Perceived versus Calibrated Income Risks in Heterogeneous-agent Consumption Models

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Outline

1. Motivation
2. Empirical evidence
   - Framework
   - Cross-sectional patterns
   - Unemployment risks
   - Perceived risks and decisions
3. Model
   - Subjective model
4. Conclusion

Motivation

- Risks matter for individual decisions
  - precautionary saving
  - stock market participation
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  - since idiosyncratic risks are not perfectly insured
    - $\rightarrow$ income/wealth inequality
    - $\rightarrow$ heterogeneous MPCs
    - $\rightarrow$ distributional channel of macroeconomic policies
    - $\rightarrow$ business cycle fluctuations

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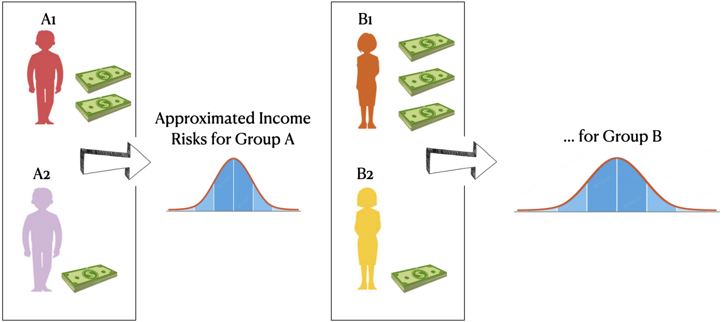
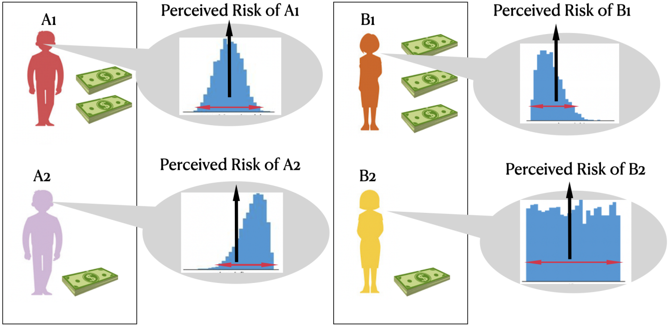
    - → income/wealth inequality
    - → heterogeneous MPCs
    - → distributional channel of macroeconomic policies
    - → business cycle fluctuations
- Income risks are central inputs of any incomplete-market model
  - Conventional approach: estimated using panel data
  - This paper: directly calibrating perceived risks from a survey

Conventional calibration: estimated from panel data



This paper: reported perceived risks in the survey



Some macro facts

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  - unless additional features such as preference heterogeneity or illiquid assets are introduced

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- Wealth inequality and heterogeneity in MPCs
  - a standard incomplete market model generates insufficient inequality compared to that seen in the data
  - unless additional features such as preference heterogeneity or illiquid assets are introduced
- Liquid assets holding
  - too low in data compared to a standard one-asset incomplete market model
- "Excessive sensitivity" to unanticipated transitory shocks
  - higher MPCs seen in the data than PIH model prediction

Preview of the findings

1. **Empirics:** perceived income risks (PRs) from a density survey
    - Heterogeneity: sizable difference across/within groups
    - Superior information/unobserved heterogeneity: lower than standard estimates/ parameterizations
    - Decisions: spending plans react to risk perceptions

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1. **Empirics:** perceived income risks (PRs) from a density survey
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   - Decisions: spending plans react to risk perceptions
2. **Model**:
   - survey-calibrated OLG / incomplete-market GE model
     - Lower PR → lower buffer-stock savings
     - Heterogeneity in PR → more wealth inequality
     - Heterogeneity in expected wage growth → more wealth inequality

Literature

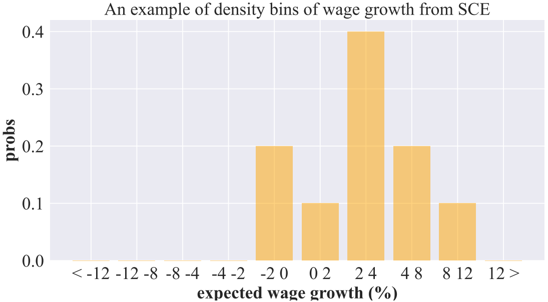
- income risks and partial insurance: Gottschalk et al. (1994), Carroll and Samwick (1997), Meghir and Pistaferri (2004), Storesletten et al. (2004), Blundell et al. (2008), Moffitt and Gottschalk (2002), Guvenen et al. (2014), Arellano et al. (2017), Bloom et al. (2018)
  - "insurance or information": Pistaferri (2001), Kaufmann and Pistaferri (2009), Meghir and Pistaferri (2011), Kaplan and Violante (2010)
- subjective/probabilistic survey of beliefs: Manski (2004), Delavande et al. (2011), Manski (2018), Bertrand and Mullainathan (2001), Armantier et al. (2017)
- incomplete market macro: Bewley (1976), Aiyagari (1994), Huggett (1996), Krusell and Smith (1998), Heathcote et al. (2009), Carroll et al. (2017), Krueger et al. (2016), Bayer et al. (2019)
- consumption/saving under incomplete information/imperfect perception: Pischke (1995), Wang (2004), Rozsypal and Schlafmann (2017), Carroll et al. (2018), Lian (2019)

Data and sample

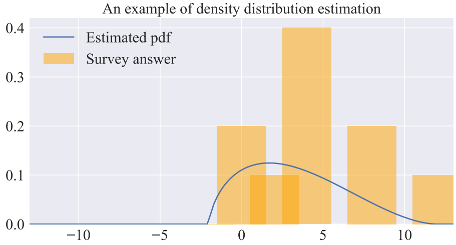
- Density survey: SCE
  - 2013M6-2020M4 (monthly)
  - 1300 households
  - 12-month panel
- Income panel: SIPP
  - 2014M1-2019M12 (monthly)
  - hourly wage
  - primary/full-time/non-self-employed job
  - 900-2700 respondents
  - CPI adjusted
  - age 30-65
  - only job-stayers with the same employer for ≥ 2 (Low et al. (2010))

The survey question

"Suppose that 12 months from now, you are working in the exact same ["main" if Q11>1] job at the same place you currently work and working the exact same number of hours. In your view, what would you say is the percentage chance that 12 months from now, your earnings on this job, before tax and deductions, will increase by x%?"



