Perceived versus Calibrated Income Risks in Heterogeneous-agent Consumption Models

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Motivation

- Risks matter for individual decisions
  - precautionary saving
  - stock market participation
  - portfolio choice

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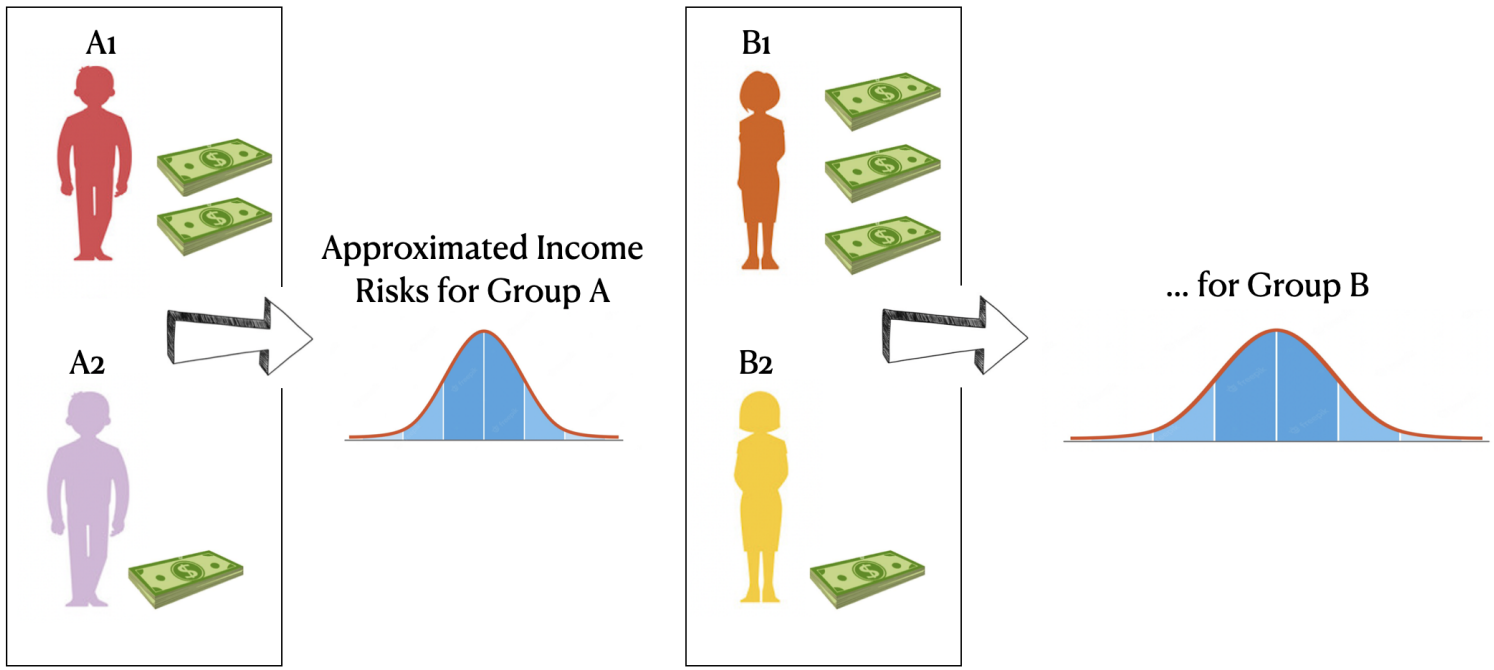
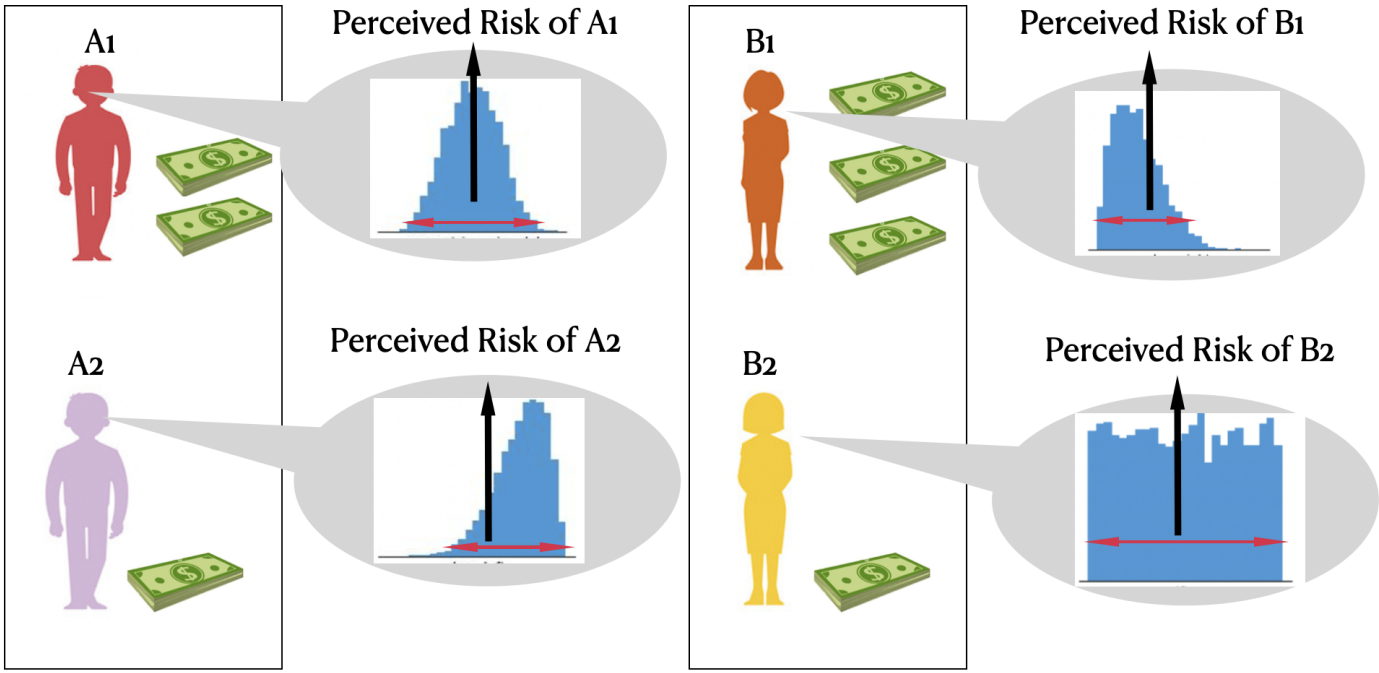
    - $\rightarrow$ distributional channel of macroeconomic policies
    - $\rightarrow$ business cycle fluctuations
- Income risks are central inputs of any incomplete-market model
  - Conventional approach: estimated using panel data
  - This paper: directly calibrating perceived risks from a survey

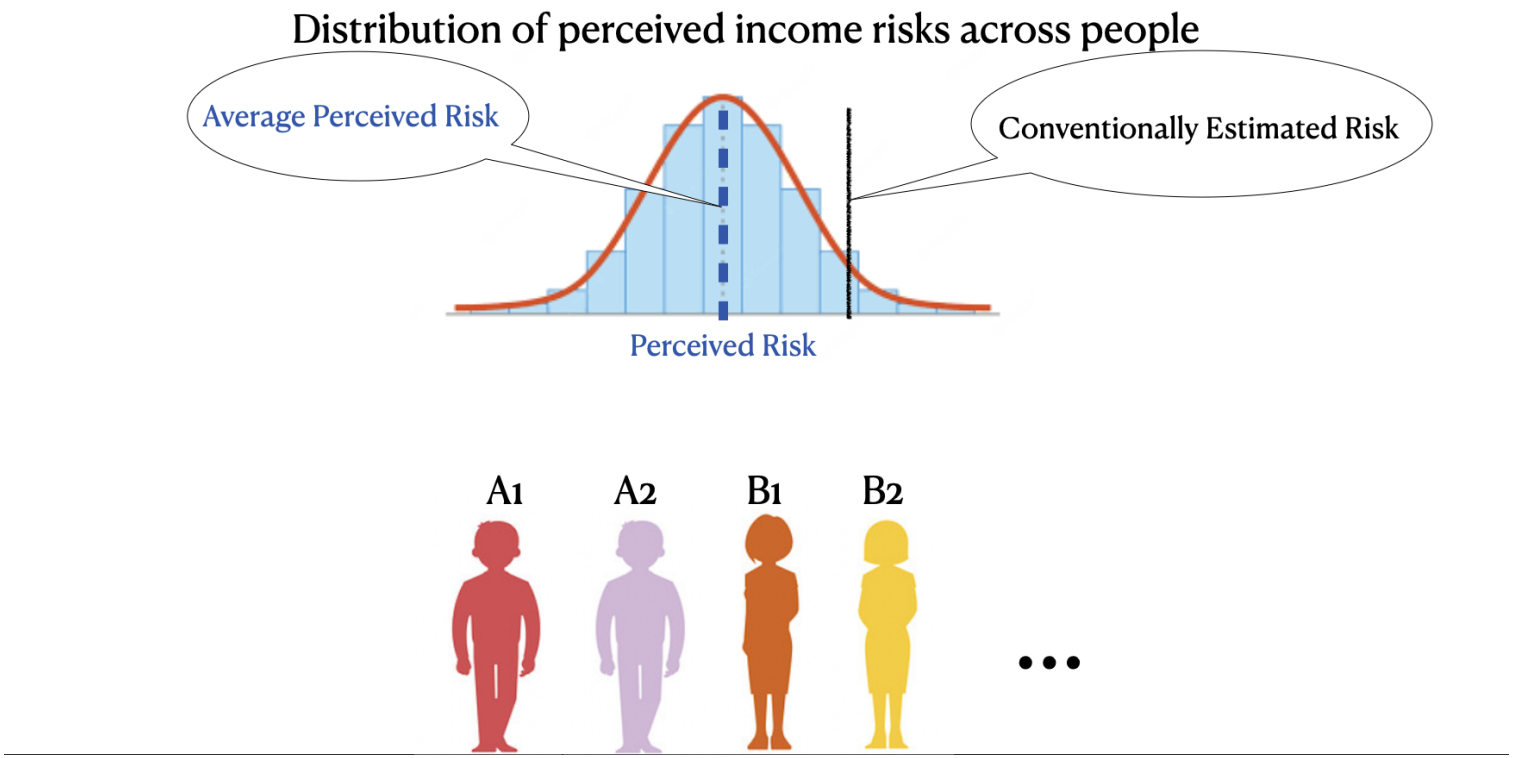
Conventional calibration: estimated from panel data



