Imperfect Risk-Sharing and the Business Cycle

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Imperfect risk-sharing and business cycles

- Does households' heterogeneity matter for business cycles?
- Recent literature (Incomplete markets + New Keynesian models): answer is "yes"
  - Idiosyncratic income risk and debt limits affect households' saving behavior
  - Time-varying precautionary motives affect aggregate demand
- Challenging to quantify these channels. Answer depends on modeling of risk-sharing mechanisms available to households and the risk they face
  - Ex: Bond vs. two assets (liquid vs illiquid) economy behave very differently
  - Ex: Cyclicality of firms' profits/timing of fiscal transfers matter for quantification
- We develop a methodology robust to these considerations

Our approach in a nutshell

We start with a *class* of New Kenesian models with heterogeneous agents

- Assets, financial constraints and nature of idiosyncratic risk mostly unrestricted

We will work with an equivalent representation (Krueger and Lustig, 2010; Werning, 2015): that of a representative-agent economy with state-dependent preferences

- Discount factor (captures time-varying precautionary motives in HA economy)
- Disutility of labor (captures changes in labor composition in HA economy)

Our main observation: These preference “shocks” are functions of households’ consumption choices and relative wages

1. Use the CEX to measure the “preference shocks”
2. Use RA economy to measure the aggregate implications of imperfect risk-sharing

Our findings: Deviations from perfect risk-sharing account for 20% of the drop in output during the Great Recession

▸ Literature

Outline

1. A class of New Keynesian models with heterogeneous agents

2. The equivalent representative agent economy with preference "shocks"

3. Measuring the preference shocks

4. An application to the US Great Recession

Overview

We consider a *class* of New Keynesian models with heterogeneous agents

- “Macro block”: Standard “three-equations” NK model
    - Rotemberg (1982) price-adjustment costs
    - Aggregate shocks: preference, technology and monetary policy
- “Micro block”: Consumption/saving problem under idiosyncratic income risk
    - Allow for many assets (nest the complete markets case)
    - Introduce *transaction costs* and *trading restrictions*

Preferences and technology

- z_t and v_t are aggregate and idiosyncratic states. Let $z^t = (z_0, \ldots, z_t)$, $v^t = (v_0, \ldots, v_t)$, $s^t = (z^t, v^t)$, with $\Pr(s^t | s^{t-1}) = \Pr(v^t | z^t, v^{t-1}) \Pr(z^t | z^{t-1})$
- Households' preferences

$$\sum_t \sum_{s^t} \Pr(s^t | s_0) \beta^t \tilde{\theta}(z^t) \left[\frac{c(s^t)^{1-\sigma}}{1-\sigma} - \chi \frac{l(s^t)^{1+\psi}}{1+\psi} \right]$$

- Competitive final good firms use intermediates to produce final good

$$Y(z^t) = \left(\int_0^1 y_i(z^t)^{1/\mu} di \right)^{\mu}$$

- Monopolistic competitive firms use labor to produce intermediate goods

$$y_i(z^t) = A(z_t) n_i(z^t)$$

where $n_i(z^t)$ is labor in efficiency units. Quadratic price-adjustment costs

The problem of the households

Households choose labor, consumption and savings

$$\max_{c,l,b,\{a_k\}_{k\in\mathcal{K}}} \sum_t \sum_{s^t} \Pr\left(s^t|s_0\right) \beta^t \tilde{\theta}(z^t) \left[\frac{c\left(s^t\right)^{1-\sigma}}{1-\sigma} - \chi \frac{l(s^t)^{1+\nu}}{1+\nu}\right]$$

subject to

$$P\left(z^t\right) c\left(s^t\right) + \sum_{k\in\mathcal{K}} q_k(s^t) a_k\left(s^t\right) + \mathcal{T}\left(\left\{a_k\left(s^{t-1}\right)\right\}, \left\{a_k\left(s^t\right)\right\}, s^t\right) + \frac{b\left(s^t\right)}{i\left(z^t\right)}$$

$$\leq W\left(z^t\right) e(v_t) l\left(s^t\right) + b\left(s^{t-1}\right) + \sum_{k\in\mathcal{K}} R_k\left(s^{t-1}, s_t\right) a_k\left(s^{t-1}\right)$$

$$\mathcal{H}\left(b(s^t), \{a_j(s^t)\}_{k\in\mathcal{K}}, s^t\right) \geq 0$$

- $\mathcal{T}(.)$ are transaction costs, $\mathcal{H}(.)$ trading restrictions
- $\mathcal{H}_b(.) \geq 0$ so agents with highest marginal valuation for b are on Euler equation
- Nests large class of models with incomplete markets

Closing the model

- New-Keynesian Phillips curve ▸ Details

$$\tilde{\pi}\left(z^t\right) = \frac{1}{\kappa\left(\mu - 1\right)} Y(z^t) \left[\mu \frac{w(z^t)}{A\left(z_t\right)} - 1\right] + \sum_{z^{t+1}} Q(z^{t+1}|z^t)\tilde{\pi}\left(z^{t+1}\right)$$

where we define $\tilde{\pi}\left(z^t\right) = [(\pi(z^t) - \bar{\pi})/(1+\bar{\pi})] \times [(\pi(z^t)+1)/(1+\bar{\pi})]$

- Monetary policy follows standard Taylor rule

$$i(z^t) = \max\left\{ [i(z^{t-1})]^{\rho_i} \left[\bar{i}\left(\frac{1+\pi(z^t)}{1+\bar{\pi}}\right)^{\gamma_\pi}\left(\frac{Y(z^t)}{Y^{\text{pot}}(z^t)}\right)^{\gamma_y}\right]^{1-\rho_i} \exp\{\varepsilon_m(z_t)\}, 1\right\}$$

- In equilibrium, labor, goods and financial markets clear

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Heterogeneity and the Euler equation

