with a ▸ simple and stylized model focusing only on the **intensive margin** of labor supply.⇒ with heterogeneity in income effects.
- Capture the fact that HtM agents after an MP hike, give away leisure time to avoid having to drop their consumption 1 to 1 with their decline in income.
- **Quantitative model** that can match our empirical evidence.
- Use it to quantify the relevance of the new channel of transmission we uncover.

# Quantitative model TANK

+ Medium Scale **TANK + capital** (Bilbiie et al. (2022a))

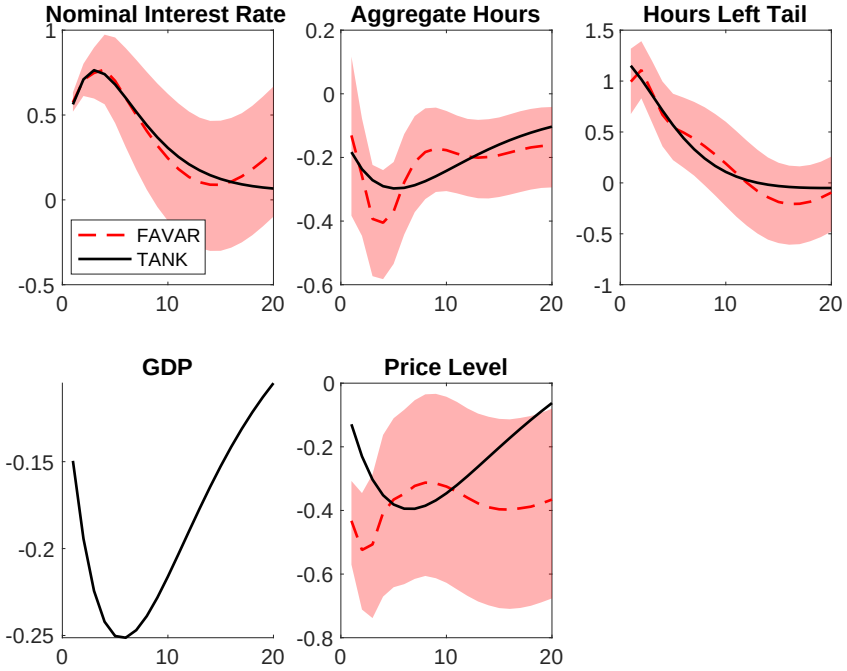
- We abstract from idiosyncratic risk, fiscal redistribution and sticky wages.

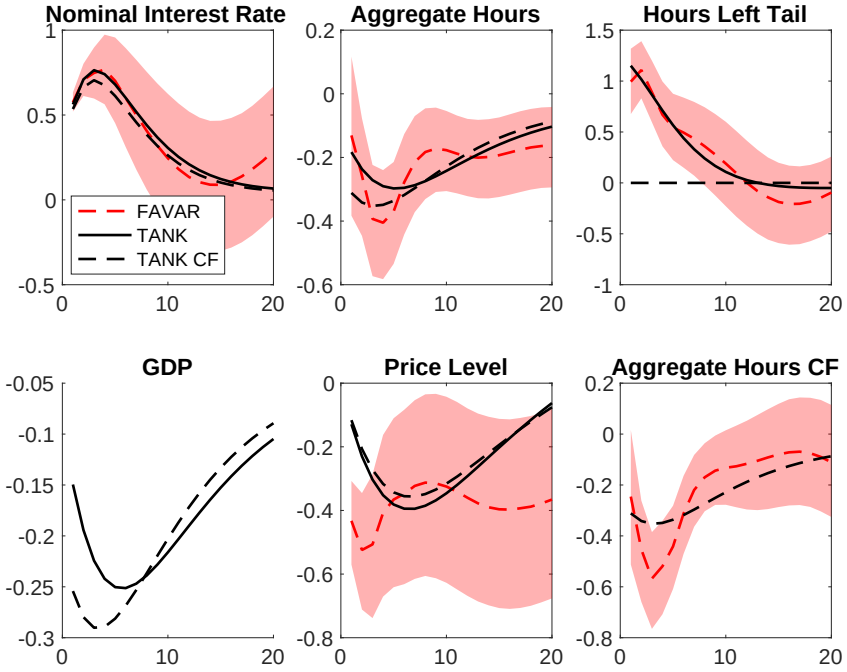
+ allow for **labor supply heterogeneity**

+ Stone-Geary preferences that generate **income effects of labor supply decreasing in income**

▶ Estimate it by Bayesian IRF matching.