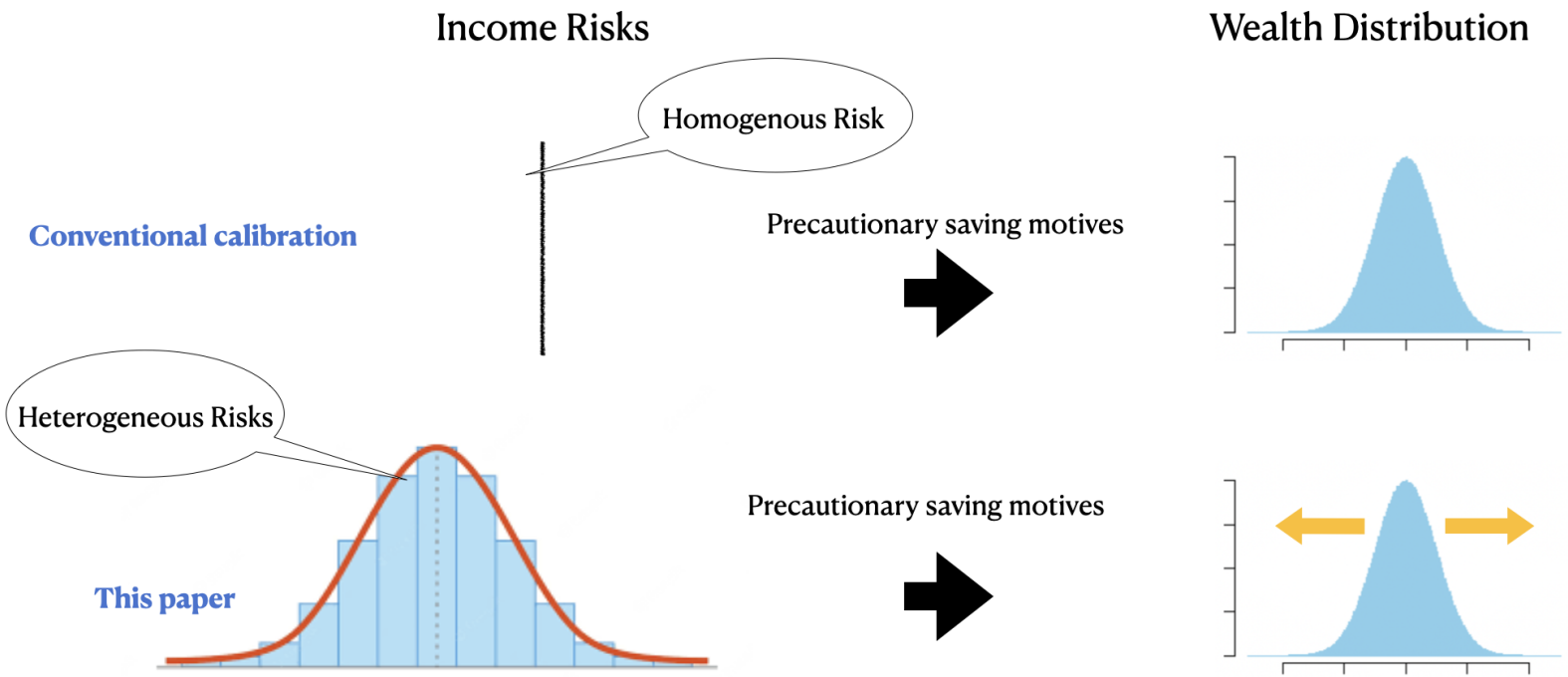
This paper: reported perceived risks in the survey