Euler equations in the model

$$\frac{1}{i(z^t)} = \lambda(s^t) \cdot \mathcal{H}_b + \beta \sum_{s_{t+1}} \Pr\left(s^{t+1} | s^t\right) \left\{ \frac{\theta(z^{t+1})}{1 + \pi\left(z^{t+1}\right)} \left(\frac{c\left(s^t, s_{t+1}\right)}{c\left(s^t\right)} \right)^{-\sigma} \right\}$$

Heterogeneity and the Euler equation

Euler equation holds for household(s) with highest marginal valuation

$$\frac{1}{i(z^t)} = \beta \max_{v^t} \sum_{s_{t+1}} \Pr\left(s^{t+1}|s^t\right) \left\{ \frac{\theta(z^{t+1})}{1+\pi\left(z^{t+1}\right)} \left(\frac{c\left(s^t, s_{t+1}\right)}{c\left(s^t\right)} \right)^{-\sigma} \right\}$$

Heterogeneity and the Euler equation

Divide and multiply by $[C(z^{t+1})/C(z^t)]^{-\sigma}$

$$\frac{1}{i(z^t)} = \beta \max_{v^t} \sum_{s_{t+1}} \Pr\left(s^{t+1}|s^t\right) \left\{ \frac{\theta(z^{t+1})}{1+\pi\left(z^{t+1}\right)} \left(\frac{c(s^t)/C(z^t)}{c(s^{t+1})/C(z^{t+1})} \right)^{-\sigma} \left(\frac{C\left(z^{t+1}\right)}{C\left(z^t\right)} \right)^{-\sigma} \right\}$$

Heterogeneity and the Euler equation

Aggregate C, π and i satisfy the Euler equation

$$\frac{1}{i(z^t)} = \beta \max_{v^t} \sum_{z_{t+1}} \Pr\left(z^{t+1}|z^t\right) \left\{ \frac{\theta(z^{t+1})\beta(v^t, z^{t+1})}{1+\pi\left(z^{t+1}\right)} \left(\frac{C\left(z^{t+1}\right)}{C\left(z^t\right)}\right)^{-\sigma} \right\}$$

where

$$\beta(v^t, z^{t+1}) = \sum_{v_{t+1}} \Pr(v_{t+1}|z^{t+1}, v^t) \left(\frac{c(v^t, z^t)/C(z^t)}{c(v^{t+1}, z^{t+1})/C(z^{t+1})}\right)^{-\sigma}$$

Same FOC of RA agent economy with state-dependent discount factor $\beta(v^t, z^{t+1})$

- With complete markets, consumption shares are constant. Euler equation as in RA economy, $\beta(v^t, z^{t+1}) = 1$
- With incomplete markets, consumption shares varies. Then $\beta(v^t, z^{t+1})$ varies

Remark : Conditional on allocation, $\beta(v^t, z^{t+1})$ does not depend on $\{\mathcal{K}, \mathcal{T}, \mathcal{H}\}$

Heterogeneity and labor supply

Optimal labor supply

$$\chi l(s^t)^{\psi} = w(z^t)e(v_t)c(s^t)^{-\sigma}$$

Heterogeneity and labor supply

Multiply both sides by $e(v_t)C(z^t)^{\frac{\sigma}{\psi}}$ and aggregate across households

$$\chi^{\frac{1}{\psi}} \underbrace{\left[\sum_{v^t} \Pr(v^t|z^t)e(v_t)l(s^t)\right]}_{L_e(z^t)} C(z^t)^{\frac{\sigma}{\psi}} = w(z^t)^{\frac{1}{\psi}} \left\{\sum_{v^t} \Pr(v^t|z^t)e(v_t)^{\frac{1+\psi}{\psi}} \left[\frac{c(s^t)}{C(z^t)}\right]^{-\frac{\sigma}{\psi}}\right\}$$

Heterogeneity and labor supply

Aggregate C, w and L_e satisfy the condition

$$\omega(z^t)\chi L_e(z^t)^{\psi} = \frac{w(z^t)}{C(z^t)^{\sigma}}$$

where

$$\omega(z^t) = \left\{ \sum_{v^t} \Pr(v^t|z^t) \left[\frac{c(s^t)}{C(z^t)} \right]^{-\frac{\sigma}{\psi}} e(v_t)^{\frac{1+\psi}{\psi}} \right\}^{-\psi}$$

Same FOC of RA agent economy with state-dependent disutility of labor

- With complete markets, consumption shares are constant. Labor supply as in RA economy with state-dependent disutility of labor (substitution effects)
- With incomplete markets, consumption shares varies. Additional wealth effects

Remark : Conditional on allocation, $\omega(z^t)$ does not depend on $\{\mathcal{K}, \mathcal{T}, \mathcal{H}\}$

An equivalent representative-agent economy

Suppose that C, Y, π, i are part of an equilibrium. Then they satisfy

$$
\begin{aligned}
\tilde{\pi}(z^t) &= \frac{Y\left(z^t\right)}{\kappa\left(\mu-1\right)}\left[\mu\chi\frac{Y(z^t)^{\psi}C\left(z^t\right)^{\sigma}\,\omega(z^t)}{A(z_t)^{1+\psi}}-1\right]+\sum_{\mathbf{s}'}Q(z^{t+1}|z^t)\tilde{\pi}(z^{t+1}) \\
\frac{1}{i\left(z^t\right)} &= \beta\max_{v^t}\sum_{z^{t+1}}\Pr\left(z^{t+1}|z^t\right)\left\{\frac{\theta(z^{t+1})\beta\left(v^t,z^{t+1}\right)}{1+\pi\left(z^{t+1}\right)}\left(\frac{C\left(z^{t+1}\right)}{C\left(z^t\right)}\right)^{-\sigma}\right\} \\
i(z^t) &= \max\left\{[i(z^{t-1})]^{\rho_i}\left[\bar{i}\left(\frac{1+\pi(z^t)}{1+\bar{\pi}}\right)^{\gamma_\pi}\left(\frac{Y(z^t)}{Y^{\text{pot}}(z^t)}\right)^{\gamma_y}\right]^{1-\rho_i}\exp\{\varepsilon_m(z_t)\},1\right\} \\
Y\left(z^t\right) &= C\left(z^t\right)+\frac{\kappa}{2}\left[\frac{\pi(z^t)-\bar{\pi}}{1+\bar{\pi}}\right]^2
\end{aligned}
$$