▸ Calibration/Estimation


Nominal Interest Rate
Aggregate Hours
Hours Left Tail
GDP
Price Level
FAVAR
TANK


Nominal Interest Rate
Aggregate Hours
Hours Left Tail
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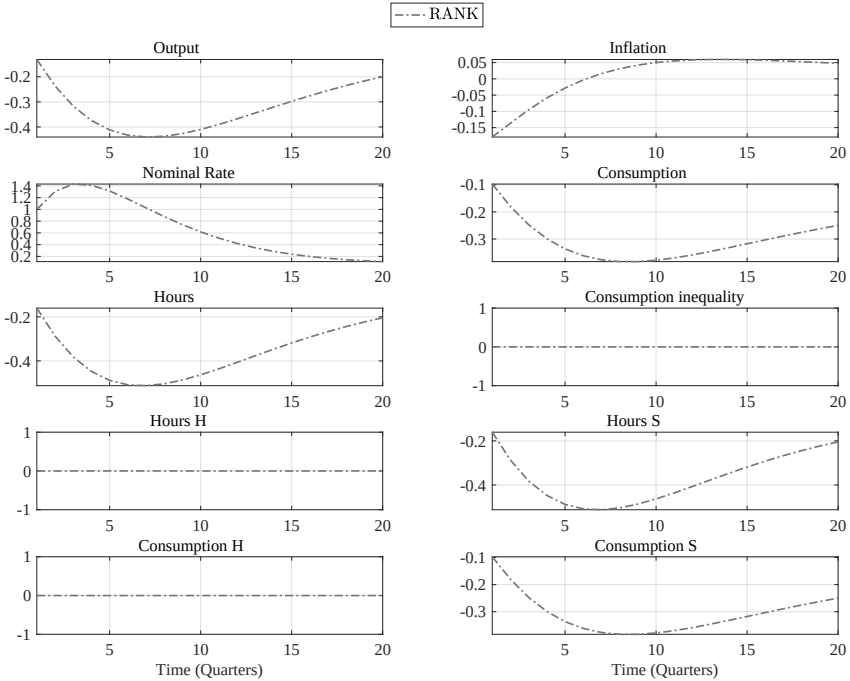
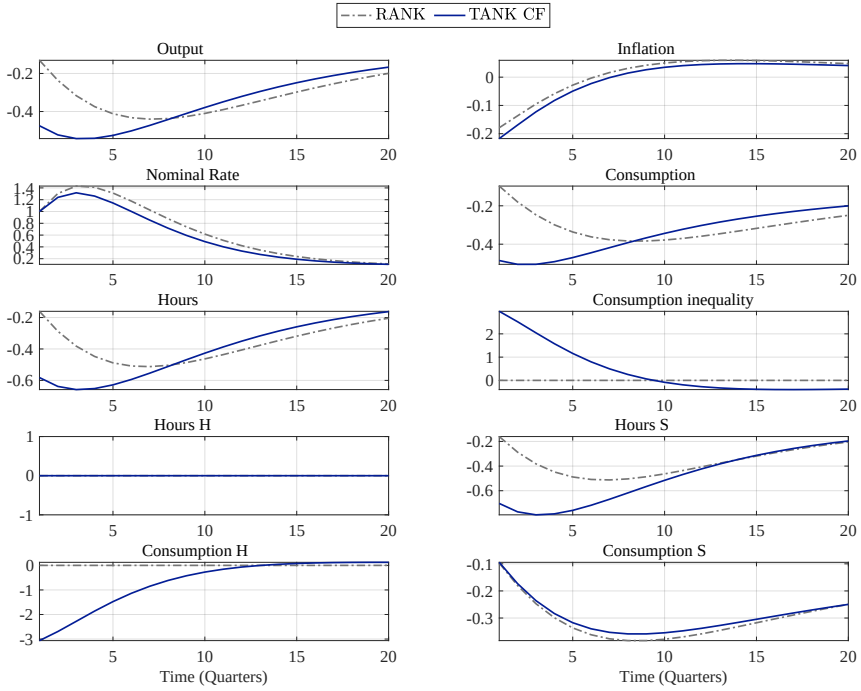
Aggregate Hours CF


RANK
Output
Inflation
Nominal Rate
Consumption
Hours
Consumption inequality
Hours H
Hours S
Consumption H
Consumption S
Time (Quarters)
Time (Quarters)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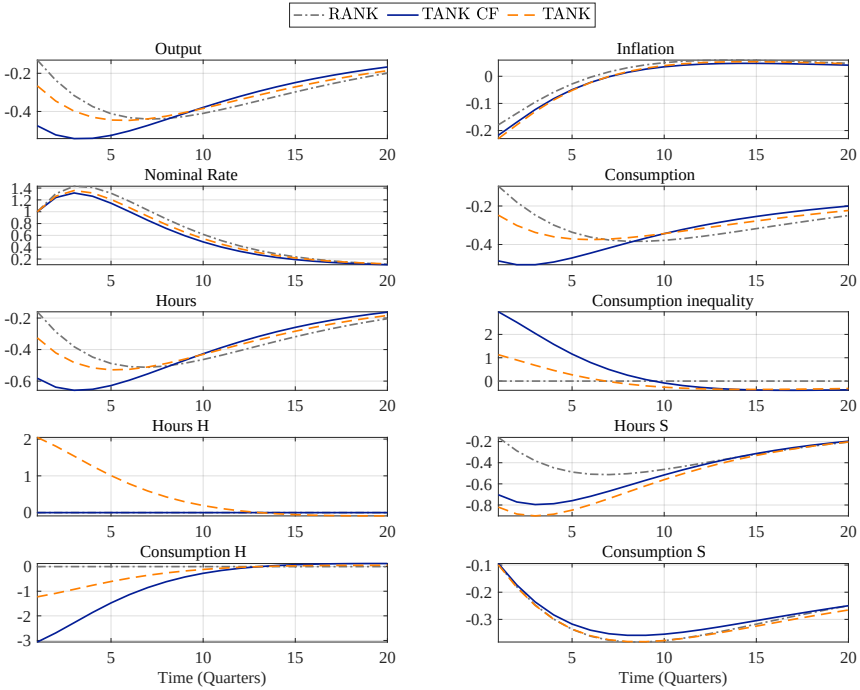
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Output
Inflation
Nominal Rate
Consumption
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Consumption inequality
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Consumption H
Consumption S
Time (Quarters)
Time (Quarters)