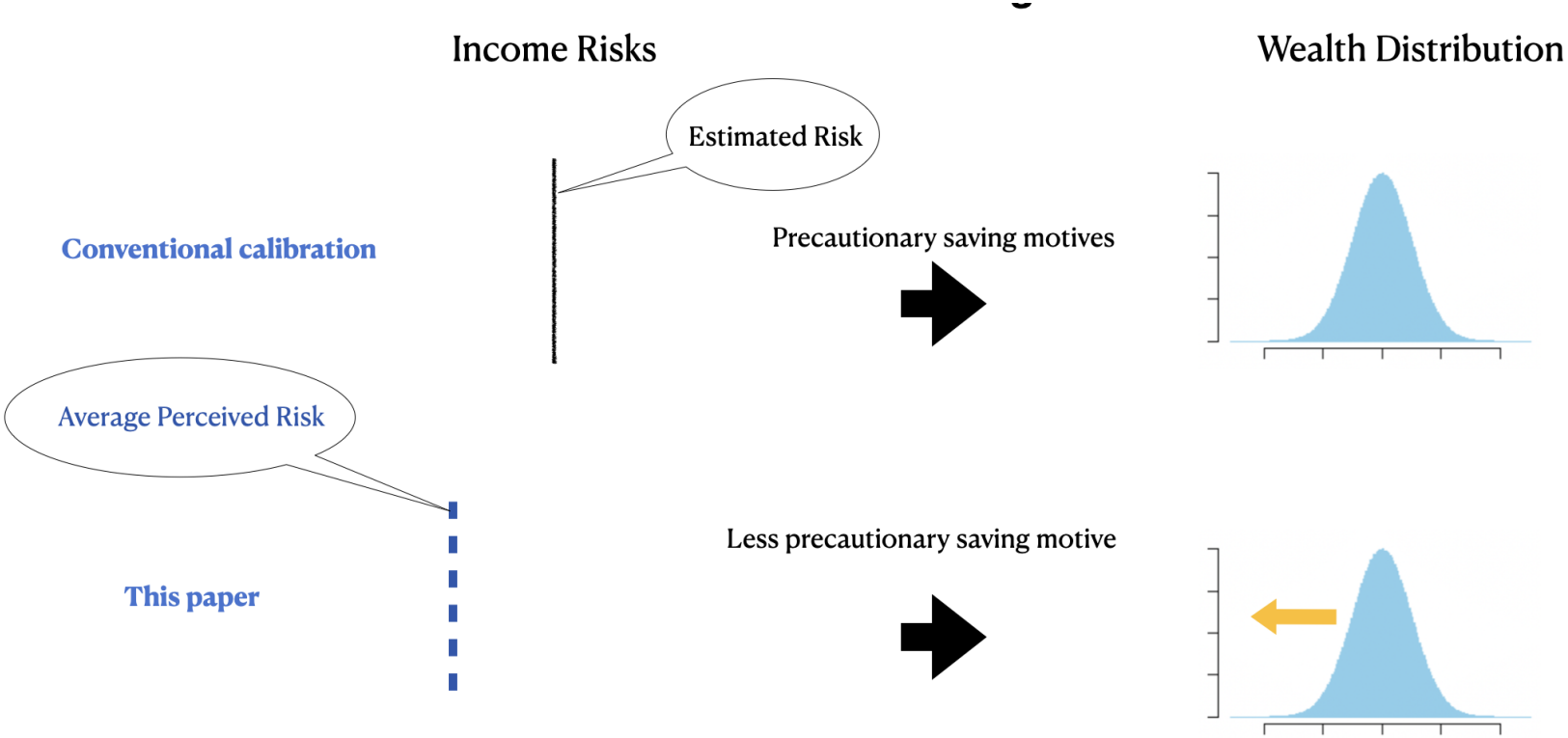
Perceived versus Calibrated Risk



Heterogeneous risks → differential savings



Smaller risks → lower level of savings

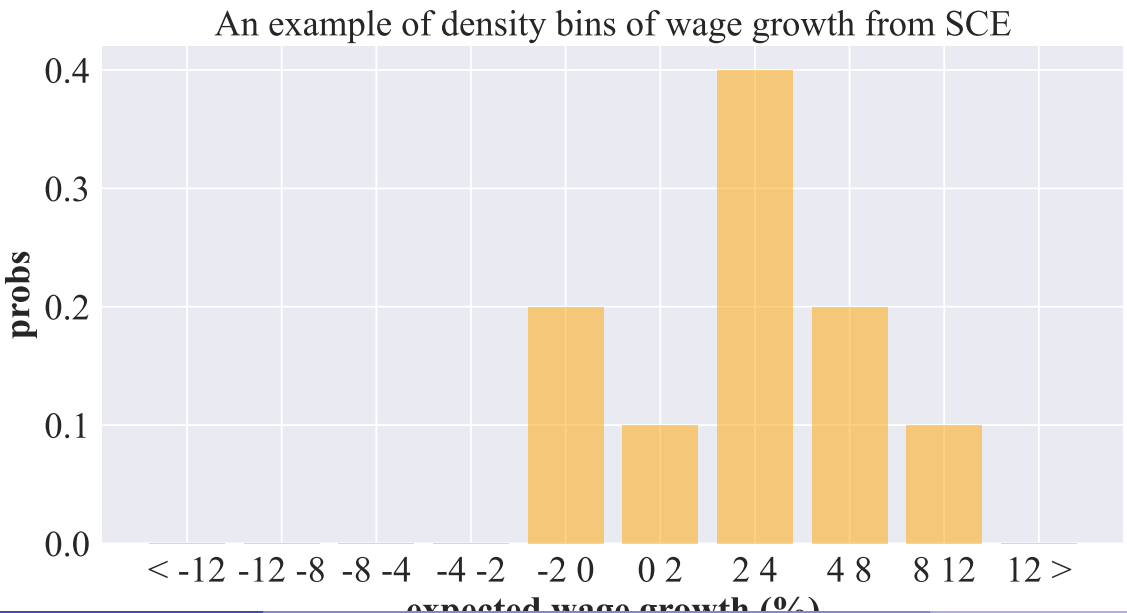


Data and sample

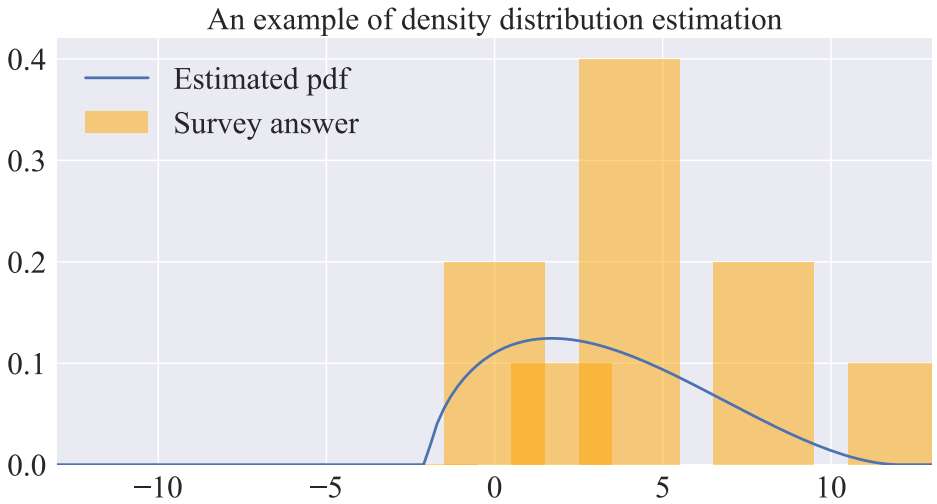
- Density survey: SCE
  - 2013M6-2020M4 (monthly)
  - 1300 households
  - 12-month panel
- Income panel: SIPP
  - 2014M1-2019M12 (monthly)
  - hourly wage
  - primary/full-time/non-self-employed job
  - 900-2700 respondents
  - CPI adjusted
  - age 30-65
  - only job-stayers with the same employer for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

The survey question: wage growth conditional on same job/position/hours

"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



Density estimation following Engelberg et al. (2009)

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

Survey questions (continued)

- Measurement of PR:
  - variance: $\overline{Var}_{i,t}(\Delta w_{i,t+1})$
  - computed from the density forecast
- exl. endogenous labor supply changes/promotion/demotion/separation
- 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

$$\Delta w_{i,t+1} = \Delta z_{i,t+1} + \Delta e_{i,t+1}$$

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- To the agent: **conditional** variance under FIRE

$$Var^*_{i,t}(\Delta w_{i,t+1}) = Var^*_{i,t}(\Delta e_{i,t+1})$$

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$$\Delta w_{i,t+1} = \Delta z_{i,t+1} + \Delta e_{i,t+1}$$

- To the agent: **conditional** variance under FIRE

$$Var^*_{i,t}(\Delta w_{i,t+1}) = Var^*_{i,t}(\Delta e_{i,t+1})$$

- 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

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
    2. Foresight about individual circumstances

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- Model misspecfication
  - Risks may differ within group c

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    1. Intrinsic heterogeneity of individual i
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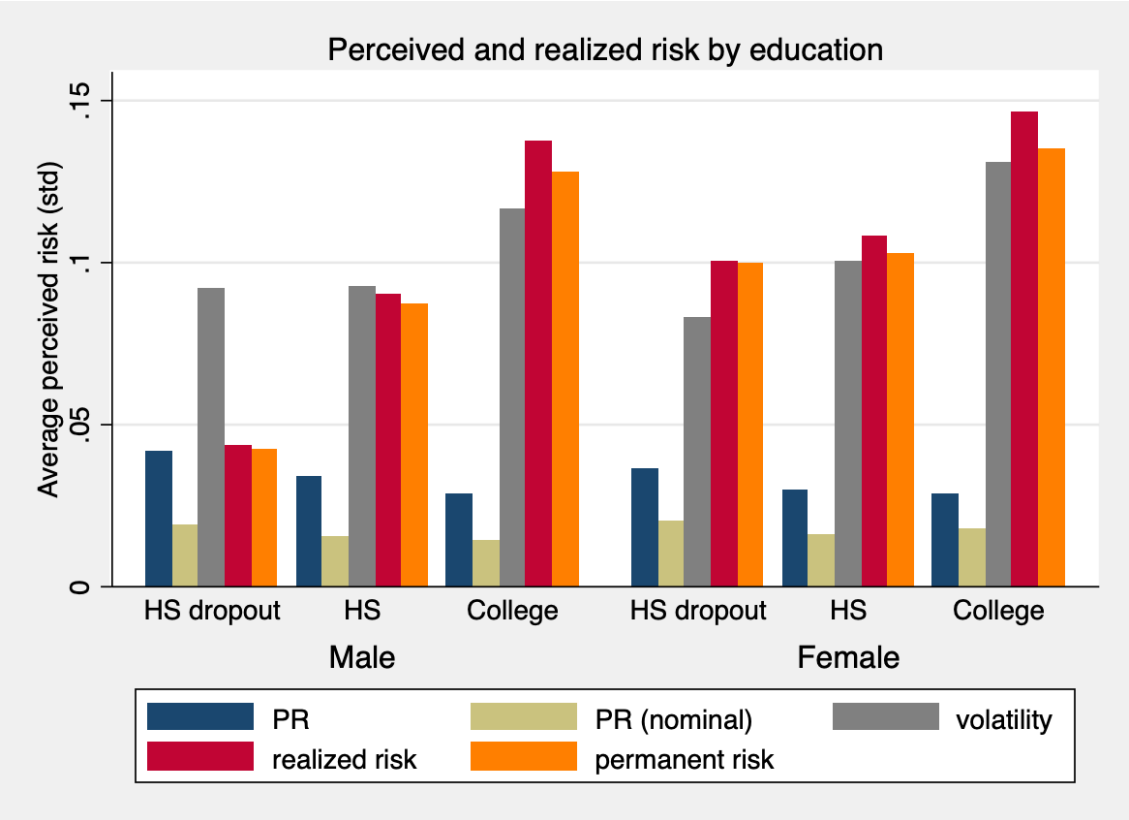
- Model misspecfication
  - Risks may differ within group c
- Surveyed PR can be a better alternative
  - Directly conditional on information set of each i at t
  - No need to restrict risk heterogeneity by group c
  - But need to be careful with measurement errors