Key observation: Knowledge of $\{\beta(v^t, z^{t+1}), \omega(z^t)\}$ is all we need from the "micro block" to characterize law of motion for aggregate variables

▸ Some examples

Counterfactuals at a conceptual level

Can use representation to assess macroeconomic effects of imperfect risk-sharing

1. Suppose we know

$$x = \{\theta(z_t), A(z_t), \epsilon_m(z_t), \beta(v^t, z^{t+1}), \omega(z^t)\}$$

   We can use equivalent representative-agent economy and x to obtain

$$y = \{Y(z^t), \pi(z^t), i(z^t)\}$$

2. Solve for the "complete markets" counterfactual $y^{\text{cm}} = \{Y^{\text{cm}}(z^t), \pi^{\text{cm}}(z^t), i^{\text{cm}}(z^t)\}$ by feeding

$$x^{\text{cm}} = \{\theta(z_t), A(z_t), \epsilon_m(z_t), \beta^{\text{cm}}(v^t, z^{t+1}), \omega^{\text{cm}}(z^t)\}$$

   in equivalent representative-agent economy

Contribution of imperfect risk-sharing to macroeconomic aggregates

$$y - y^{\text{cm}}$$

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Taking stock

- To perform the counterfactual we need to measure $\{\beta(v^t, z^{t+1}), \omega(z^t), \omega^{\text{cm}}(z^t)\}$
- These are functions of consumption shares and relative wages
- We use the Consumption Expenditure Survey (CEX) to measure these objects and construct empirical counterpart to $\{\beta(v^t, z^{t+1}), \omega_t, \omega_t^{\text{cm}}\}$
- Main findings
  - $\beta(v^t, z^{t+1})$ of "savers" increases substantially in Great Recession
  - $\omega(z^t)$ and $\omega^{\text{cm}}(z^t)$ close to each other

Constructing $\beta(v^t, z^{t+1})$

$$\beta(v^t, z^{t+1}) = \sum_{v_{t+1}} \Pr(v_{t+1}|z^{t+1}, v^t) \left[\frac{c(z^t, v^t)/C(z^t)}{c(z^{t+1}, v^t, v_{t+1})/C(z^{t+1})} \right]$$

Want

- Expected inverse change in consumption shares for an individual with history v^t

Problem

- For each individual, v^t, we observe only one realization of v_{t+1}

Constructing $\beta(v^t, z^{t+1})$

$$\beta(v^t, z^{t+1}) = \sum_{v_{t+1}} \Pr(v_{t+1}|z^{t+1}, v^t) \left[\frac{c(z^t, v^t)/C(z^t)}{c(z^{t+1}, v^t, v_{t+1})/C(z^{t+1})}\right]$$

What we do

- Group individuals with same history v^t
- Compute realized cross-sectional mean of inverse change in consumption shares
- By law of large numbers, it equals $\beta(v^t, z^{t+1})$

Constructing $\beta(v^t, z^{t+1})$

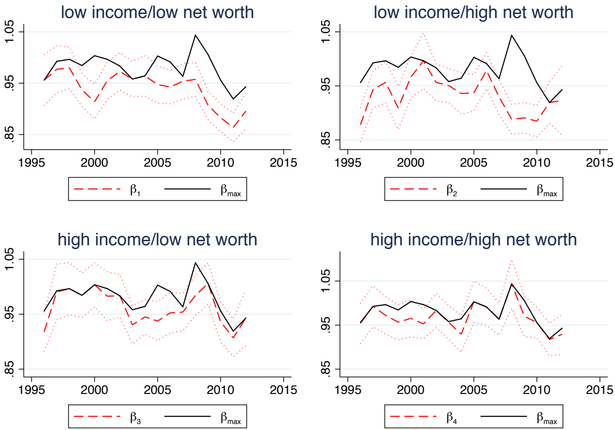
$$\beta(v^t, z^{t+1}) = \sum_{v_{t+1}} \Pr(v_{t+1}|z^{t+1}, v^t) \left[\frac{c(z^t, v^t)/C(z^t)}{c(z^{t+1}, v^t, v_{t+1})/C(z^{t+1})} \right]$$

In particular

- Group individuals by income and net worth
  - Logic: Sufficient statistic for v^t in baseline incomplete markets economies
- Within each group i, compute

$$\beta_{it+1} = \frac{1}{N_i} \sum_{j=1}^{N_i} \frac{c_{jt}/C_t}{c_{jt+1}/C_{t+1}}$$

Path for β_{it+1} for each group



Two patterns:

1. High income households have higher β_{it+1} (more incentives to save) ▸ Details
2. β_{it+1} increases during Great Recession

▸ Robustness

Constructing $\omega(z^t)$

$$\omega(z^t) = \left\{ \sum_{v^t} \Pr(v^t|z^t) \left[\frac{c(s^t)}{C(z^t)} \right]^{-\frac{\sigma}{\psi}} e(v_t)^{\frac{1+\psi}{\psi}} \right\}^{-\psi}$$

- For each household, compute $e_{it} = w_{it}/W_t$ and $\varphi_{it} = c_{it}/C_t$
- Compute cross-sectional average