# The inflation-output trade-off

## Barnichon and Mesters (2021)

- The yearly cost in terms of output to bring down inflation by 1% conditional on MP shocks.

| RANK | TANK CF | TANK |
|---|---|---|
| 1.76 | 3.10 | 1.95 |

# Conclusions

## interaction between Monetary Policy and individual labor supply decisions

1. **New empirical facts**:
   - **Heterogeneous** response of hours worked to MP shock across the income distribution,
   - **Labor supply of poor household increases ⇒ Labor supply as insurance**
   - Hours at the left tail also exhibit a **larger elasticity**
2. We rationalize these results allowing for **heterogeneity in income effects** in a **TANK model**.
   - HtM that are able to stay in the labor market have an extra tool to use in response to a decline in their income. They can **increase their labor supply, substituting leisure for consumption**.
   - Novel transmission channel of inequality on Monetary policy which *reduces the amplification* of aggregate demand.

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# Hours and Wage data

## US CPS ORG

- We use hours worked last week in all jobs (hourslw) as our main measure of weekly hours.
- Our measure of hourly earnings is constructed by using the variable (rw), the amount earned per hour in 2019 dollars.
- We drop respondents that lie in the top and bottom percentile of the earnings distribution or are aged less than 18 or more than 66.

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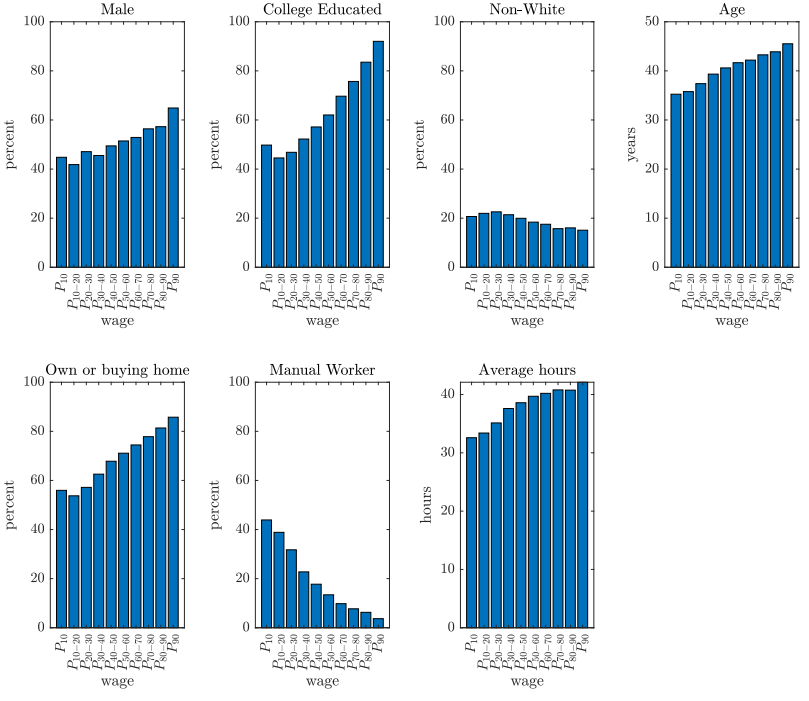
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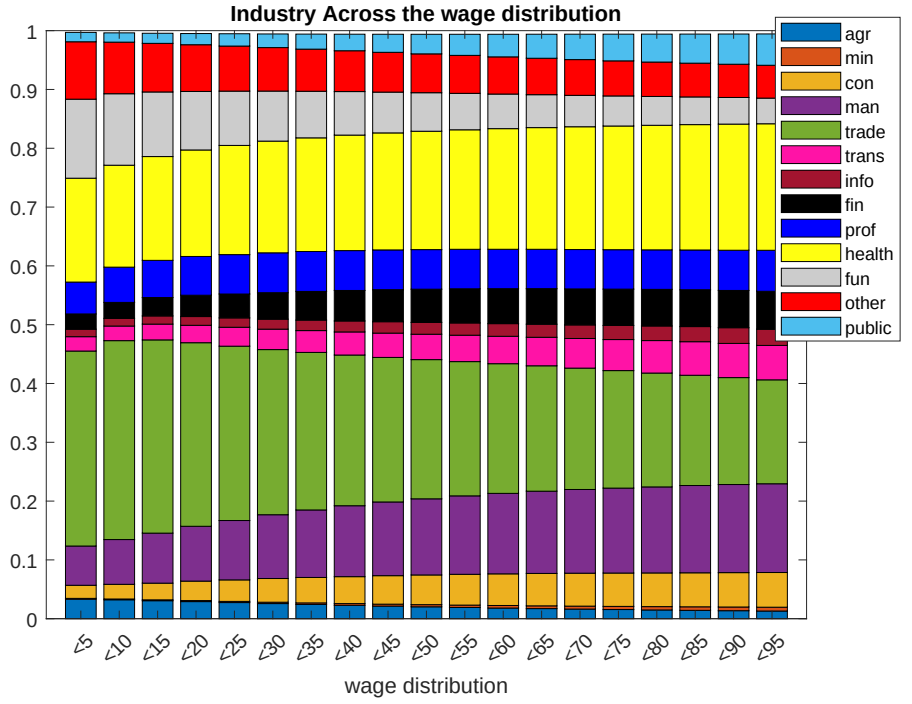
Industry Across the wage distribution
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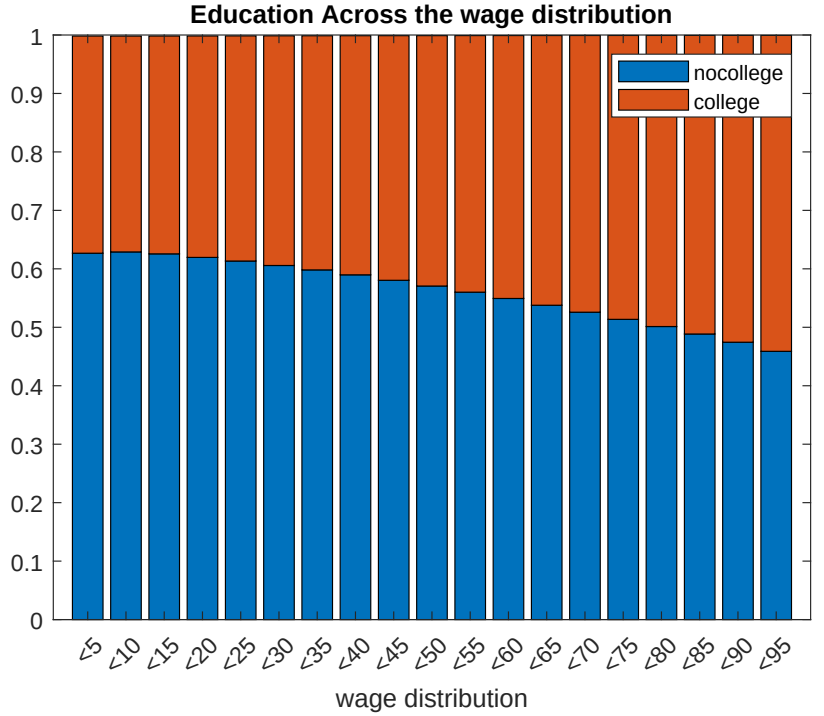
Education Across the wage distribution
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wage distribution