Survey PR < Estimated PR within groups



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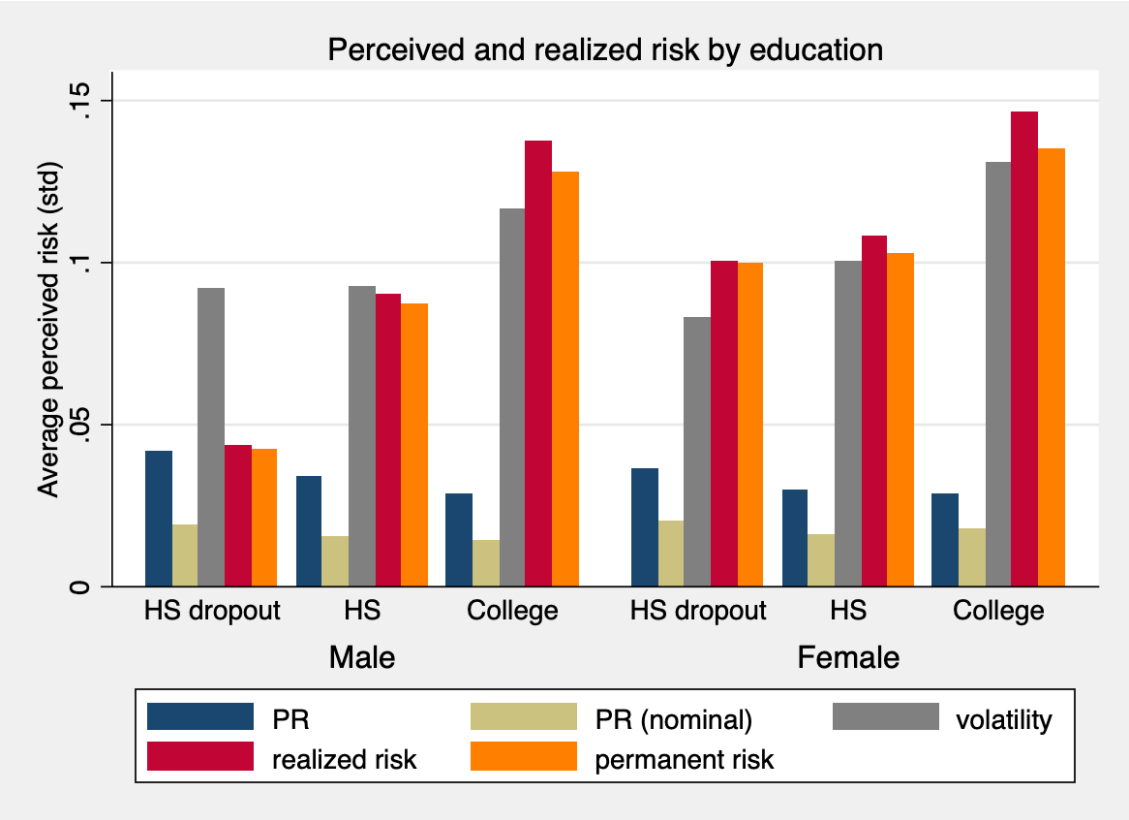
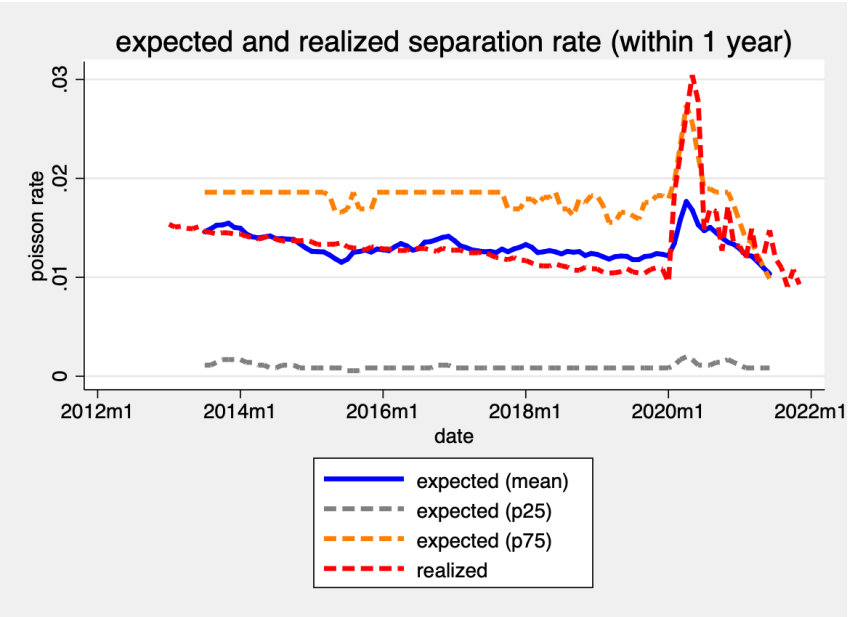


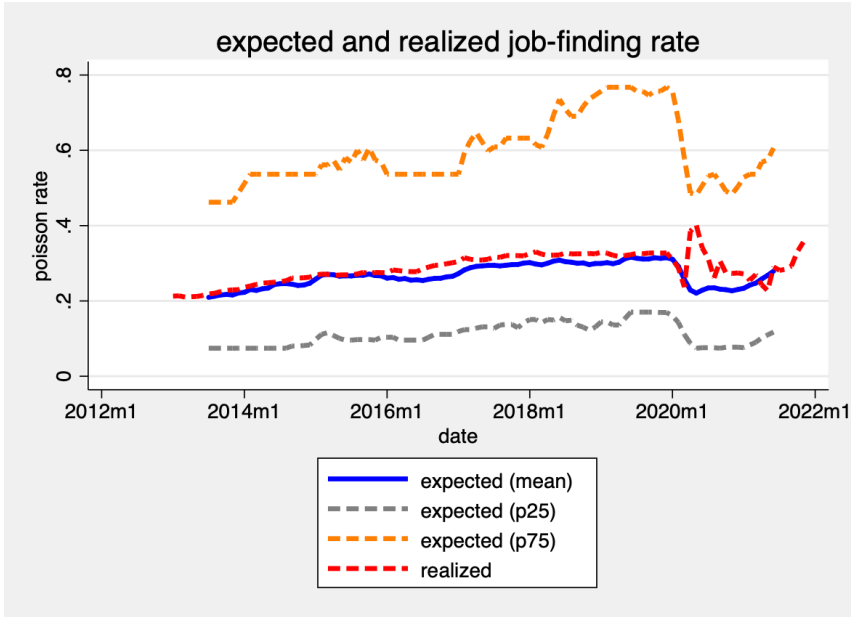
- The wage risk estimates by Low et al. (2010):
  - low education: permanent risk = 0.09, transitory risk = 0.08
  - high education: permanent risk = 0.106, transitory risk = 0.08

What explains the PR heterogeneity?

- Observables + time FE: $R^2 = 0.10$
- Individual fixed-effects only: $R^2 = 0.60$

Perceived UE risks and realization





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

Perceived risks and household spending

$$E_{i,t}(\Delta c_{i,t+1}) = u_0 + u_1 E_{i,t}(\Delta w_{i,t}) + u_2 \text{Var}_{i,t}(\Delta w_{i,t+1}) + \xi_{i,t}$$

	(1)	(2)	(3)	(4)	(5)
expected wage growth	0.324***	0.306***	0.254***	0.243***	
	(0.0825)	(0.0828)	(0.0334)	(0.0334)	
perceived wage risk	6.127***	6.185***	2.096***	1.711***	
	(1.163)	(1.165)	(0.439)	(0.442)	
perceived UE risk next 4m					0.353***
					(0.0553)
R-squared	0.000939	0.00318	0.953	0.953	0.633
Sample Size	56046	56046	56046	56046	6269
Time FE	No	Yes	No	Yes	Yes
Individual FE	No	No	Yes	Yes	Yes

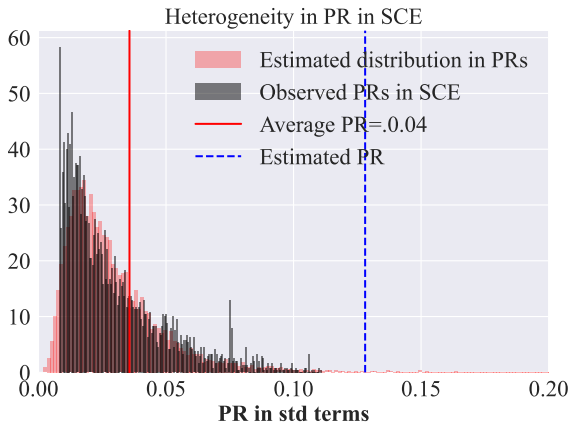
- Higher perceived risks → higher expected spending growth.

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 model
  - subjective PR $\neq$ objective income risks

Calibrating heterogenous PRs

- 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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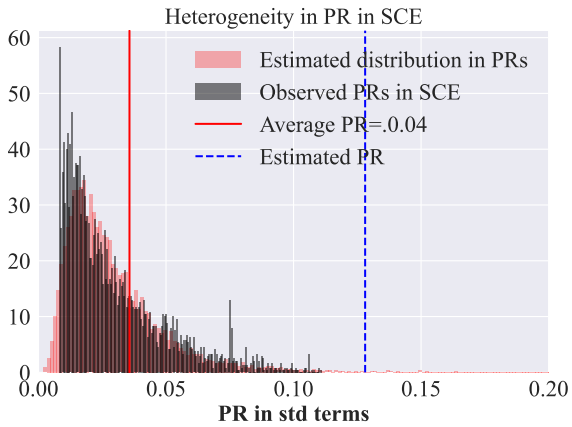