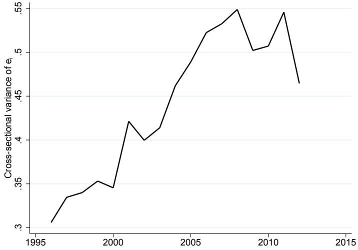
$$\omega_t = \left[\frac{1}{N} \sum_{i=1}^{N} \times \varphi_{it}^{-1} e_{it}^2 \right]^{-1}$$

- For ω_t^{cm}, set distribution of consumption shares to 1996 value

$$\omega_t^{\text{cm}} = \left[\frac{1}{N} \sum_{i=1}^{N} \varphi_{i1996}^{-1} \times \frac{1}{N} \sum_{i=1}^{N} e_{it}^2 + \text{Cov}\left(\varphi_{i1996}^{-1}, e_{i1996}^2 \right) \right]^{-\psi}$$

Path for $\omega(z^t)$ and $\omega^{\text{cm}}(z^t)$

(a) ω_t and ω_t^{cm}



(b) Variance of e_i

- ω_t mostly driven by increase in dispersion in relative wages
- Not much difference between ω_t and ω_t^{cm}

Outline

Counterfactuals in practice

We have detected an increase in β_{it+1} during the Great Recession. Is it big enough to induce sizable macroeconomic effects?

We use the equivalent representative-agent economy to answer this question

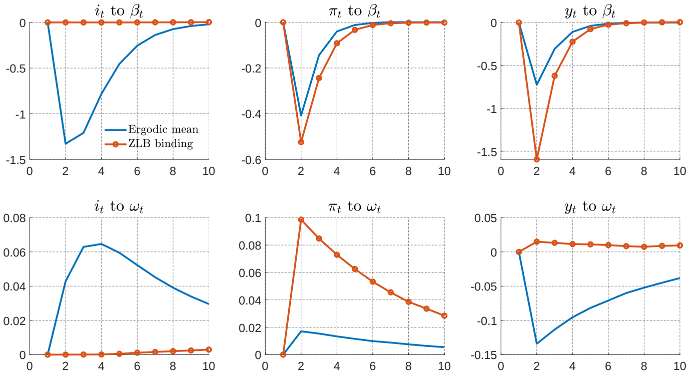
- Estimate structural parameters using data on $\{Y_t, \pi_t, i_t, \max_i \beta_{it+1}, \omega_t\}$
- Apply particle filter to estimate $\{\theta_t, A_t, \epsilon_{mt}\}$
- Solve equivalent RA economy under complete markets and compute counterfactual $y^{\text{cm}} = \{Y_t^{\text{cm}}, \pi_t^{\text{cm}}, i_t^{\text{cm}}\}$ by feeding $\{\theta_t, A_t, \varepsilon_{m,t}, \omega_t^{cm}\}$

Contribution of imperfect risk-sharing to macroeconomic aggregates

$$y - y^{\text{cm}}$$

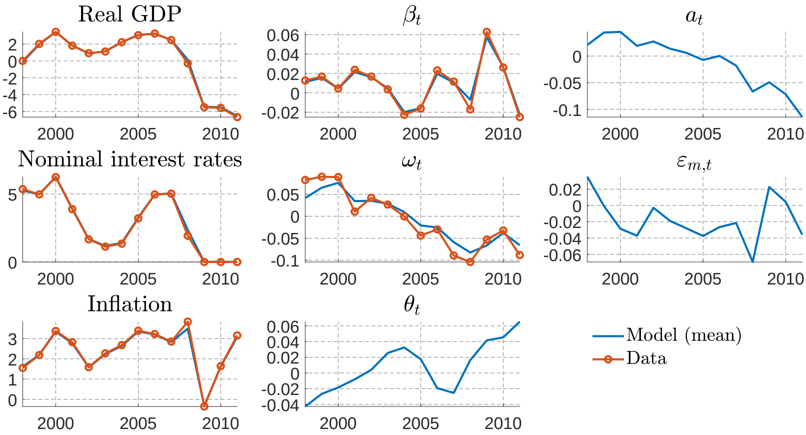
IRFs to β_t and ω_t in estimated model

2sd shocks to β_t and ω_t in estimated model



- $\uparrow \beta_t \rightarrow$ Lower aggregate demand, lower inflation $\rightarrow$ effects stronger if monetary authority constrained by ZLB
- $\uparrow \omega_t \rightarrow$ Higher marginal costs, higher inflation, lower output $\rightarrow$ Effects on output mitigated at the ZLB

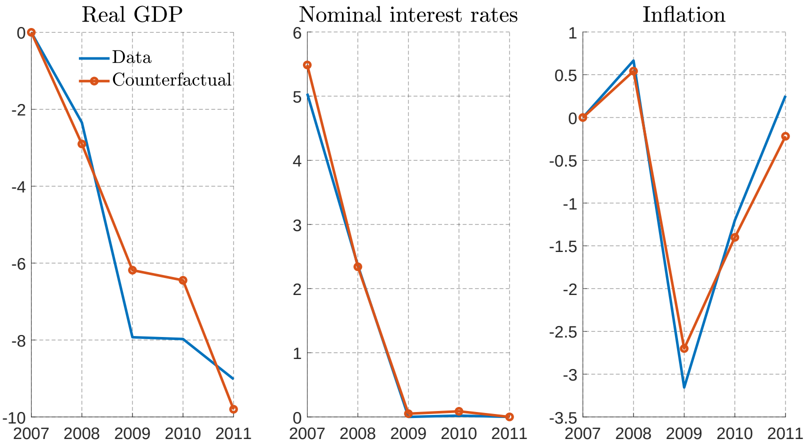
Estimate latent shocks via particle filter