# Comparison with aggregate data

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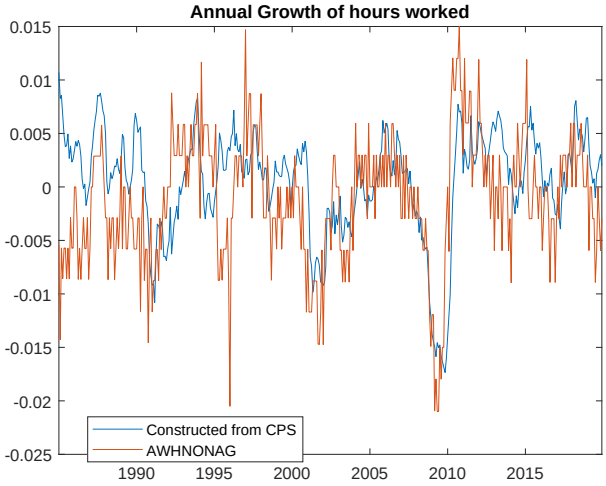


**Figure** Comparison of survey based total hours (blue) with aggregate (orange), US.

# Empirical Model

return

- We estimate a Factor Augmented VAR (FAVAR) in **levels**

$$Y_t = \begin{pmatrix} R_t \\ F_t \end{pmatrix} = c + \sum_{j=1}^{P} B_j Y_{t-j} + u_t \tag{1}$$

$$X_t = \beta_0 + \beta_1 \tau + \Lambda F_t + \Xi_t \tag{2}$$

  $R_t$ denotes the interest rate, $X_t$ contains **many** times series including surveys and $\hat{F}_t$ represent factors that summarize this information.
- Reduced form $u_t$ are related to structural macro shocks $\varepsilon_t$ via

$$u_t = A_0 \varepsilon_t$$

- Why a FAVAR?
  - Measurement errors in survey data. [$\Xi_t$ could be I(0) or I(1)]. Loadings control the extent to which different percentile respond to macro shocks. In a VAR these two sources of fluctuations may be conflated.
  - Identification.