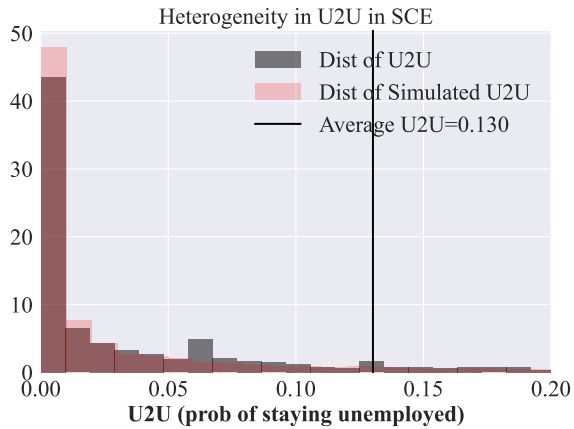

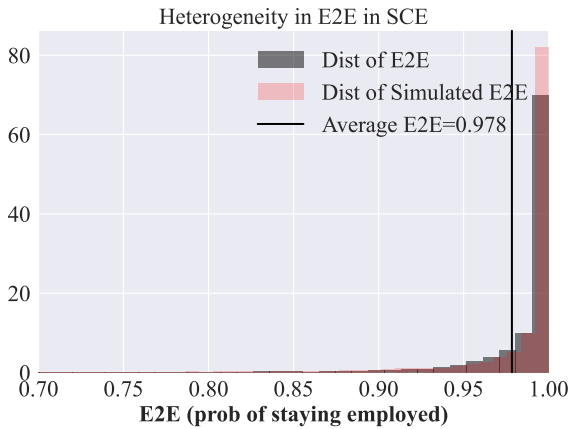

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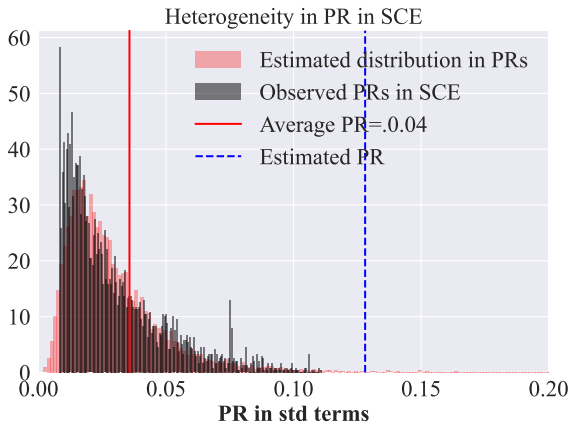
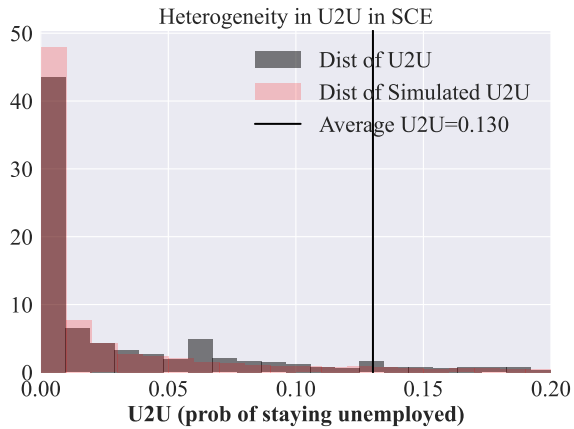
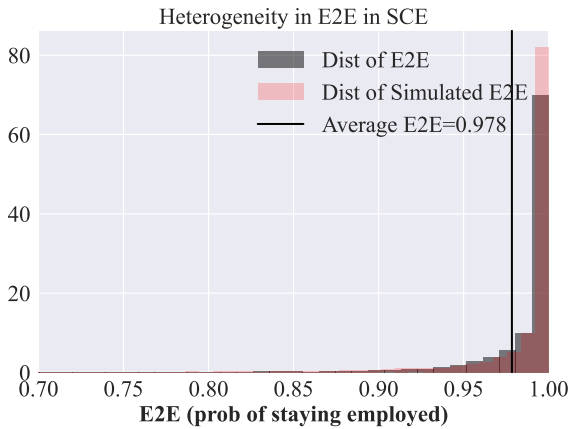
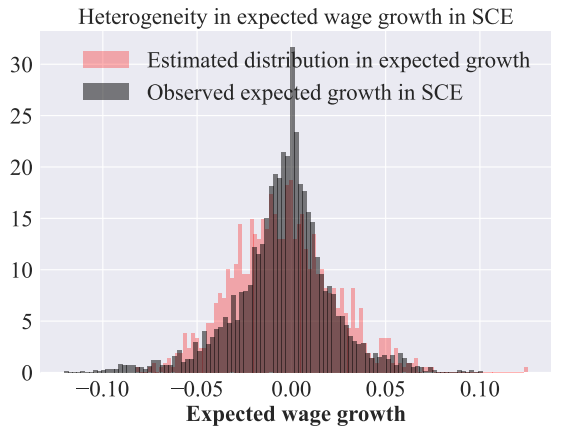








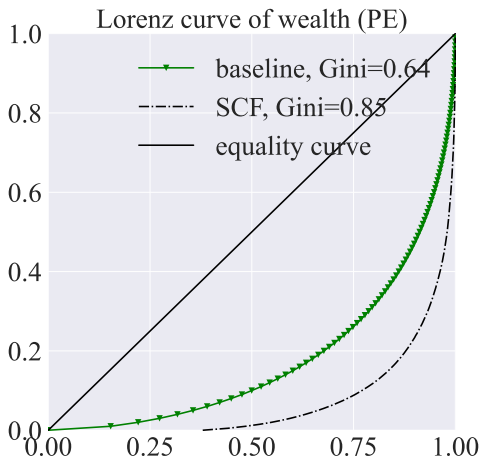
Preview of the model mechanisms

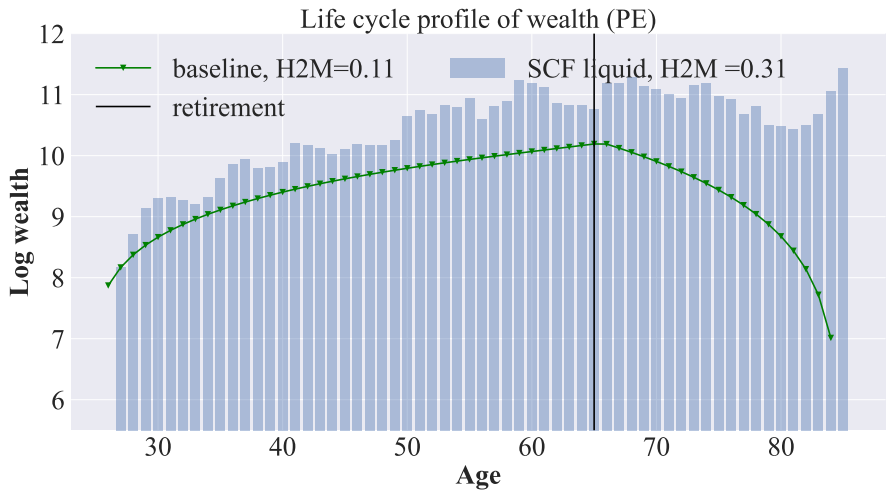
- On level of savings
  1. $\downarrow$ lower PR: lower precautionary saving motives $\rightarrow$ less liquid holding $\rightarrow$ higher MPC

Preview of the model mechanisms

- On level of savings
  1. ↓ lower PR: lower precautionary saving motives → less liquid holding → higher MPC
- On wealth inequality
  - ↑ heterogeneous PR → heterogeneity in saving/wealth

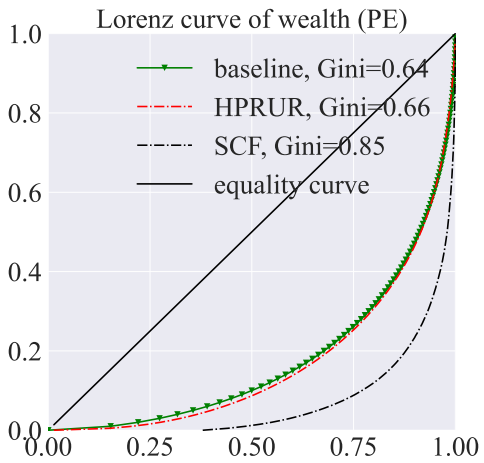
StE Distribution in different models in PE and GE

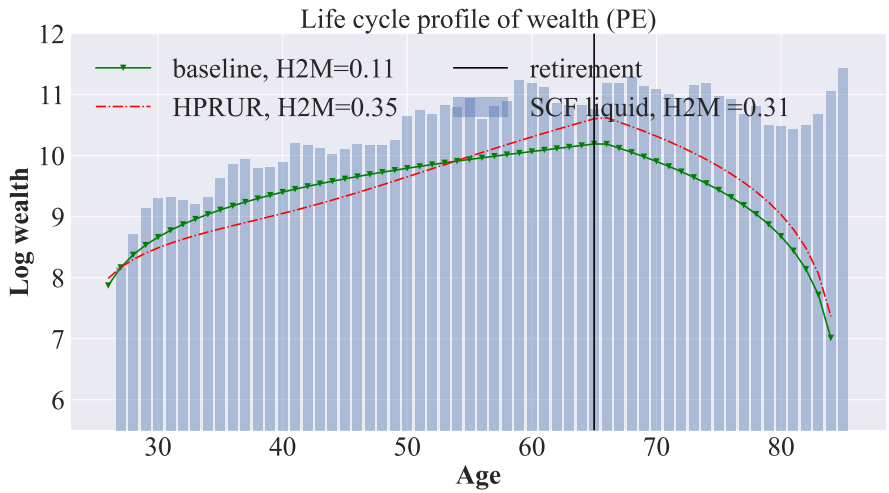




$\sigma_\psi = 0.15$, $\sigma_\theta = 0.15$, $U2U = 0.18$, $E2E = 0.96$ other parameters