Model needs positive shocks to θ_t to reach the ZLB

Counterfactual

Feed estimated $\{\theta_t, A_t, \varepsilon_{m,t}\}$ and ω_t^{cm} on model with $\beta_{it} = 1\ \forall t$



Milder recession ($\approx 20\%$) in 2009-2010 if households perfectly insured

▸ Model with capital ▸ Inspecting the mechanism

Conclusion

- Novel approach to evaluate macro models with incomplete markets
- Measure preference "shocks" of equivalent RA economy using the CEX
- Document increase in "discounting" around the Great Recession
  - Sizable aggregate effects when interpreted through the lens of NK models
- In the paper: use CEX to discriminate among different mechanisms that can generate increase in β_t
  - Evidence in favor of models that emphasize deterioration of risk-sharing mechanisms during Great Recession rather than an increase in idiosyncratic labor income risk

Additional Material

Literature

1. Aggregation results for models with incomplete markets
   - Nakajima (2005), Krueger and Lustig (2010), Werning (2015)
2. New Keynesian models with incomplete markets
   - Monetary and Fiscal policy: Auclert (2016), Kaplan, Moll and Violante (2017), McKay, Nakamura and Steinsson (2016), Auclert, Ronglie and Straub (2018), Bhandari et al. (2018), ...
   - Business cycles: Role of precautionary savings for business cycles
     - Occasionally binding financial constraints: Guerrieri and Lorenzoni (2017), Jones, Midrigan and Philippon (2018)
     - Time-varying idiosyncratic risk: Heathcote and Perri (2018), Challe et al. (2017), Bayer et al. (2019), ...
3. Asset pricing with incomplete markets
   - Vissing-Jorgensen (2002), Kocherlakota and Pistaferri (2009), Krueger, Lustig and Perri (2008), ...

Return

The problem of intermediate goods producers

- We assume that the firm discounts future profits using the real state price

$$Q\left(z^{t+1}\right)=\beta\max_{v^{t}}\left\{\Pr\left(z^{t+1}|z^{t}\right)\theta(z^{t+1})\sum_{v_{t+1}}\Pr\left(v^{t+1}|z^{t+1},v^{t}\right)\left[\frac{c\left(z^{t+1},v^{t+1}\right)}{c\left(z^{t},v^{t}\right)}\right]^{-\sigma}\right\}$$

- The firm's problem can be written recursively as

$$\begin{aligned} V\left(P_{j},z^{t}\right) &= \max_{p_{j},y_{j},n_{j}}\frac{y_{j}}{P\left(z^{t}\right)}-w(z^{t})n_{j}(z^{t})-\frac{\kappa}{2}\left[\frac{p_{j}}{P_{j}(1+\bar{\pi})}-1\right]^{2} \\ &+ \sum_{z^{t+1}}Q(z^{t+1}|z^{t})V\left(p_{j},z^{t+1}\right) \end{aligned}$$

- New-Keynesian Phillips curve

$$\tilde{\pi}\left(z^{t}\right)=\frac{1}{\kappa\left(\mu-1\right)}Y(z^{t})\left[\mu\frac{w(z^{t})}{A\left(z_{t}\right)}-1\right]+\sum_{z^{t+1}}Q(z^{t+1}|z^{t})\tilde{\pi}\left(z^{t+1}\right)$$

where we define $\tilde{\pi}\left(z^{t}\right)=\left[(\pi(z^{t})-\bar{\pi})/(1+\bar{\pi})\right]\times\left[(\pi(z^{t})+1)/(1+\bar{\pi})\right]$

Return

Some examples

"β" shocks important to explain Great Recession in representative-agent economies

- $\beta \uparrow \rightarrow$ representative household wants to save more
- Aggregate demand and inflation fall. Large effects if ZLB binds

HA economies endogenously induce time-variation in β. What mechanisms?

1. Time-varying idiosyncratic risk (Heathcote and Perri, 2018, ...) ▸ Example
   - Increase in idiosyncratic income risk + incomplete markets $\rightarrow$ more precautionary savings $\rightarrow$ *as if* $\beta \uparrow$
2. Tightening of borrowing constraints
   - Borrowers cannot borrow $\rightarrow$ Savers cannot save $\rightarrow$ *as if* $\beta \uparrow$ (Eggertson and Krugman, 2012)
   - Expectation of tightening in the future $\rightarrow$ more precautionary savings $\rightarrow$ *as if* $\beta \uparrow$ (Guerrieri and Lorenzoni, 2018)

▸ Return

A simple example

- Assume $\sigma = 1$
- Law of motion for idiosyncratic efficiency

$$\Delta \log[e(v_t)] = -\frac{\sigma(z_t)}{2} + \sigma(z_t)\varepsilon_{v,t}$$

- Asset market structure
  - Households can only trade a risk-free bond
  - Face a tight borrowing limit: $b(s^t) \geq 0$

In equilibrium financial autarky: every agent is hand-to-mouth

- Labor supply is the same for all households ($\sigma = 1$)
- Individual consumption: $c(s^t) = e(v_t)C(z^t)$

Idiosyncratic risk and aggregate demand

We can compute the "micro block"

$$\begin{aligned}
\beta(v^t, z^{t+1}) &= \sum_{v^{t+1}} \Pr(v^{t+1}|v^t, z^{t+1}) \exp\{-\Delta \log[e(v_{t+1})]\} \\
&= \exp\{\sigma(z^{t+1})\} \\
\omega(z^t) &= 1
\end{aligned}$$

Mechanism: high expected $\sigma(z_{t+1})$ increases precautionary motives. Higher desired savings manifests itself in the aggregate as increase in β