An illustration of the density forecast estimation



- case 1. 3+ intervals with positive probs, a generalized beta dist
- case 2. exactly 2 adjacent intervals with positive probs: a triangle dist
- case 3. one interval only: a uniform dist

Survey questions (continued)

- Individual-specific bin-based forecast on $\Delta w_{i,t+1}$
  - wage growth of the same job/position/hours
  - exl. endogenous labor supply changes/promotion/demotion/separation
- Measurement of PR:
  - variance: $\overline{Var}_{i,t}(\Delta w_{i,t+1})$
  - computed from the density forecast
- density estimation following Engelberg et al. (2009)
- restricted to attentive/high numeracy score sample
- both nominal and real terms (adjusted by inflation uncertainty)

Log wage process

$$\underbrace{w_{i,t}}_{\text{log wage}} = \underbrace{z_{i,t}}_{\text{predictable by the agent}} + \underbrace{e_{i,t}}_{\text{stochastic component}}$$

- individual i at time t
- the time-series nature of $e_{i,t}$ to be specified later

Perceived risks (PR)

- Wage growth

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- To econometricians: **approximated unconditional** variance

$$Var_c(\Delta \hat{e}_{i,c,t+1}) = Var_c(\Delta w_{i,t+1} - \Delta \hat{z}_{i,t+1})$$

- $\hat{e}_{i,c,t+1}$: the first-step regression residual controlling observable vars
- group c: **assumed** to share income process/risks
  - i.e. education/year of birth/gender/age

Time series structure of wage shocks

$$e_{i,t} = \underbrace{p_{i,t}}_{\text{permanent}} + \underbrace{\theta_{i,t}}_{\text{transitory}}$$

$$p_{i,t+1} = p_{i,t} + \psi_{i,t+1}$$

$$\psi_{i,t} \sim N(0, \sigma^2_{i,t,\psi})$$

$$\theta_{i,t} \sim N(0, \sigma^2_{i,t,\theta})$$

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- The agent's PR

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- Econometricians' approximated PR

$$\widehat{Var}_{c,t}(\Delta \hat{e}_{i,c,t+1}) = \hat{\sigma}^2_{c,t+1,\psi} + \hat{\sigma}^2_{c,t+1,\theta}$$

Limitations with risk estimates from panel data

- Superior information/unobservable heterogeneity: $\hat{z}_{i,t} \neq z_{i,t}$
  - $\hat{z}_{i,t}$ unlikely capture all in the information set of i at t
    1. Intrinsic heterogeneity of individual i not observable by economists
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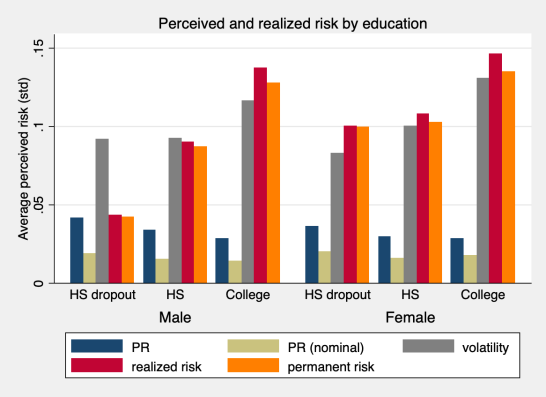
- Model misspecfication
  - Risks may differ within group c, but economists have to estimate it at the group level.
- Surveyed PR can be a better alternative
  - Directly conditional on information set of each i at t
  - No need to restrict risk heterogeneity by group c
  - But need to be careful with measurement errors

Survey PR < Estimated PR within groups



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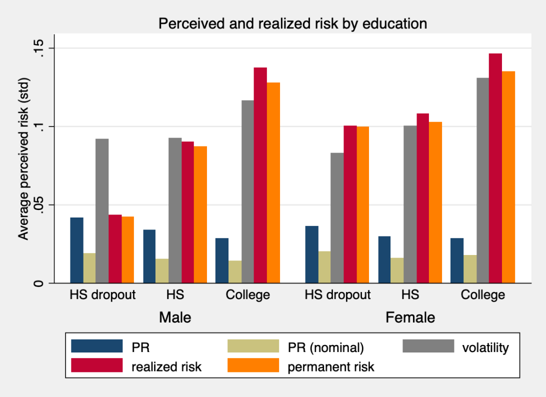
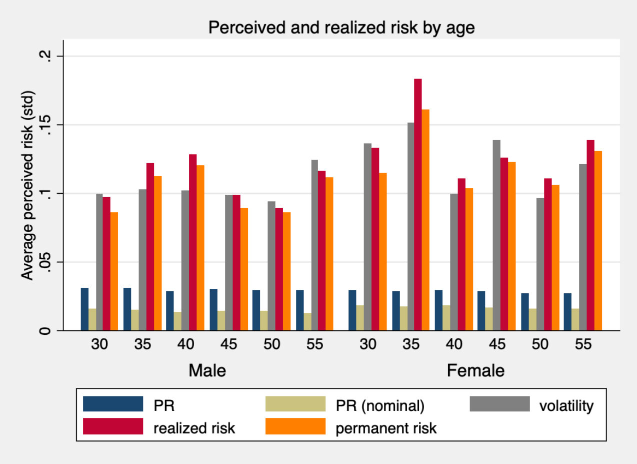
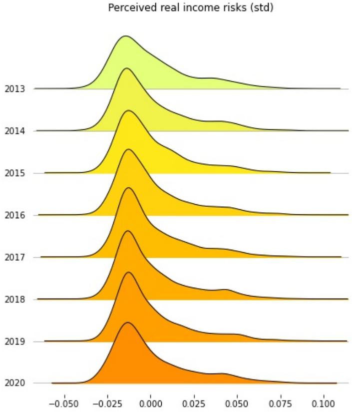


- The wage risk estimates by Low et al. (2010):
  - low education: permanent risk = 0.09, transitory risk = 0.08
  - high education: permanent risk = 0.106, transitory risk = 0.08