# Empirical Model

return

- $m_t$ observed proxy of monetary policy *surprise*. [Stock and Watson (2008) and Mertens and Ravn (2013)]
- Relevance and exogeneity conditions

$$E(m_t \varepsilon_t') = [\alpha \;\; 0]$$
$$E(m_t u_t') = [\alpha \;\; 0] A_0' = b$$

- The latter parametrized and stacked with the FAVAR equations

$$m_t = b u_t + v_t \tag{3}$$

- the correlation is not spurious if $u_t$ and $m_t$ are unpredictable based on $t-1$ info set. With small scale VARs, $u_t$ might be predictable

# Empirical Model

return

- The number of factors in the FAVAR model for the US are chosen via the information criteria of Bai and Ng (2002).
- The $PC_p$ criteria suggest the presence of 11 factors for the US.
- The number of factors for the UK FAVAR are set to 13 (15 for LFS). ($PC_p$ suggests 11 but IRFs not consistent with theory: large price puzzle)
- The lag length is set to 2.
- The parameters of the VAR model and the instrument equation are estimated using the Gibbs sampling algorithm introduced by Bahaj (2020).

# US Monetary Policy Shock

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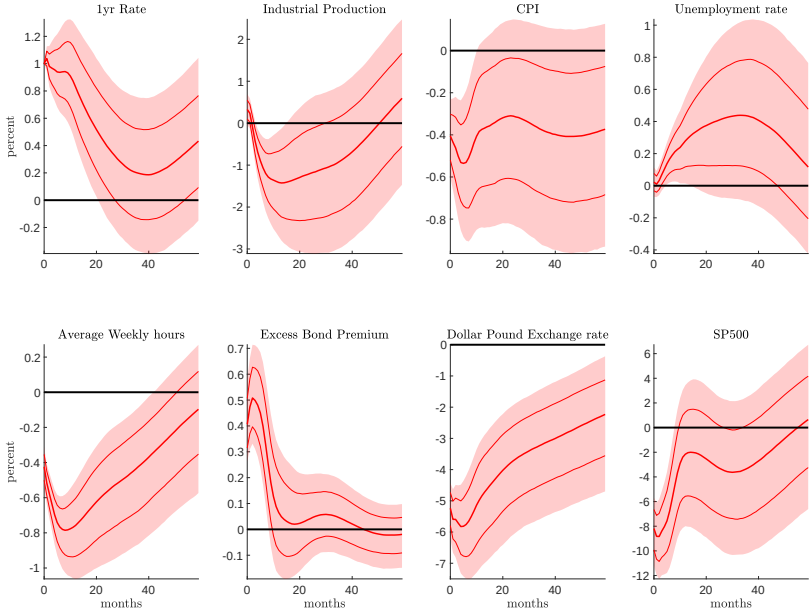

# Real wages across the enarnings distribution

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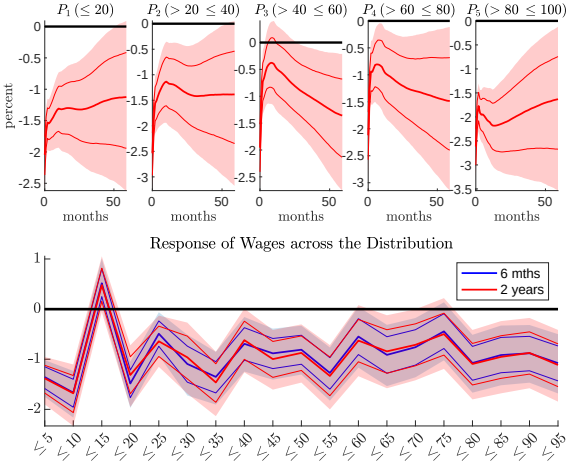

# Unemployment across the enarnings distribution

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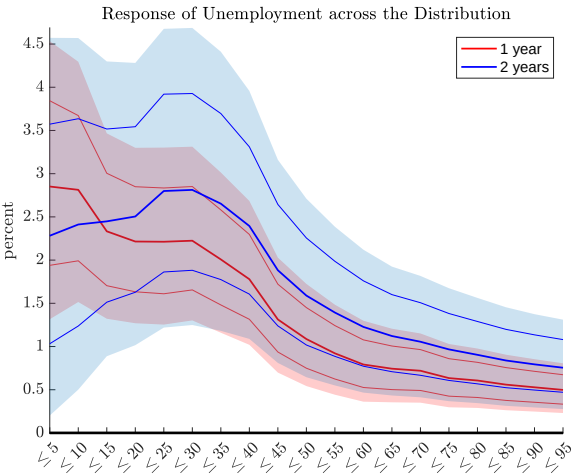

# Hours of continuosly employed individuals (3 months)

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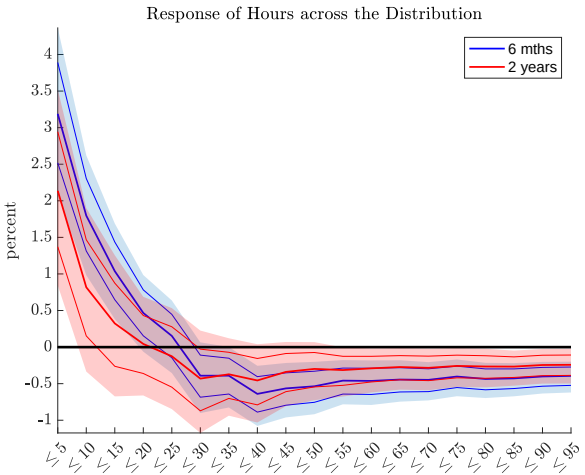