In benchmark NK models, these shocks lead to a fall in aggregate demand

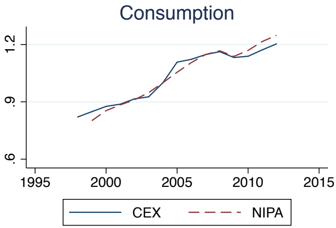
Return

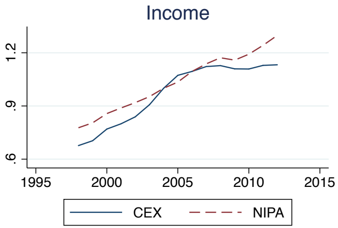
Data

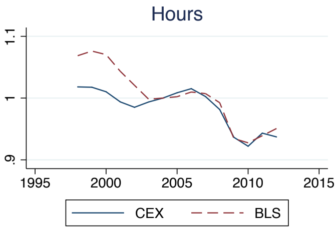
- We use the CEX (1996-2012). Head of household between 22 and 64 years old
- Data definitions
  - Consumption: Dollar spending in non-durables and services
  - Earnings: Labor + business income
  - Hours: Total hours worked per year
  - Net worth: Total assets (checking/savings accounts, bonds, stocks, house, car) minus total liabilities (mortgage and car loans)
- Mapping between model and data
  - Measure at household level and adjust for number of members
  - Control for characteristics that are not in the model: education, age, sex, race and state of residence
- Set $\sigma = 1$ and $\psi = 1$

▸ Comparison to NIPA ▸ Households' characteristics ▸ Measurement errors ▸ Return

Comparison with NIPA Aggregates







Return

Households’ characteristics in 2006

	CEX
Age of head	44.10
Household size	2.71
Head with college (%)	34.25
Consumption expenditures per person	10330.98
Labor income per person	26456.95
Disposable income per person	26492.00
Hours worked per person	1301.17
Wage per hour	21.69
Household’s net worth	142174.40
Liquid assets	14296.21

Notes: *The sample size is 2328 households. All statistics are computed using sample weights. All monetary variables are expressed in 2000 U.S. dollars.*

Return

Measurement errors

A concern is that time-series variation in $\{\beta_{it}, \omega_t\}$ are due to measurement errors.

- One form of measurement errors is recording errors that create extreme outliers. We remove top and bottom 1% for all variables used in the analysis

- We follow Vissing-Jorgensen (2002) and compute semi-annual changes in consumption to minimize both time aggregation and category switching concerns

$$\frac{c_m + c_{m+1} + c_{m+2} + c_{m+3} + c_{m+4} + c_{m+5}}{c_{m+6} + c_{m+7} + c_{m+8} + c_{m+9} + c_{m+10} + c_{m+11}}$$

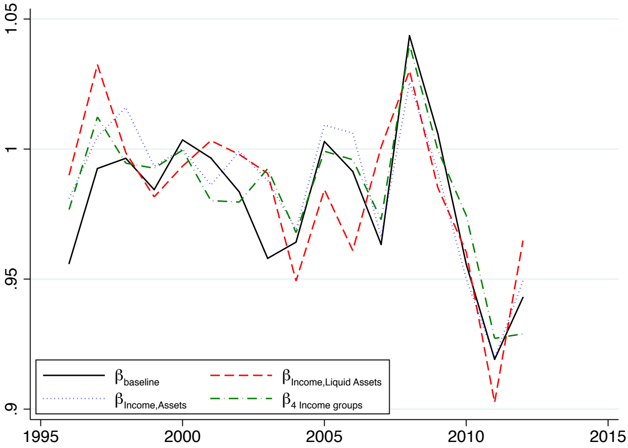
- β_{it} as cross-sectional averages across individuals. Under classical multiplicative measurement errors $(c_{it} = \tilde{c}_{it} \times \exp\{\eta_{it}\})$, we have as $N \to \infty$

$$\beta_{it} \approx \tilde{\beta}_{it} \times \exp\{\sigma_\eta\}$$

- We introduce measurement errors on $\{\beta_{it}, \omega_t\}$ (10% of their sample variance) when estimating the model and performing counterfactuals

Return

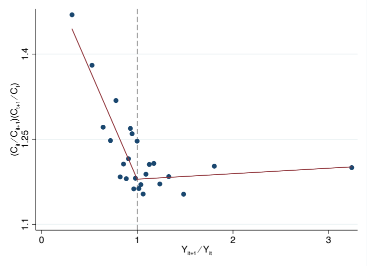
Path for β_{it+1} for each group



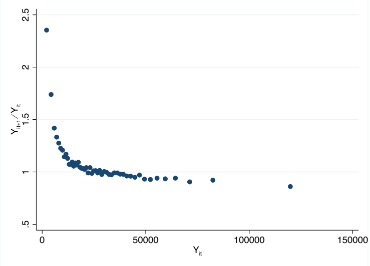
Pattern robust to alternative partitions based on income, assets, liquid assets

Return

Why high income households have higher β_{it+1}?



(c) $\frac{c_{it}/C_t}{c_{it+1}/C_{t+1}}$ vs $\frac{y_{it+1}}{y_{it}}$



(d) $\frac{y_{it+1}}{y_{it}}$ vs y_{it}

- Consumption shares falls when income falls (consumption sensitive to income)
- High income today predicts low income growth (mean reversion)

High income today predicts consumption shares to fall next period

Return

Estimation

- Restricted VAR(1) process for stochastic process
  - Structural shocks orthogonal
  - Do not allow for feedback of aggregate shocks on $\{\beta_{it+1}, \omega_t\}$ (imprecisely estimated given small sample)

- We set $\sigma = 1$, $\nu = 1$, $\mu = 1.2$, $\chi = 1/\mu$, $\bar{\pi} = 0.02$, $\beta = 0.99$

- Remaining parameters: $[\kappa, \rho_i, \gamma_\pi, \gamma_y]$ and those of stochastic process

- Evaluate likelihood function of equivalent representative-agent economy and estimate parameters using $\mathbf{Y}_t = \{Y_t, \pi_t, i_t, \max_i \beta_{it+1}, \omega_t\}$ as observables