Survey PR < Estimated PR within groups, continued



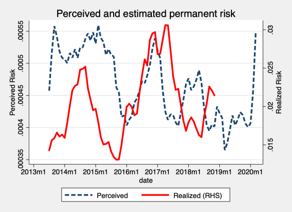
Unobservable heterogeneity



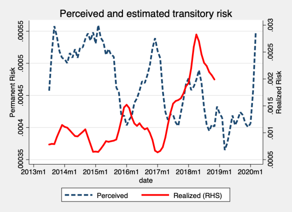
- PR residuals controlling for observables + time FE ($R^2 = 0.10$)
- average PR: 3.5% in std; 10/90 IQR: 5.2% in std nominal

Permanent versus transitory risks

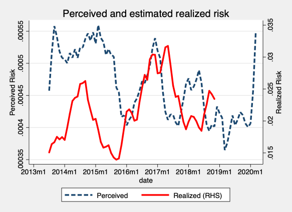
(a) permanent



(b) transitory



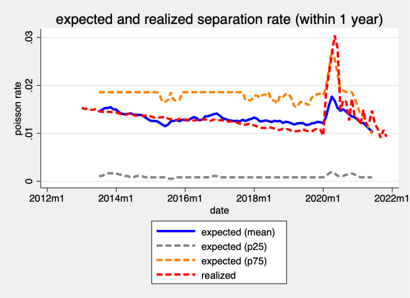
(c) volatility

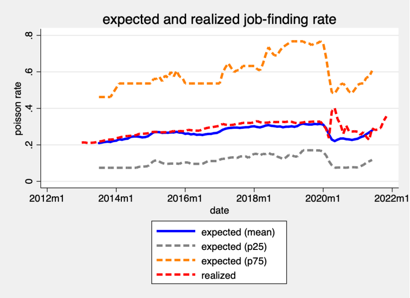


- i.e. one-year-ahead perceived risk at 2014m1 v.s. realized risk over the same period
- wage rate for the same job/hours/position
- estimated monthly risks aggregated into annual frequency

More details

Perceived UE risks and realization





- the realization computed from CPS panel data of workers following Fujita and Ramey (2009)

Perceived risks and household spending

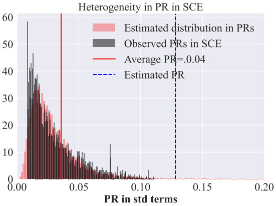
$$E_{i,t}(\Delta c_{i,t+1}) = u_0 + u_1 \text{Var}_{i,t}(\Delta w_{i,t+1}) + \xi_{i,t}$$

	(1)	(2)	(3)	(4)	(5)	(6)
perceived earning risk	8.394***	8.399***	3.642***	3.243***		
	(1.175)	(1.176)	(0.533)	(0.537)		
perceived earning risk (nominal)					3.656***	
					(0.990)	
perceived ue risk						0.353***
						(0.0553)
R-squared	0.0010	0.00282	0.928	0.928	0.941	0.633
Sample Size	53178	53178	53178	53178	54584	6269
Time FE	No	Yes	No	Yes	Yes	No
Individual FE	No	No	Yes	Yes	Yes	Yes

- Higher perceived risks → higher expected spending growth.

Calibrating heterogenous PRs from SCE survey

- Fit a truncated log-normal dist over the cross-section of PRs
- Uncover unobserved heterogeneity in wage growth using the difference between reported PR and the estimated PR.



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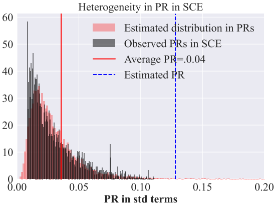

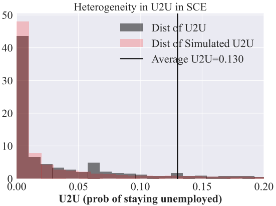

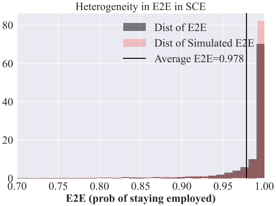

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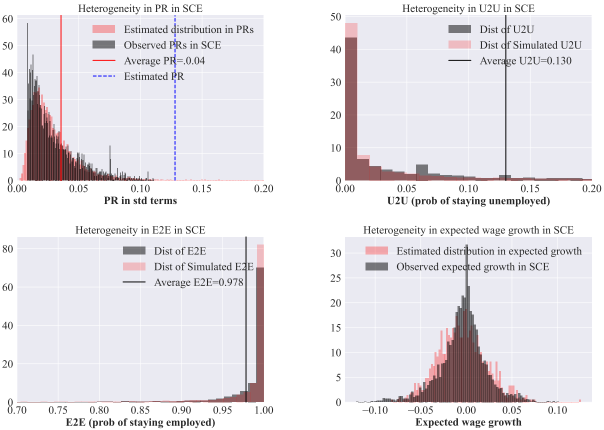

Model overview

- Overlapping generation
- General equilibrium
- Uninsured idiosyncratic income risks
  - Permanent+ transitory idiosyncratic wage shock
  - Persistent unemployment spells
- No aggregate risk a la Krusell and Smith (1998)
- A blend of Huggett (1996) and Carroll (1997)
- Only one risk-free asset
- Calibrating income risks using survey versus estimates from panel
- Extension: subjective risk perceptions
  - Individuals swing between low/high risk perceptions

Preview of the model mechanisms

- On level of savings
  1. $\downarrow$ lower PR: lower precautionary saving motives $\rightarrow$ less liquid holding $\rightarrow$ higher MPC

Preview of the model mechanisms

- On level of savings
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- On wealth inequality
  - $\uparrow$ heterogeneous PR $\rightarrow$ heterogeneity in saving/wealth