# The Left Tail of Labor supply using Miranda-Agrippino and Ricco (2021)

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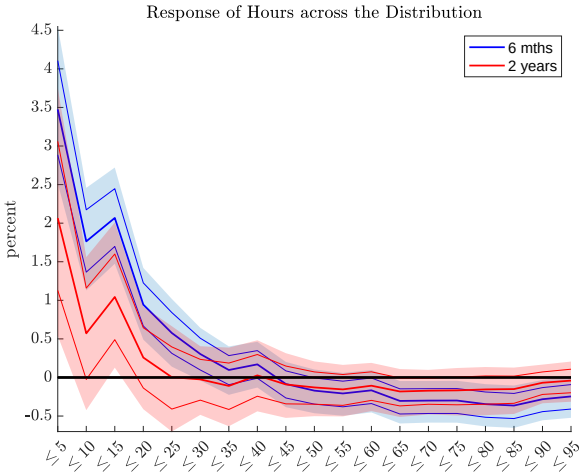

# The Left Tail of Labor supply using sign restrictions

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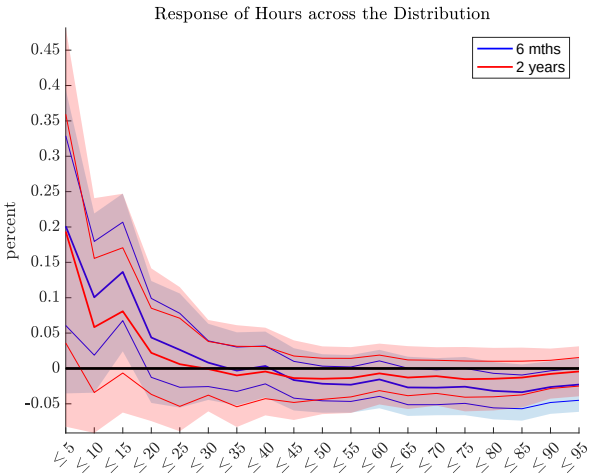
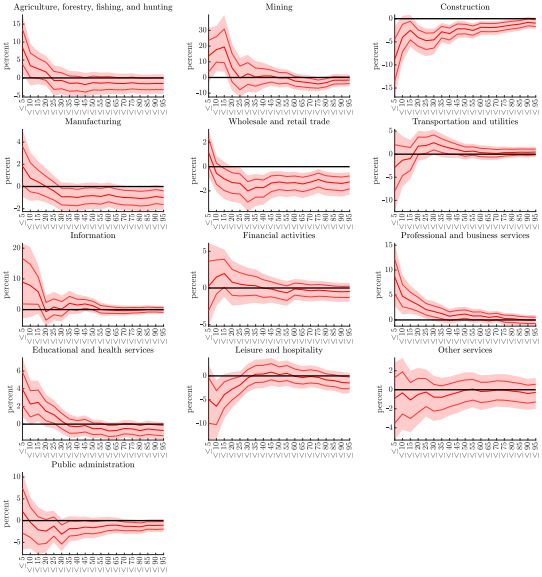


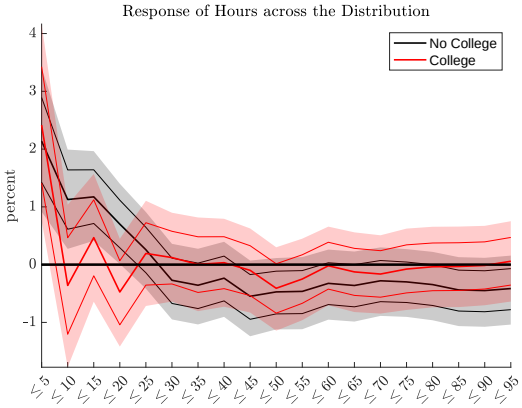
# Results by industry

return



# Results by education

return



# The left tail of Hours

## Variance contribution

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- Proportion of the variance of hours explained by the left tail of the earnings distribution:

| Percentile | Log Hours | Hours Growth (%) |
|---|---|---|
| **20 %** | 15.74% | 27.8% |
| **30 %** | 29.5% | 44.42% |

# Simple TANK model

## Bilbiie (2008)

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- The economy consists of households, firms and a central bank.
- There is a continuum of households $[0, 1]$.
- There are two types of households: A share $\lambda$ of households are HtM (**H**) who work and consume all of their income.
- The remaining $1-\lambda$ are savers (**S**) who hold bonds and shares in monopolistic firms and get firm profits.
- **Income effect (MUC) Heterogeneity**: $\left( \frac{(c_t^j)^{1-\frac{1}{\sigma_j}}}{1-\frac{1}{\sigma_j}} - \nu \frac{(H_t^j)^{1+\varphi}}{1+\varphi} \right)$ (with j=S,H). microfundation
- The firm sector is standard. Only labor used in production and Rotemberg price adjustment costs. **No extensive margin** for now.
- The central bank follows a Taylor type rule to choose the *real* interest rate. Only Monetary policy shocks.