▸ Parameters ▸ Model fit ▸ Montecarlo ▸ Return

Bayesian estimation

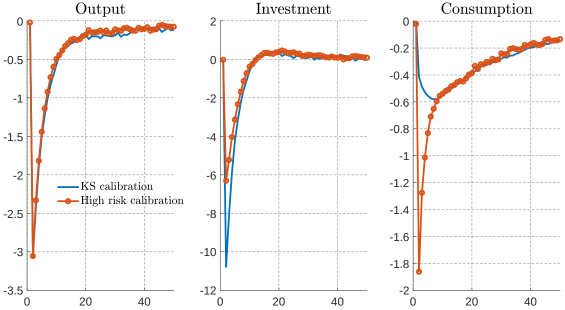
Estimate the first-order approximation of the model with Bayesian methods

	Prior			Posterior	
Parameter	Distribution	Mean	St. dev.	Mean	90% Interval
$4 \times \kappa$	Gamma	85.00	15.00	73.71	[52.17, 93.81]
ρ_i	Beta	0.50	0.25	0.57	[0.34, 0.80]
γ_π	Normal	1.50	2.00	3.72	[1.91, 5.41]
γ_y	Normal	1.00	2.00	0.18	[0.00, 0.42]
ρ_θ	Beta	0.50	0.28	0.69	[0.49, 0.90]
ρ_a	Beta	0.50	0.28	0.91	[0.83, 0.99]
$\Phi_{\beta,\beta}$	Beta	0.50	0.25	0.33	[0.06, 0.55]
$\Phi_{\omega,\omega}$	Beta	0.50	0.25	0.86	[0.74, 0.99]
$100 \times \sigma_\theta$	InvGamma	1.00	5.00	2.48	[1.02, 4.02]
$100 \times \sigma_a$	InvGamma	1.00	5.00	2.18	[0.73, 2.89]
$100 \times \sigma_m$	InvGamma	1.00	5.00	1.94	[1.15, 2.69]
$100 \times \sigma_\beta$	InvGamma	1.00	5.00	2.24	[1.51, 2.96]
$100 \times \sigma_\omega$	InvGamma	1.00	5.00	2.28	[1.29, 3.25]

Return

Monte Carlo Analysis

- We consider Krussel and Smith (1998) economy: RBC model where households
  - Face idiosyncratic productivity risk: $l_{it} \in \{0, \ell\}$
  - Can save by accumulating capital
- Two parametrizations:
  - KS calibration: $p(l_{it} = 0 | z_t = G) = 0.04$, $p(l_{it} = 0 | z_t = B) = 0.10$ and unemployment duration of 1.5 (2.5) quarters in good (bad) productivity states
  - "High risk" calibration: $p(l_{it} = 0 | z_t = G) = 0.30$, $p(l_{it} = 0 | z_t = B) = 0.2x$ and unemployment duration of 1.5 (7.5) quarters in good (bad) productivity states



Experiment

- Simulate panel of households' consumption shares, labor income and assets
- For each t, group households by income and assets (4 groups) and compute

$$\beta_{it+1} = \frac{1}{N_i} \sum_{j=1}^{N_i} \frac{c_{jt}/C_t}{c_{jt+1}/C_{t+1}}$$

- Select savers by picking group with highest average β_{it+1} in sample
- Estimate stochastic process for β^s_{it+1}

$$\beta^s_{it+1} = b_0 + b_1\beta_{it} + b_2 z_t + b_3 z_{t+1} + b_4 k_t + b_5 k_{t+1} \tag{1}$$

- Solve a RA economy where households has time-varying discount factor as in (1)
- Two specifications: large sample (T=15000, N=10000), small sample (T=100, N=5000)

Results: KS calibration

We compare business cycle properties of original HA economy and the equivalent representative agent economy

	HA economy	Ls	Ss (mean)	Ss (80% CI)
Stdev(y_t)	0.034	0.032	0.034	[0.033,0.035]
Stdev(c_t)	0.017	0.016	0.018	[0.017,0.019]
Stdev(i_t)	0.105	0.101	0.101	[0.086,0.116]
Corr(y_t, c_t)	0.687	0.691	0.681	[0.130,0.644]
Corr(c_t, i_t)	0.392	0.418	0.391	[0.492,0.854]
Corr(y_t, y_{t-1})	0.801	0.789	0.805	[0.792,0.817]
Corr(c_t, c_{t-1})	0.976	0.982	0.975	[0.940,0.995]
Corr(i_t, i_{t-1})	0.732	0.724	0.733	[0.725,0.741]

Under KS calibration, procedure recovers behavior of HA economy both in large and small samples

Results: High risk calibration

We perform the same experiment for the high risk calibration

	HA economy	Ls	Ss (mean)	Ss (80% CI)
Stdev(y_t)	0.034	0.032	0.032	[0.031,0.034]
Stdev(c_t)	0.023	0.021	0.022	[0.019,0.028]
Stdev(i_t)	0.073	0.071	0.077	[0.043,0.106]
Corr(y_t, c_t)	0.880	0.894	0.777	[0.509,0.982]
Corr(c_t, i_t)	0.604	0.671	0.497	[0.101,0.855]
Corr(y_t, y_{t-1})	0.793	0.778	0.788	[0.768,0.805]
Corr(c_t, c_{t-1})	0.821	0.910	0.928	[0.824,0.992]
Corr(i_t, i_{t-1})	0.769	0.706	0.706	[0.694,0.721]