Benchmark model

$$\max \quad \mathbb{E}\left[\sum_{\tau=0}^{\tau=L-1}(1-D)^{\tau}\beta^{\tau}u(c_{i,\tau})\right]$$

$$\underbrace{a_{i,\tau}}_{\text{Savings}} = \underbrace{m_{i,\tau}}_{\text{Cash in hand}} - c_{i,\tau}$$

$$b_{i,\tau+1} = a_{i,\tau}R$$

$$m_{i,\tau+1} = b_{i,\tau+1} + (1 - \underbrace{\lambda}_{\text{Income tax}})(1 - \underbrace{\lambda_{SS}}_{\text{SS tax}})y_{i,\tau+1}$$

$$a_{i,\tau} \geq 0$$

- CRRA: $u(c) = \frac{c^{1-\rho}}{1-\rho}$
- Work age: $\tau = 1, 2..., T$ (since entering job market)
- Life length: $\tau = 1, 2..., L$ (since entering job market)
- Survival probability: 1-D

Income process over the life-cycle

- income

$$y_{i,\tau} = n_{i,\tau} W$$
$$n_{i,\tau} = p_{i,\tau}\xi_{i,\tau}$$

- permanent component

$$p_{i,\tau} = G_\tau p_{i,\tau-1}\psi_{i,\tau}, \quad log(\psi_{i,\tau}) \sim N(-\sigma^2_\psi/2, \sigma^2_\psi) \quad \forall \tau \leq T$$

- persistent/transitory component

$$\xi_{i,\tau} = \begin{cases} \theta_{i,\tau} \quad \text{if} \quad \nu_{i,\tau} = e \quad \& \quad \tau \leq T, \quad log(\theta_{i,\tau}) \sim N(-\frac{\sigma^2_\theta}{2}, \sigma^2_\theta) \\ \zeta \quad \text{if} \quad \nu_{i,\tau} = u \quad \& \quad \tau \leq T \\ \mathbb{S} \quad \text{if} \quad \tau > T \end{cases}$$

- transition probability between $\nu = u$ and $\nu = e$

$$\pi(\nu_{\tau+1}|\nu_\tau) = \begin{bmatrix} \mho & 1-\mho \\ 1-E & E \end{bmatrix}$$

Macroeconomic environment

- Technology

$$Y = ZK^{\alpha}N^{1-\alpha}$$

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- Government (balance budget)

$$\lambda\left[1-\Pi^{\mho}+\zeta\Pi^{\mho}\right]=\zeta\Pi^{\mho}$$

$$\lambda_{SS}\sum_{\tau=1}^{T}G_{\tau}(1-\Pi^{\mho})=\mathbb{S}\sum_{\tau=T+1}^{L}G_{\tau}$$

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- Demographics
  - Stable age distribution $\{\mu_{\tau}\}_{\mu=1,2,..L}$

$$\mu_{\tau+1}=(1-D)\mu_{\tau},\quad \sum_{\tau=1}^{L}\mu_{\tau}=1$$

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  - Stable age distribution $\{\mu_{\tau}\}_{\mu=1,2,..L}$

$$\mu_{\tau+1}=(1-D)\mu_{\tau},\quad \sum_{\tau=1}^{L}\mu_{\tau}=1$$

- Zero or positive accidental bequests: lum-sum of a fraction of the deceased' wealth

Value function and transitions

- Value function

$$V_\tau(\underbrace{\nu_{i,\tau}, m_{i,\tau}, p_{i,\tau}}_{x_{i,\tau}}) = \max_{\{c_{i,\tau}, a_{i,\tau}\}} \quad u(c_{i,\tau}) \\ + (1-D)\beta\mathbb{E}_\tau\left[V_{\tau+1}((\nu_{i,\tau}, m_{i,\tau+1}, p_{i,\tau+1})\right]$$

- Transitions

$$\psi_\tau(B) = \int_{x\in X} \underbrace{P(x, \tau-1, B)}_{\text{transition funcs}} \mathrm{d}\psi_{\tau-1} \quad \text{for all} \quad B \in B(X)$$

Stationary equilibrium (StE)

- Optimal consumption and saving policies given W, R, λ
- Distribution evolution consistent with optimal c and a policies and income risks
- The factor markets clear

$$\sum_{\tau} \mu_\tau \int_X a(x,\tau) \mathrm{d}\psi_\tau = K$$

$$\sum_{\tau=0}^{T-1} \mu_\tau \Pi_\tau^E = N$$

- Firm optimization under competitive factor markets.

$$W = Z(1-\alpha)(K/N)^\alpha$$

$$R = 1 + Z\alpha(K/N)^{\alpha-1} - \delta$$

- Balanced government budget

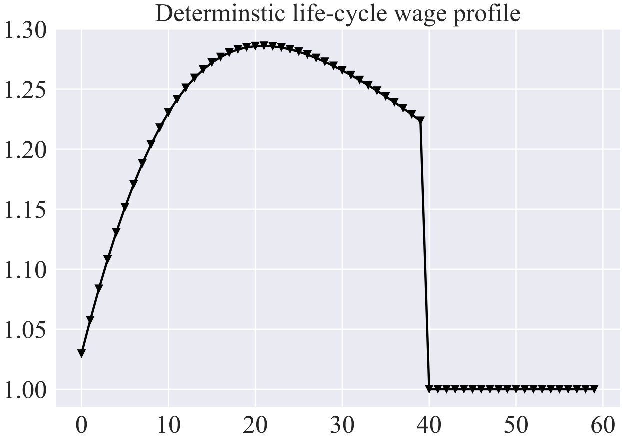
Calibration of the benchmark model

Table: Model parameters

block	parameter name	values	source
risk	σ_ψ	0.15	Median estimates from the literature
risk	σ_θ	0.15	Median estimates from the literature
risk	$U2U$	0.18	Median estimates from the literature
risk	$E2E$	0.96	Median estimates from the literature
initial condition	$\sigma_\psi^{\text{init}}$	0.629	Estimated for age 25 in the 2016 SCF
initial condition	bequest ratio	0	assumption
life cycle	T	40	standard assumption
life cycle	L	60	standard assumption
life cycle	$1-D$	0.994	standard assumption
preference	ρ	1	standard assumption
preference	β	0.98	standard assumption
policy	$\mathbb{S}$	0.65	U.S. average
policy	λ	0	endogenously determined
policy	λ_{SS}	0	endogenously determined
policy	μ	0.15	U.S. average
production	W	1	target values in steady state
production	K2Y ratio	3	target values in steady state
production	α	0.33	standard assumption
production	δ	0.025	standard assumption