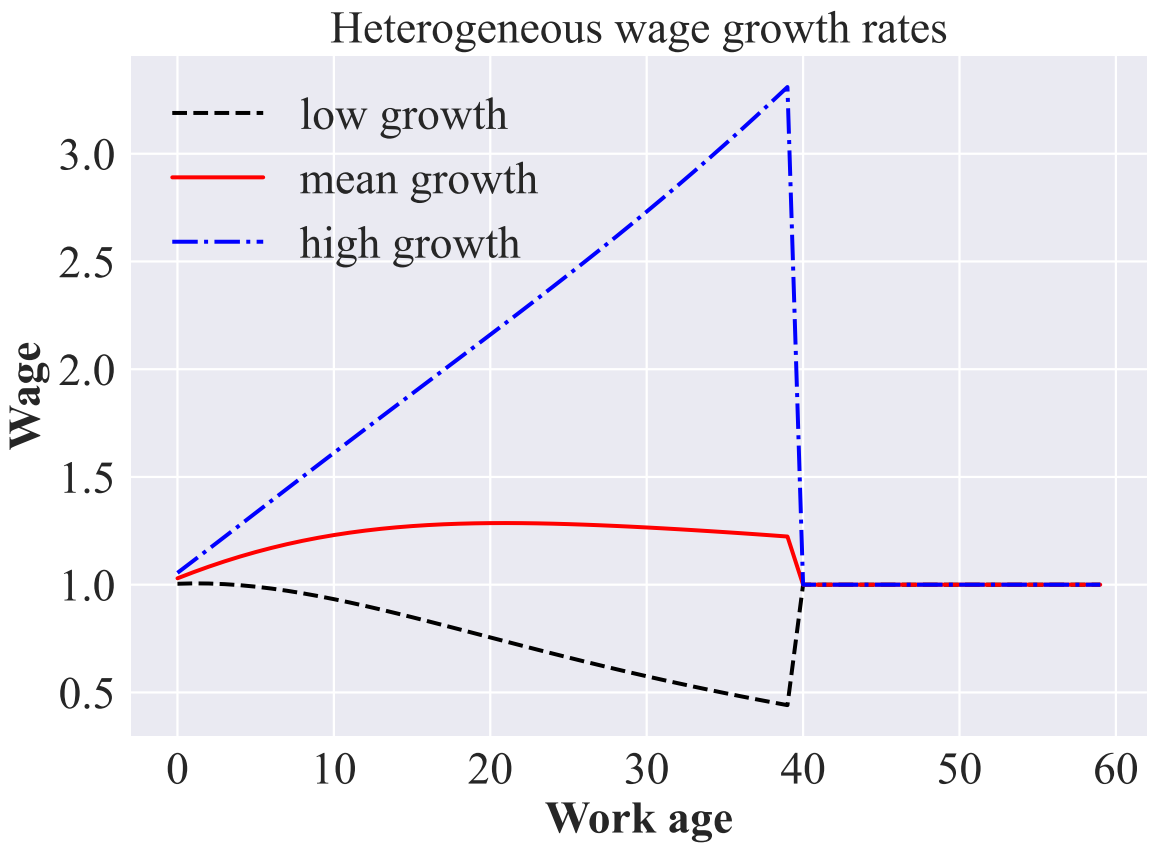
Heterogeneous perceived wage /UE risks (HPRUR)



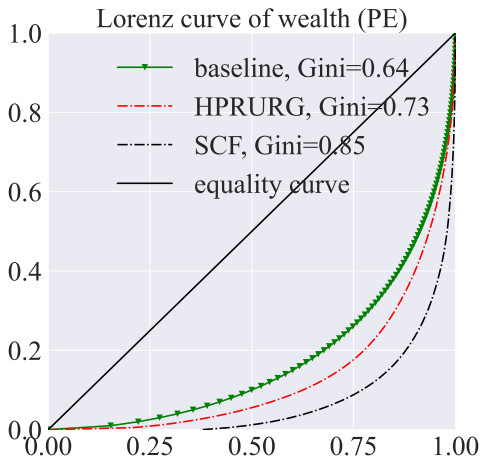


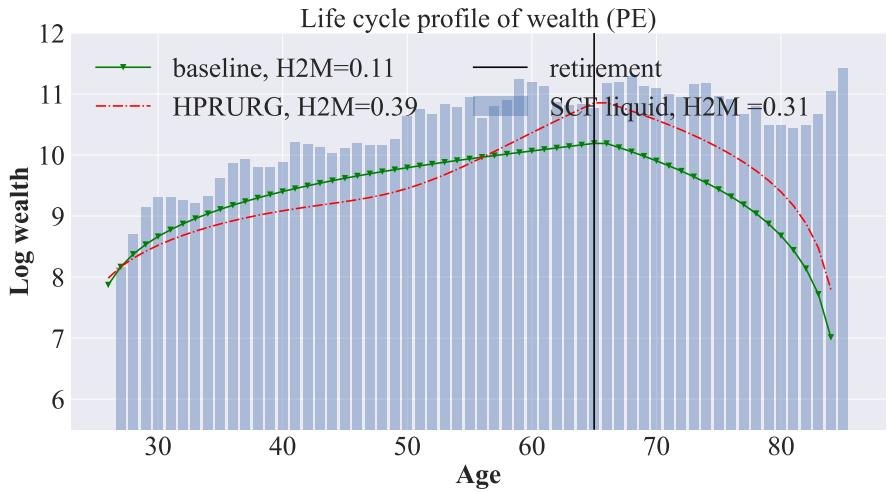
$\sigma_\psi = \sigma_\theta = [0.01, 0.02, 0.04]$, $U2U = [0, 0.02, 0.24]$, $E2E = [0.96, 0.99, 1.0]$

Hetero wage growth rates



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





$\sigma_\psi = \sigma_\theta = [0.01, 0.02, 0.04]$, $U2U = [0.1, 0.5, 0.8]$, $E2E = [0.85, 0.97, 0.99]$, $\text{std}(G) = 0.03$

Taking stock

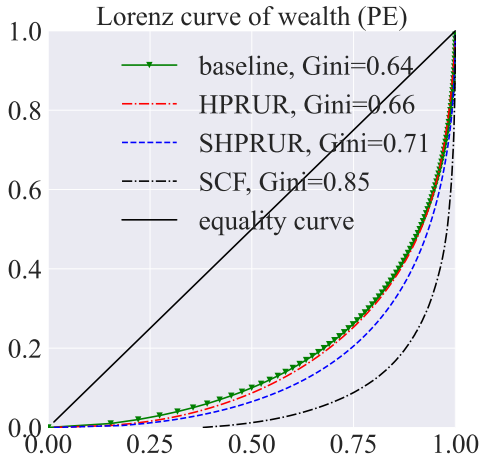
Model/Data	Gini coeff	H2M share (0.1)	H2M share (0.3)	H2M share (0.5)
SCF (liquid)	0.85	0.18	0.26	0.31
baseline (PE)	0.64	0.02	0.05	0.11
LPR (PE)	0.53	0.03	0.08	0.16
HPR (PE)	0.60	0.04	0.09	0.17
HPRUR (PE)	0.66	0.13	0.26	0.35
HPRURG (PE)	0.73	0.19	0.27	0.39
HPRURGTP (PE)	0.76	0.26	0.41	0.57
baseline (GE)	0.64	0.02	0.05	0.10
LPR (GE)	0.54	0.02	0.05	0.10
HPR (GE)	0.60	0.02	0.06	0.13
HPRUR (GE)	0.63	0.04	0.13	0.21
HPRURG (GE)	0.68	0.11	0.17	0.26
HPRURGTP (GE)	0.76	0.23	0.36	0.51

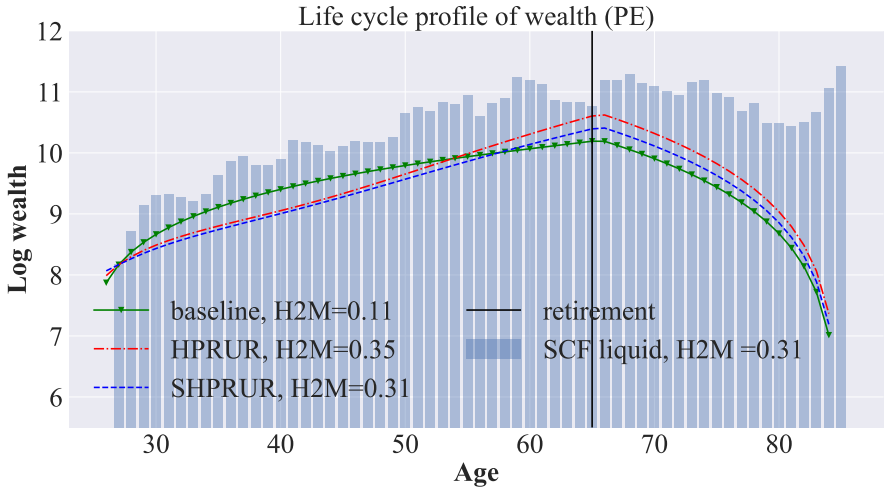
Extension: subjective PR

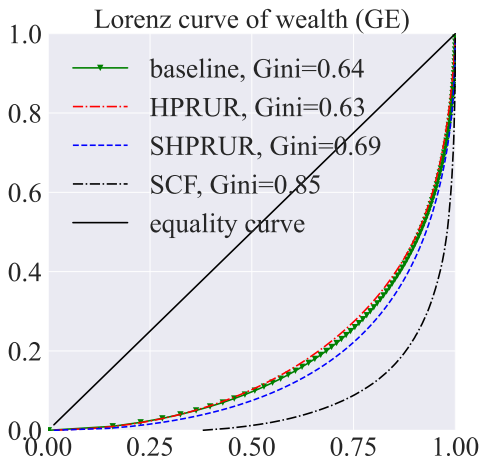
Key assumption:

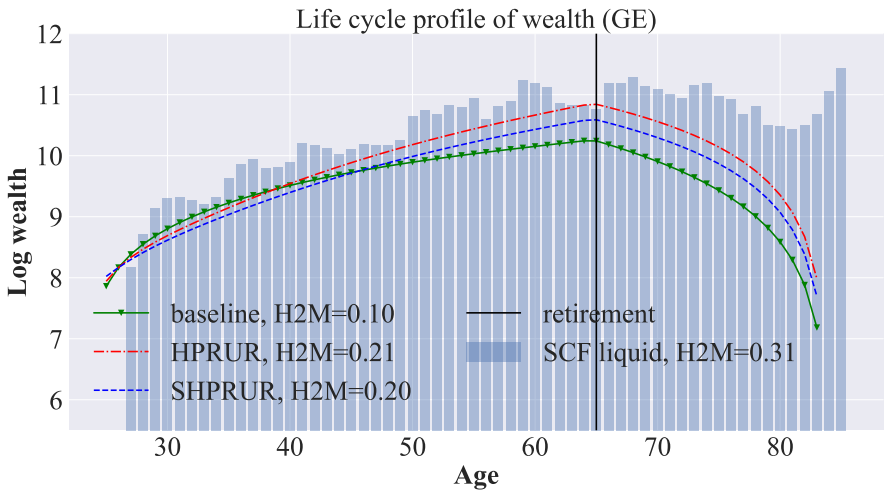
- Saving decisions made according to subjective PRs
- But income shocks drawn from the objective size of income risks
- Killing two birds with one stone
  - A robustness check against possible mis-perception by the agents
  - An breakdown of model implications into two channels
    - Ex-ante precautionary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

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

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), Low et al. (2010), 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)

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

$$Var^*_{i,t}(\Delta w_{i,t+1}) = \sigma^2_{i,t+1,\psi} + \sigma^2_{i,t+1,\theta}$$

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- The agent's PR

$$Var^*_{i,t}(\Delta w_{i,t+1}) = \sigma^2_{i,t+1,\psi} + \sigma^2_{i,t+1,\theta}$$

- Econometricians' approximated PR

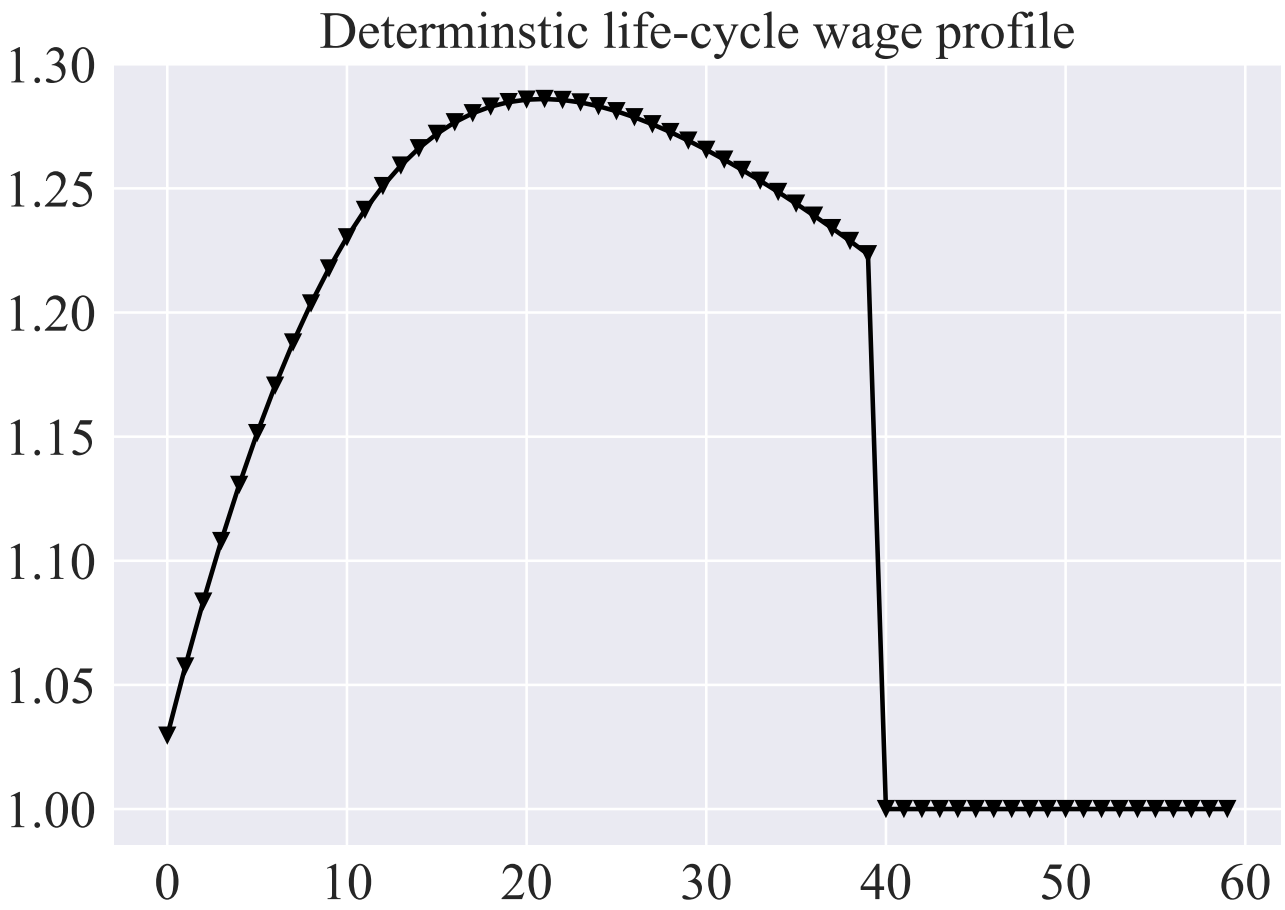
$$\widehat{Var}_{c,t}(\Delta \hat{e}_{i,c,t+1}) = \hat{\sigma}^2_{c,t+1,\psi} + \hat{\sigma}^2_{c,t+1,\theta}$$

Calibration of the benchmark model

Table: Model parameters

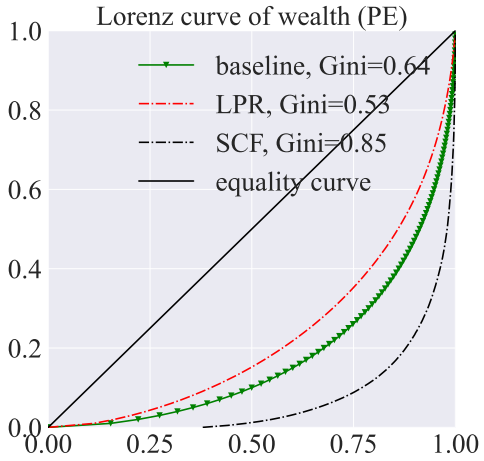
block	parameter name	values	source
risk	σ_ψ	0.15	Median estimates from the literature
risk	σ_θ	0.15	Median estimates from the literature
risk	$U2U$	0.18	Median estimates from the literature
risk	$E2E$	0.96	Median estimates from the literature
initial condition	$\sigma_\psi^{\text{init}}$	0.629	Estimated 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

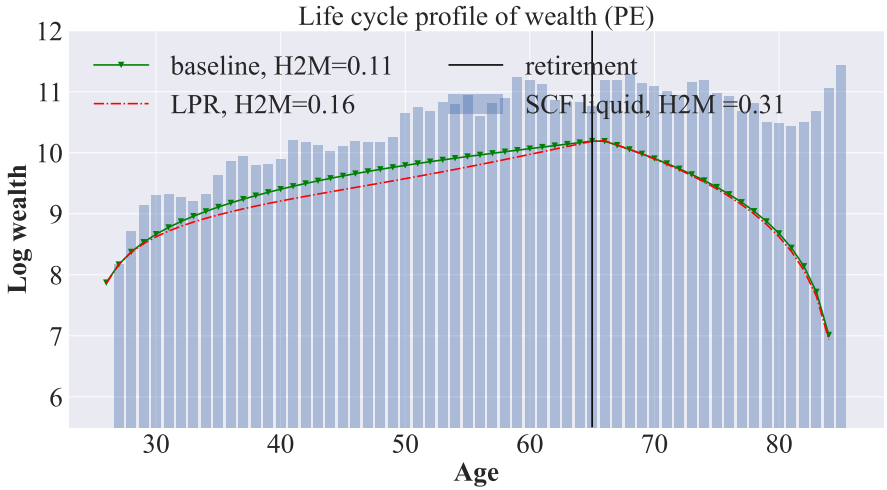
Deterministic wage profile over life cycle