Again, procedure recovers behavior of HA economy both in large and small samples

Return

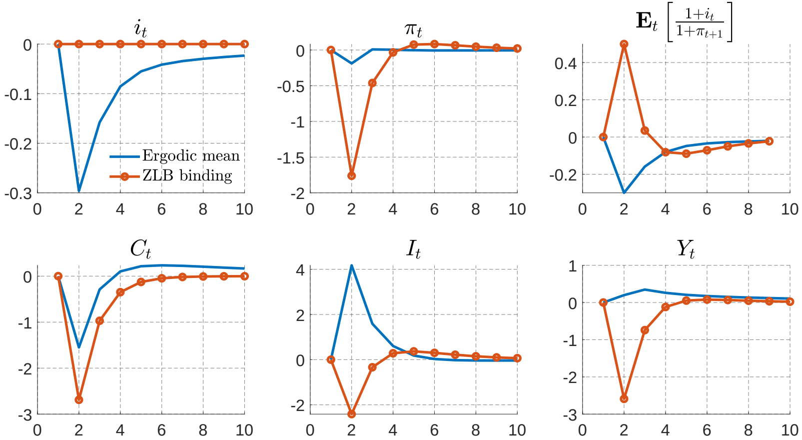
Model Fit

	Data	Model (linear)	Model (non-linear)
Mean(π_t)	2.69	2.00	1.87
Mean(i_t)	3.87	3.00	3.57
Stdev(Y_t)	4.15	3.42	5.85
Stdev(π_t)	1.23	1.59	1.50
Stdev(i_t)	3.02	2.68	3.16
Corr(Y_t, Y_{t-1})	0.93	0.85	0.81
Corr(i_t, i_{t-1})	0.90	0.72	0.42
Corr(π_t, π_{t-1})	0.51	0.14	0.17
Corr(Y_t, i_t)	0.11	-0.08	0.04
Corr(Y_t, π_t)	0.14	0.12	0.14
Corr(i_t, π_t)	0.71	0.52	0.68

Return

Model with capital

We consider version of the model with physical capital. At the ZLB, positive comovement between consumption, investment and output conditional on β_t shock



Return

Inspecting the mechanism

- Our analysis silent about drivers of β_{it+1}. Can use CEX to evaluate different mechanisms proposed in the literature

- Decompose β_{t+1} as

$$\beta_{it+1} = \underbrace{\left[\frac{C_{t+1}/C_t}{\frac{1}{N_i}\sum_{j=1}^{N_i} c_{jt+1}/c_{jt}}\right]}_{\text{Between group inequality}} \times \underbrace{\sum_{j=1}^{N_i}\left[\frac{\sum_{j=1}^{N_i} c_{jt+1}/c_{jt}}{c_{jt+1}/c_{jt}}\right]}_{\text{Within group inequality}}.$$

  - Most of the increase due to higher dispersion of consumption shares within high income/high net worth households
  - Two agents (TANK) models don't feature a Jensen term in β_{it+1}

- Two mechanisms can generate increase in dispersion of consumption shares

  1. Increase in the dispersion of labor income changes (Bayer et al., 2019; ...)
  2. Increase in sensitivity of consumption to income changes (Guerrieri and Lorenzoni, 2017; Jones, Midrigan and Philippon, 2018; ...)

- Limited evidence for 1, some evidence for 2

Return

Why β_{it+1} increases in Great Recession?

Mechanically, β_{it+1} can increase because of two forces

- The average consumption share of the group falls
- The dispersion in consumption share within the group increases

$$\beta_{it+1} = \underbrace{\left[\frac{C_{t+1}/C_t}{\frac{1}{N_i}\sum_{j=1}^{N_i} c_{jt+1}/c_{jt}}\right]}_{\beta_{AVG,it+1}} \times \underbrace{\sum_{j=1}^{N_i}\left[\frac{\sum_{j=1}^{N_i} c_{jt+1}/c_{jt}}{c_{jt+1}/c_{jt}}\right]}_{\beta_{JEN,it+1}}.$$

Return

Distribution of income changes

Distribution of Income changes									
Y_H Households	p1	p5	p10	p25	p50	p75	p90	p95	p99
2006-2007	0.25	0.44	0.69	0.80	0.94	1.06	1.23	1.41	2.00
2008-2009	0.21	0.45	0.69	0.81	0.95	1.07	1.23	1.38	1.89
Y_H, NW_H Households									
2006-2007	0.25	0.44	0.61	0.80	0.94	1.05	1.23	1.45	2.06
2008-2009	0.23	0.44	0.58	0.79	0.95	1.06	1.24	1.43	1.93

- For high income households, distribution of income changes very similar before and during Great Recession

Return

Sensitivity of consumption shares to income

We estimate the following relation, conditioning of $y_{it}/y_{it-1} < 1$

$$\frac{c_{it-1}/C_{t-1}}{c_{it}/C_t} = \alpha + \beta\frac{y_{it}}{y_{it-1}} + \delta \text{rec}_t + \gamma\frac{y_{it}}{y_{it-1}} \times \text{rec}_t + e_{it},$$

Consumption Response to Income Changes in 2006-2009					
	All Groups	Separate Groups			
		(Y_L, NW_L)	(Y_L, NW_H)	(Y_H, NW_L)	(Y_H, NW_H)
α	1.468***	1.726***	1.472***	1.438***	1.318***
	(17.49)	(7.95)	(11.77)	(7.66)	(10.22)
β	-0.247**	-0.579**	-0.213	-0.203	-0.0909
	(-2.47)	(-2.28)	(-1.39)	(-0.90)	(-0.59)
δ	0.287	-0.240	-0.0274	0.179	1.078**
	(1.59)	(-0.88)	(-0.16)	(0.73)	(1.96)
γ	-0.369*	0.220	-0.0584	-0.198	-1.272**
	(-1.74)	(0.69)	(-0.28)	(-0.68)	(-1.96)
N	9016	2032	2166	2305	2513

- For high income/high net worth households, consumption shares more sensitive to income changes in Great Recession

Return