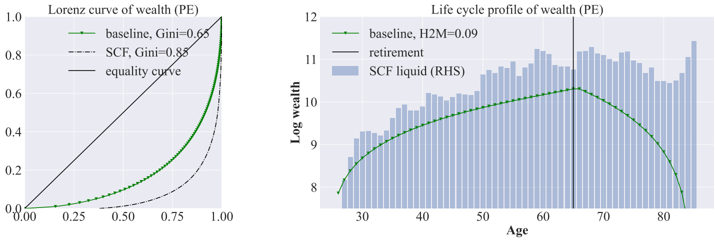
Back

Deterministic wage profile over life cycle



- Estimated from SIPP with a fourth-order age polynomial regression

StE Distribution in different models in PE and GE



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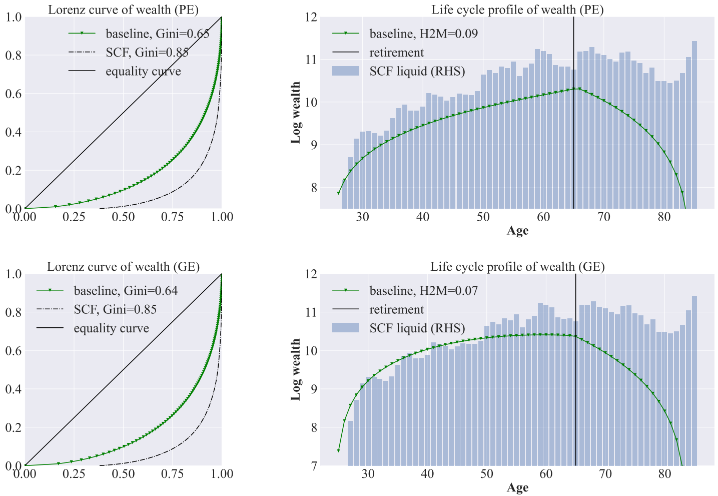
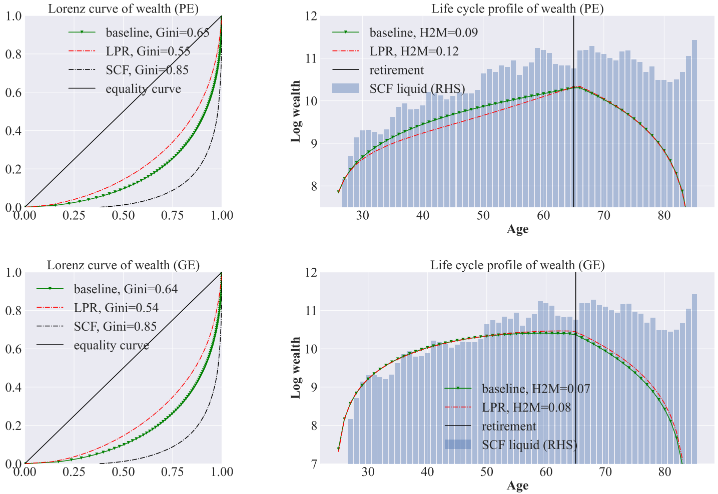


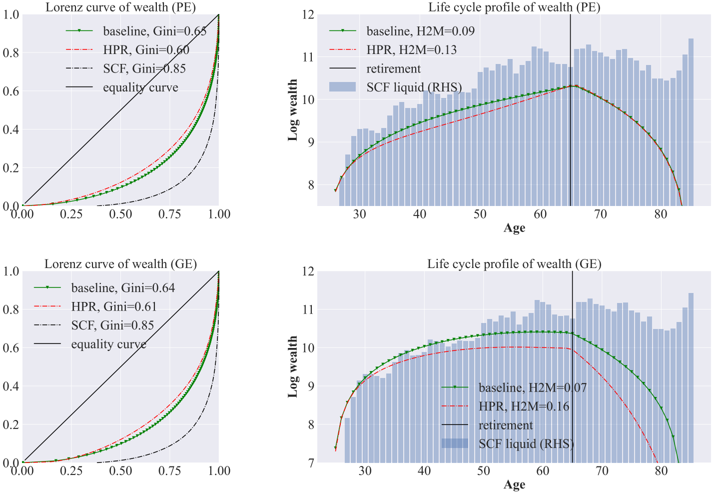
$\sigma_\psi = 0.15$, $\sigma_\theta = 0.15$, $U2U = 0.18$, $E2E = 0.96$ other parameters

Lower perceived risks (LPR)



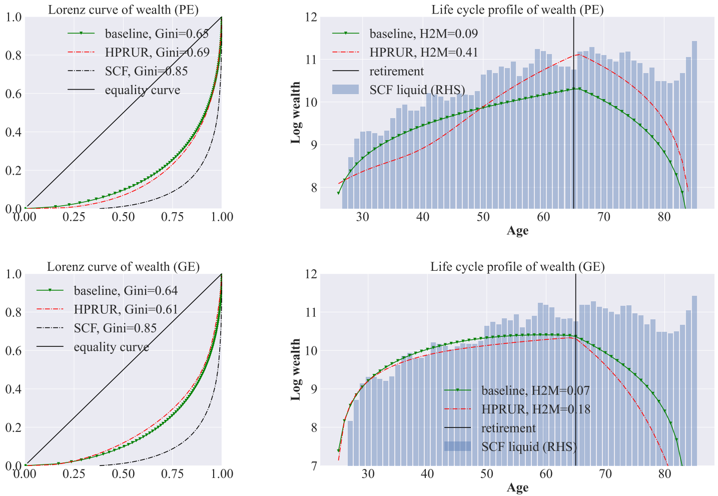
$\sigma_\psi = 0.03$, $\sigma_\theta = 0.02$, $U2U = 0.18$, $E2E = 0.96$ other parameters

Heterogeneous perceived wage risks (HPR)