| Log-linearized Conditions of TANK with HtM | | |
|---|---|---|
| 1: | Aggregate Condition | $(1-\lambda)\hat{H}_t^S + \lambda\hat{H}_t^H = \hat{H}_t = \hat{c}_t = (1-\lambda)\hat{c}_t^S + \lambda\hat{c}_t^H$ |
| 2: | Euler | $\hat{c}_t^S = \hat{c}_{t+1|t}^S - \sigma_S\left(\hat{R}_t - \hat{\Pi}_{t+1|t}\right)$ |
| 3-4: | Labor Supply $j = S, H$ | $\varphi\hat{H}_t^j = \hat{w}_t - \frac{1}{\sigma_j}\hat{c}_t^j$ |
| 5: | Budget constraint H | $\hat{c}_t^H = \hat{H}_t^H + \hat{w}_t$ |
| 6: | Phillips Curve | $\hat{\Pi}_t = \beta\hat{\Pi}_{t+1|t} + \kappa\hat{w}_t$ |
| 7: | Taylor Rule | $\hat{R}_t = \hat{\Pi}_{t+1|t} + \epsilon_t^m$ |

**Table** $S$ PIH *Savers*; $H$ poor HtM. Symmetric steady state: $c^H = c^S = H^H = H^S = 1$

▸ details

# Homogeneous Income Effects $\Rightarrow \sigma_H = \sigma_S$

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- **Savers**: $\hat{c}_t^S = -\sigma_S \epsilon_t^m$; **HtM**: $\hat{H}_t^H = \frac{\sigma_H - 1}{\sigma_H \varphi + 1}\hat{w}_t$; $\hat{c}_t^H = \frac{\sigma_H(\varphi+1)}{\sigma_H \varphi + 1}\hat{w}_t$
- Income effect heterogeneity helps also to capture the different Labor supply elasticities

- $\hat{c}_t^H = \chi \hat{y}_t$. $\chi$ is the **elasticity of HtM consumption to aggregate income**.
- $\chi = 1 + \varphi \geq 1 \Rightarrow$ **Monetary policy *amplification***

- Aggregate Euler:

$$\hat{c}_t = \hat{c}_{t+1|t} - \underbrace{\frac{(1-\lambda)\sigma_S}{1-\chi\lambda}}_{(+) \text{ when } \lambda\uparrow}(\hat{R}_t - \hat{\Pi}_{t+1|t})$$

Standard Aggregate Demand Logic (SADL)$\left(\lambda < \frac{1}{\chi}\right)$ = the slope of the aggregate IS curve remains negative.

# Heterogeneous Income Effects $\Rightarrow \sigma_H \neq \sigma_S$

return

- $\chi$ depends on $\lambda$ and relative strength of the income effects $\frac{\sigma_H}{\sigma_S}$

$$\chi = \frac{\frac{\sigma_H}{\sigma_S}(\varphi+1)\left(\sigma_S\varphi+1\right)}{\lambda\left(\frac{\sigma_H}{\sigma_S}-1\right)(\varphi+1)+\sigma_H\varphi+1}.$$

- Aggregate Euler equation:

$$\hat{c}_t = \hat{c}_{t+1|t} - \underbrace{\frac{(1-\lambda)\sigma_S}{1-(1+\varphi)\lambda}}_{(+)\text{ when }\lambda\uparrow} \times \underbrace{\frac{\lambda\left(\frac{\sigma_H}{\sigma_S}-1\right)(\varphi+1)+\sigma_H\varphi+1}{\sigma_H\varphi+1}}_{(-)\text{ when }\lambda\uparrow\text{ if }\frac{\sigma_H}{\sigma_S}<1} \times (\hat{R}_t - \hat{\Pi}_{t+1|t}).$$

numerical example

# Heterogeneity in Marginal Rate of Substitution (MRS)

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- The dampening effect is a consequence of the **additional heterogeneity in the MRS** between hours and consumption.

- With **homogeneous income effect** individual and aggregate MRS move in the same proportion $\varphi \hat{H}_t + \frac{\hat{c}_t}{\sigma_S} = \hat{w}_t$.
- With **heterogeneous income effects** this is no longer true:

$$\left(\varphi \hat{H}_t + \frac{\hat{c}_t}{\sigma_S}\right) \underbrace{+\lambda \left(1 - \frac{\sigma_H}{\sigma_S}\right) \frac{\hat{c}_t^H}{\sigma_H}}_{\Downarrow \text{ when } \lambda \uparrow \,\&\, \frac{\sigma_H}{\sigma_S} < 1} = \hat{w}_t$$

- Income effect heterogeneity makes the sign of the slope of the Euler equation depend on $\lambda$ even if we restrict our attention to the SADL region.

# TANK with non-homothetic preferences

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$$U(c_t^j, H_t^j) = \frac{(c_t^j - \bar{c})^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \nu^j \frac{(H_t^j)^{1+\varphi}}{1+\varphi}$$

- for $c^j \geq \bar{c}$ **Income effects decreasing (RA) in steady state consumption**:

$$\sigma_j = -c^j \frac{U''_{c^j}}{U'_{c^j}} = \frac{c^j}{\sigma(c^j - \bar{c})}$$

- Log-linear Labor supply: $\varphi \hat{H}_t^j = \hat{w}_t - \frac{c^j}{\sigma(c^j-\bar{c})} \hat{c}_t^j$
- If $\sigma < \frac{c^H}{(c^H-\bar{c})} \Leftrightarrow \frac{\partial \hat{H}_t^j}{\partial \hat{w}_t} < 0$