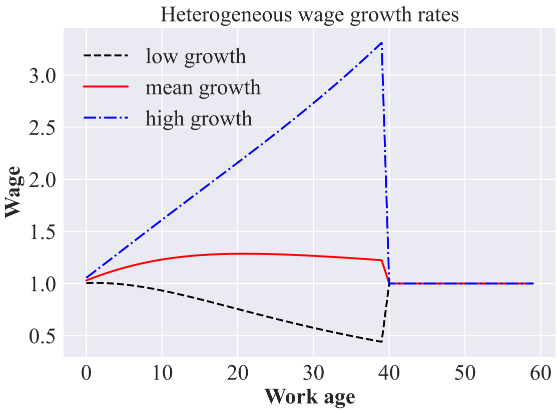
$\sigma_\psi = \sigma_\theta = [0.01, 0.02, 0.04]$, $U2U = 0.18$, $E2E = 0.96$

Heterogeneous perceived wage /UE risks (HPRUR)

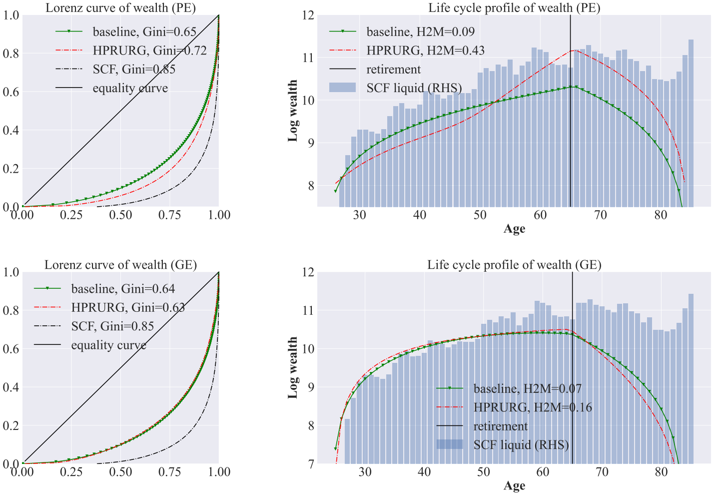


$\sigma_\psi = \sigma_\theta = [0.01, 0.02, 0.04]$, $U2U = [0, 0.02, 0.24]$, $E2E = [0.96, 0.99, 1.0]$

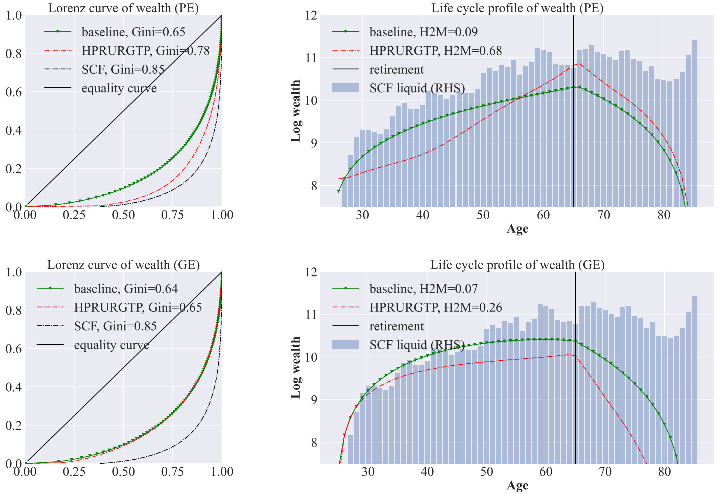
Hetero wage growth rates



Hetero perceived wage /UE risks/ growth rates (HPRURG)



Hetero perceived wage /UE risks/ growth rates/time preference (HPRURGTP)



Taking stock

Model/Data	Gini coeff	H2M share (0.1)	H2M share (0.3)	H2M share (0.5)
SCF (liquid)	0.85	0.18	0.26	0.31
baseline (PE)	0.65	0.02	0.04	0.09
LPR (PE)	0.55	0.02	0.06	0.12
HPR (PE)	0.60	0.03	0.07	0.13
HPRUR (PE)	0.69	0.17	0.28	0.41
HPRURG (PE)	0.72	0.17	0.29	0.43
HPRURGTP (PE)	0.78	0.36	0.58	0.68
baseline (GE)	0.64	0.02	0.05	0.07
LPR (GE)	0.54	0.02	0.05	0.08
HPR (GE)	0.61	0.08	0.13	0.16
HPRUR (GE)	0.61	0.07	0.13	0.18
HPRURG (GE)	0.63	0.08	0.13	0.16
HPRURGTP (GE)	0.65	0.15	0.20	0.26

Extension: subjective PR

Key assumption:

- Consumption/saving decisions made based on the subjective perceptions from the survey
- But income shocks drawn from the objective size of income risks
- Killing two birds with one stone
  - A robustness check against possible mis-perception by the agents
  - An breakdown of model implications into two channels
    - Ex-ante precautionary saving behaviors
    - Ex-post realized income inequality

Value functions under different profiles

- objective:

$$V_\tau(\underbrace{\nu_{i,\tau}, m_{i,\tau}, p_{i,\tau}}_{x_{i,\tau}}) = \max_{\{c_{i,\tau}, a_{i,\tau}\}} \quad u(c_{i,\tau})$$

$$+ (1-D)\beta \mathbb{E}_\tau \left[V_{\tau+1}((\nu_{i,\tau}, m_{i,\tau+1}, p_{i,\tau+1}) \right]$$

- subjective:

$$\tilde{V}_\tau(\underbrace{\tilde{\Gamma}_\tau, \nu_\tau, m_\tau, p_\tau}_{\tilde{x}_{i,\tau}}) = \max_{\{c_\tau\}} \quad u(c_\tau)$$

$$+ (1-D)\beta \mathbb{E}_\tau \left[\tilde{V}_{\tau+1}(\tilde{\Gamma}_{\tau+1}, \nu_\tau, m_{\tau+1}, p_{\tau+1}) \right]$$

Evolution of the distribution over state variables

- objective:

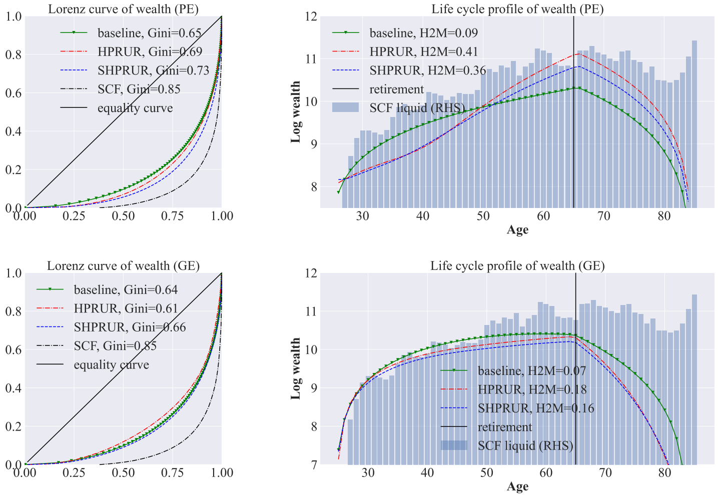
$$\psi_\tau(B) = \int_{x \in X} \underbrace{P(x, \tau-1, B)}_{\text{transition funcs}} d\psi_{\tau-1} \quad \text{for all} \quad B \in B(X)$$

  - $B(X)$: distribution measure on state space X
  - ψ_τ: distribution over state variables x for agents in age τ
  - ψ_1 depends on initial draws of income shocks

- subjective:

$$\tilde{\psi}_\tau(\tilde{B}) = \int_{\tilde{x} \in \tilde{X}} \tilde{P}(\tilde{x}, \tau-1, \tilde{B}) d\tilde{\psi}_{\tau-1} \quad \text{for all} \quad \tilde{B} \in \tilde{B}(X)$$

Subjective HPRUR



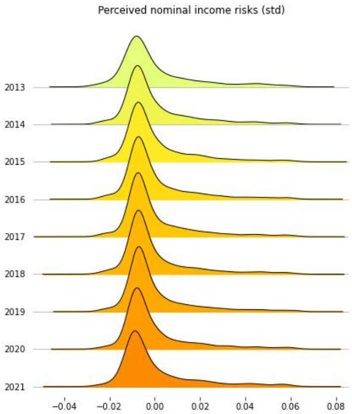
Other results

- Other drivers of PR
  - Macroeconomic conditions
  - Experienced labor market outcomes
  - Experienced income volatility
- State-dependent PR
  - Individuals stochastically swing between low and high PR states
  - Transition estimated from survey data details

Conclusion

- Survey data can inform incomplete-market macro models
  - Direct evidence for heterogeneity in perceptions that *matter*
  - Closer to agents' information set that truly affects their decisions
  - No need to make stringent assumptions on expectation formation
- More work needed on
  - heterogeneous beliefs in HM models
  - understanding risk perception formation

Within-group dispersion in nominal PR



- residuals controlling for observables /time fixed effects
- average PR: 2.1% in std; 10/90 IQR: 3.2% in std

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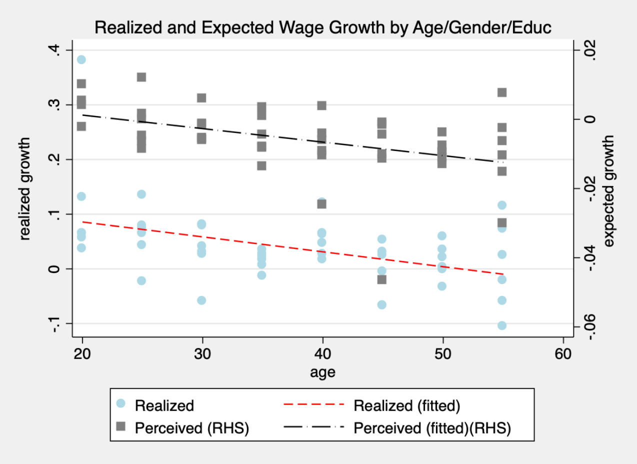
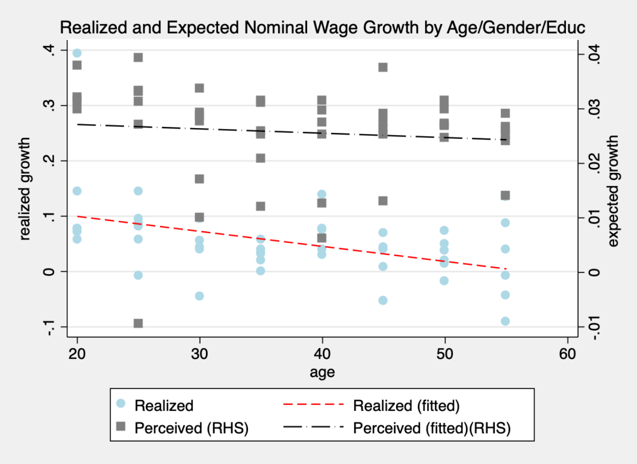
Appendix: expected growth by age



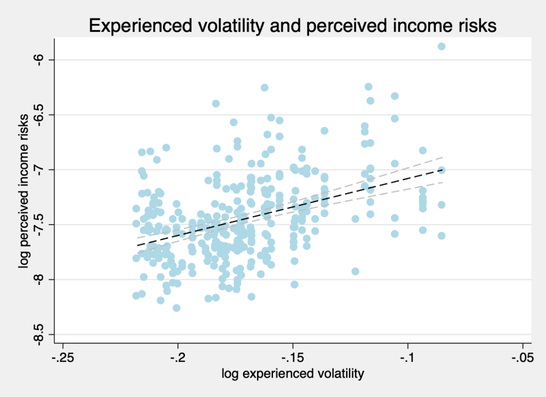
- e.g. a male high school graduate aged 30

Appendix: expected **nominal** growth by age



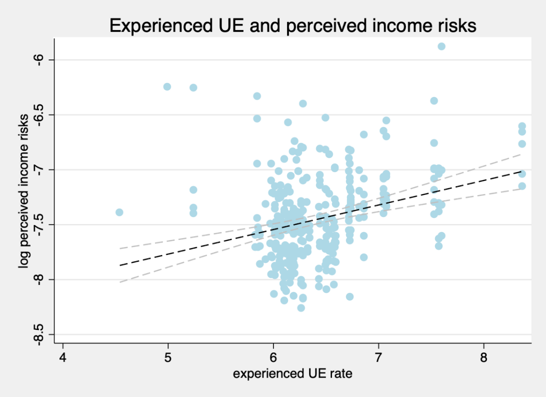
- e.g. a male high school graduate aged 30