# Savers

return

- Savers maximize their lifetime utility subject to their budget constraint, taking prices and wages as given:

$$\max_{c_t^S, b_t^S, H_t^S} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left( \frac{(c_t^S)^{1-\frac{1}{\sigma_S}}}{1-\frac{1}{\sigma_S}} - \nu^S \frac{(H_t^S)^2}{2} \right) \quad \text{subject to}$$

$$c_t^S + b_t^S = \frac{1}{1-\lambda} d_t + H_t^S w_t + \frac{R_{t-1}}{\Pi_t} b_{t-1}^S,$$

- $\Pi_t$ is inflation, $w_t$ are real wages, $R$ is the gross nominal interest rate on bonds and $d_t$ are firm profits. $\sigma_S$ is the inter-temporal elasticity of substitution and $\nu^S$ indicates how leisure is valued relative to consumption.

# Hand to Mouth

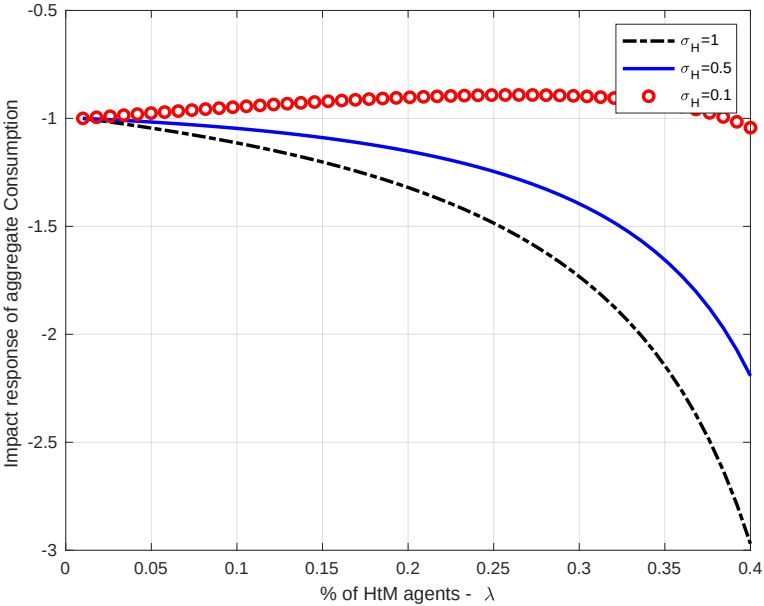
return

- HtM have no assets and thus consume their labor income as well as the transfer they get from the government:

$$\max_{c_t^H, H_t^H} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left( \frac{(c_t^H)^{1-\frac{1}{\sigma_H}}}{1-\frac{1}{\sigma_H}} - \nu^H \frac{(H_t^H)^2}{2} \right) \quad \text{subject to}$$

$$c_t^H \leq H_t^H w_t.$$

return


-0.5
-1
-1.5
-2
-2.5
-3
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Impact response of aggregate Consumption
% of HtM agents - λ
σH=1
σH=0.5
σH=0.1

# Calibration

return

| Parameter | Value | Description |
|---|---|---|
| $\beta$ | 0.99 | Discount Factor |
| $\varphi_H$ | 3 | Frisch$^{-1}$, HtM |
| $\varphi_S$ | 3 | Frisch$^{-1}$, HtM |
| $\delta$ | 0.025 | Capital depreciation |
| $s^L$ | 0.68 | Labor share |
| $\eta$ | 6 | Elasticity of substitution goods |
| $\lambda$ | 0.2 | Share of HtM Agents |
| $\bar{\Pi}$ | 1 | Steady State Inflation Convention |
| $\bar{H}^H$ | 0.275 | Steady State Hours, HtM |
| $\bar{H}^S$ | 0.33 | Steady State Hours, Savers |

# Estimation

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| Parameter | Description | Prior | Posterior |
|---|---|---|---|
| $\sigma_H$ | $RA^{-1}$, HtM | N(1,0.2) | 0.05 (0.01,0.12) |
| $\sigma_S$ | $RA^{-1}$, Savers | N(1,0.2) | 0.32 (0.21,0.47) |
| $b_H$ | Habits, HtM | B(0.7,0.15) | 0.89 (0.82,0.96) |
| $b_S$ | Habits, Savers | B(0.7,0.15)) | 0.29 (0.21,0.37) |
| $\iota$ | Investment adjustment costs | N(5,1.5) | 7.43 (5.61,9.03) |
| $\rho^{r1}$ | AR(1) Monetary Policy shock | B(0.7,0.15) | 0.71 (0.55,0.89) |
| $\rho^{r2}$ | AR(2) Monetary Policy shock | N(0,0.5) | 0.11 (-0.09,0.23) |
| $\phi^r$ | Interest rate smoothing | B(0.7,0.2) | 0.62 (0.49,0.76) |
| $\phi^\pi$ | Taylor rule coeff of inflation | $\Gamma$(1.7,0.15) | 1.71 (1.55,1.93) |
| $\phi^y$ | Taylor rule coeff of output | $\Gamma$(0.1,0.1) | 0.02 (0.00,0.6) |
| $\phi^p$ | Calvo prices | B(0.7,0.2) | 0.89(0.81,0.93) |