Appendix: Experienced volatility and PR



- income volatility conditional on macroeconomic history Storesletten et al. (2004)
- e.g. the experience by a 25-year old till 2015 is between 1990-2015

Experienced labor market and perceived risks



- e.g. experienced UE by a 25-year old in 2015 is between UE over 1990-2015

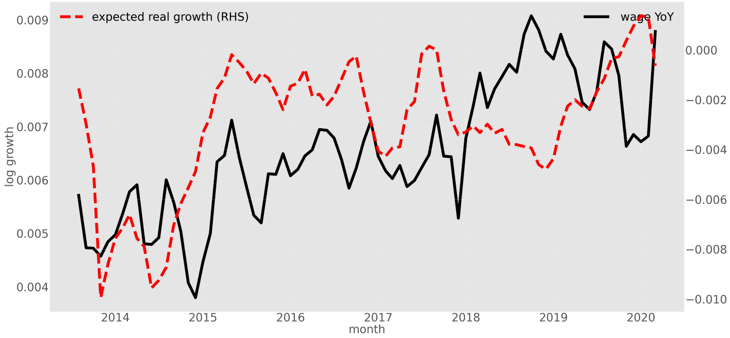
Appendix: Extrapolation from individual experiences

- higher experienced volatility → higher PR
- recent unemployment experience → higher PR

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
income shock squared	0.0225***	0.0222***	0.0217***	0.0207***	0.000773	0.00205***	0.000566	0.00183***	0.000614	0.00184***
	(0.00562)	(0.00570)	(0.00562)	(0.00564)	(0.000743)	(0.000516)	(0.000744)	(0.000515)	(0.000745)	(0.000516)
recently unemployed				0.511*	0.228***	0.0895***				
				(0.260)	(0.0330)	(0.0200)				
unemployed since m-8							0.161***	0.0783***		
							(0.0207)	(0.0121)		
unemployed since y-1									0.138***	0.0701***
									(0.0193)	(0.0113)
Observations	3662	3662	3662	3662	3701	1871	3701	1871	3701	1871
R-squared	0.004	0.013	0.016	0.017	0.015	0.030	0.019	0.041	0.016	0.039

Appendix: expected income growth and recent (past) wage growth

- $\overline{\exp_t}$: average expected growth across individuals
- quarterly growth in average hourly wage



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Appendix: PR and current labor market condition

$$\underbrace{\overline{\text{risk}_t}}_{\text{average perceived risk}} = \alpha + {\color{red}\beta} \underbrace{\left(log(\text{wage}_{t-k/12}) - log(\text{wage}_{t-(k-3)/12})\right)}_{\text{wage growth}} + \epsilon_{i,t}$$

$$\forall k = 0...4$$

	mean:var	mean:iqr	mean:rvar	mean:skew
0	-0.28**	-0.42***	-0.48***	-0.02
1	-0.42***	-0.53***	-0.51***	0.12
2	-0.43***	-0.48***	-0.44***	-0.01
3	-0.43***	-0.48***	-0.42***	-0.1
4	-0.31***	-0.41***	-0.32***	-0.21*

- Counter-cyclical income risks: Storesletten et al. (2004), Guvenen et al. (2014), Bayer et al. (2019)

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Appendix: PR and current labor market condition

$$\underbrace{\overline{\text{risk}}_{s,t}}_{\text{median perceived risk in state } s} = r + \color{red}{\psi} \underbrace{LM_{s,t}}_{\text{state labor market condition}} + \eta_{s,t}$$

	(1)	(2)	(3)	(4)
	log(var)	log(risk)	log(iqr)	log(iqr)
wage growth	-0.05***		-0.03***	
	(0.01)		(0.01)	
unemp rate		0.04*		0.04***
		(0.02)		(0.01)
Observations	3529	3529	3546	3546
R-squared	0.023	0.020	0.025	0.028

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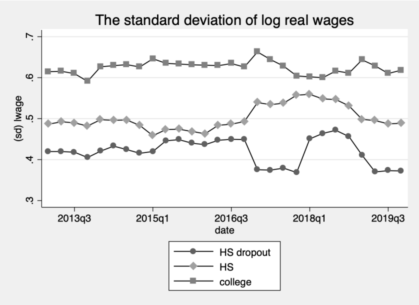
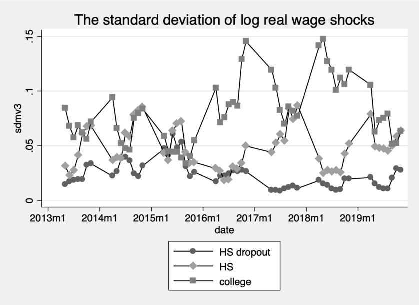
Appendix: monthly earning inequality and volatility

(a) Inequality



(b) Volatility



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Appendix: estimating state-dependent PR using survey

$$\underbrace{\tilde{\Gamma}^s_{i,t}}_{\text{reported PR}} = \underbrace{\tilde{\Gamma}_l + \mathbb{1}(\overbrace{J_{i,t}}^{\text{Hidden state}} = 1)(\tilde{\Gamma}_h - \tilde{\Gamma}_l)}_{\tilde{\Gamma}_{i,t}} + \xi_t + \eta_i + \epsilon_{i,t}$$

$$\text{Prob}(J_{i,t+1}|J_{i,t}) = \Omega$$

- $J_{i,t} = 0$ for low and $= 1$ for high PR state
- a short time series of $\tilde{\Gamma}_{i,t}$ for many is observed in the survey
- $\{\tilde{\Gamma}_l \, \tilde{\Gamma}_h, \Omega\}$ can be estimated by MLE
- a modified Hamilton (1989) 2-regime-switching model
- $J_{i.t}$ can be also dependent upon business cycles

More details

Appendix: estimating state-dependent PR using survey

$$\log(\tilde{\text{var}}_{i,t}) = (12 + \frac{1}{12\kappa^2})\tilde{\sigma}^2_{i,t,\psi} + \xi_t + \eta_i + \epsilon_{i,t}$$

- κ: externally assumed ratio of permanent and transitory risks $\frac{\tilde{\sigma}_{i,t,\psi}}{\tilde{\sigma}_{i,t,\theta}}$

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