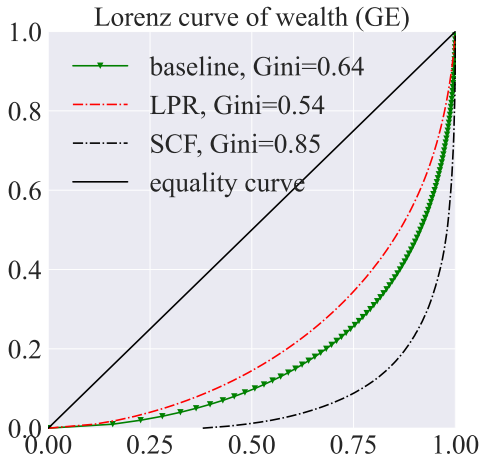


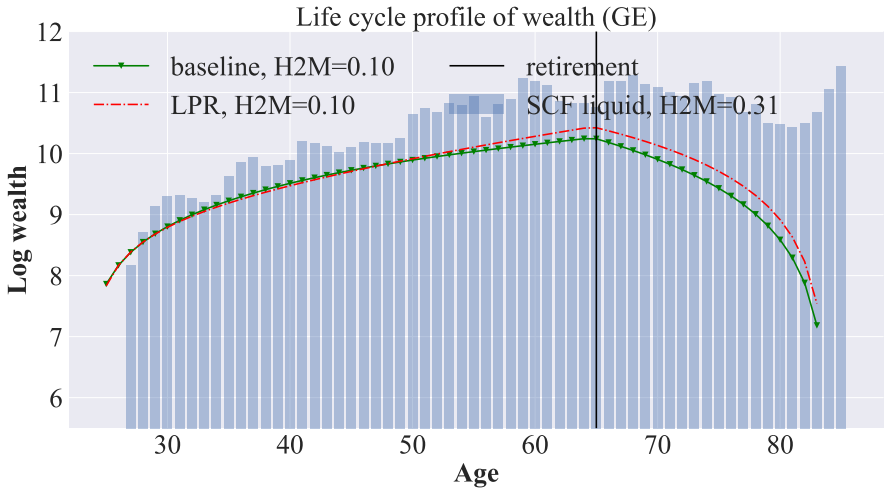
- Estimated from SIPP with a fourth-order age polynomial regression

Lower perceived risks (LPR)



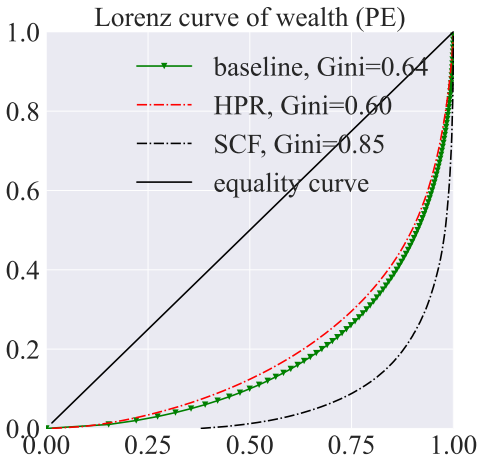


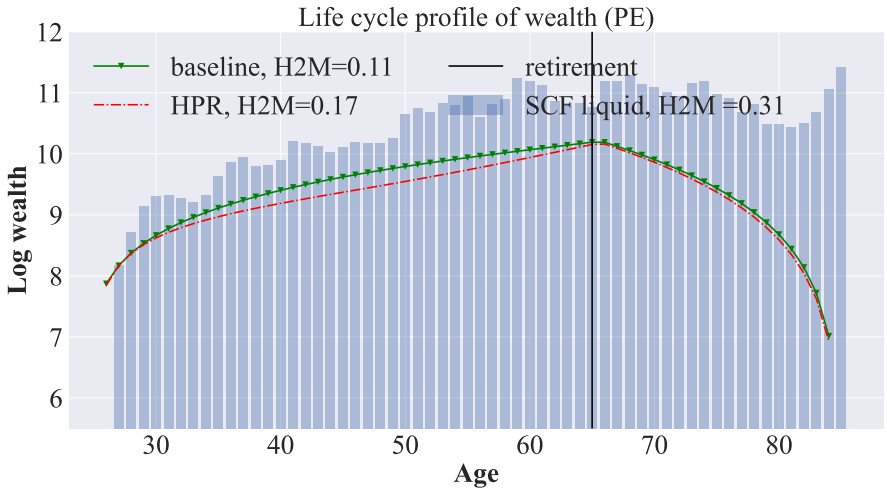


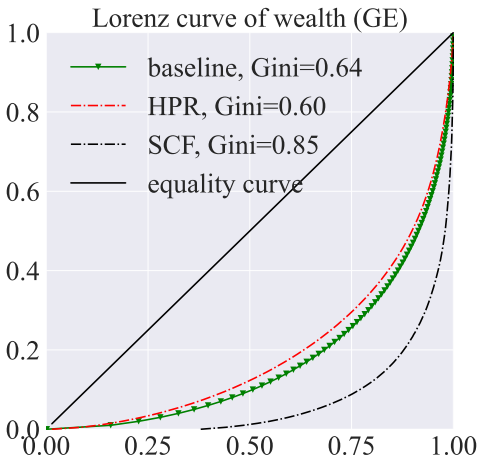


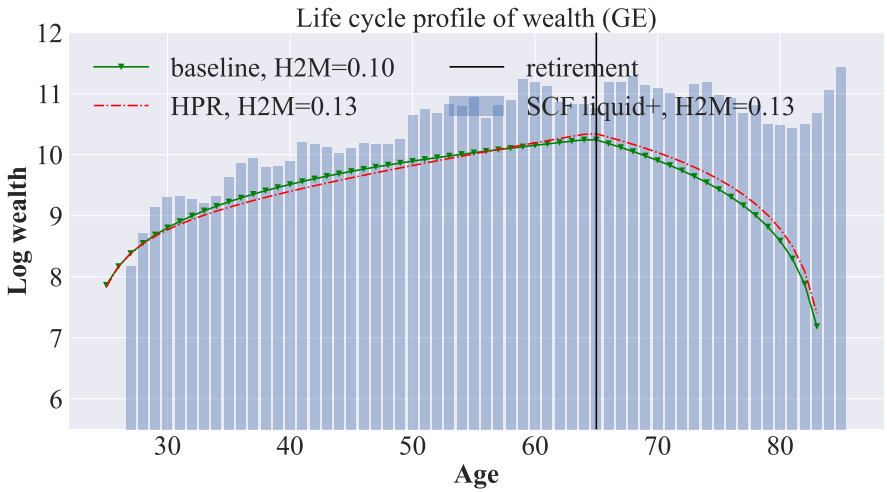
$\sigma_\psi = 0.03$, $\sigma_\theta = 0.02$, $U2U = 0.18$, $E2E = 0.96$ other parameters

Heterogeneous perceived wage risks (HPR)









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

Evolution of the distribution over state variables

- objective:

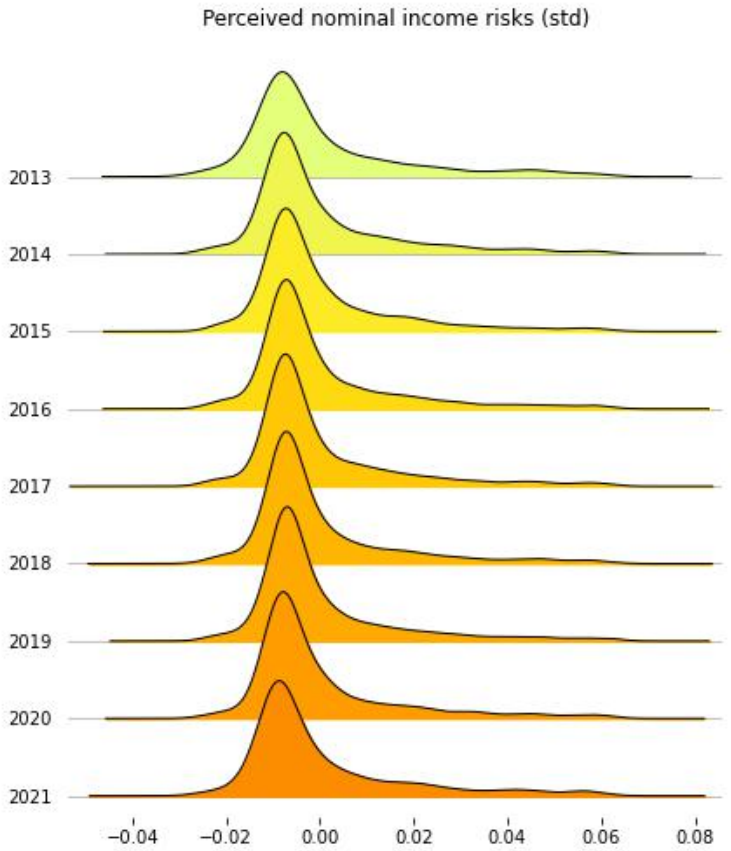
$$\psi_\tau(B) = \int_{x \in X} \underbrace{P(x, \tau - 1, B)}_{\text{transition funcs}} \mathrm{d}\psi_{\tau-1} \quad \text{for all} \quad B \in B(X)$$

- subjective:

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

  - $\tilde{P}$ depends on both subjective and objective risks

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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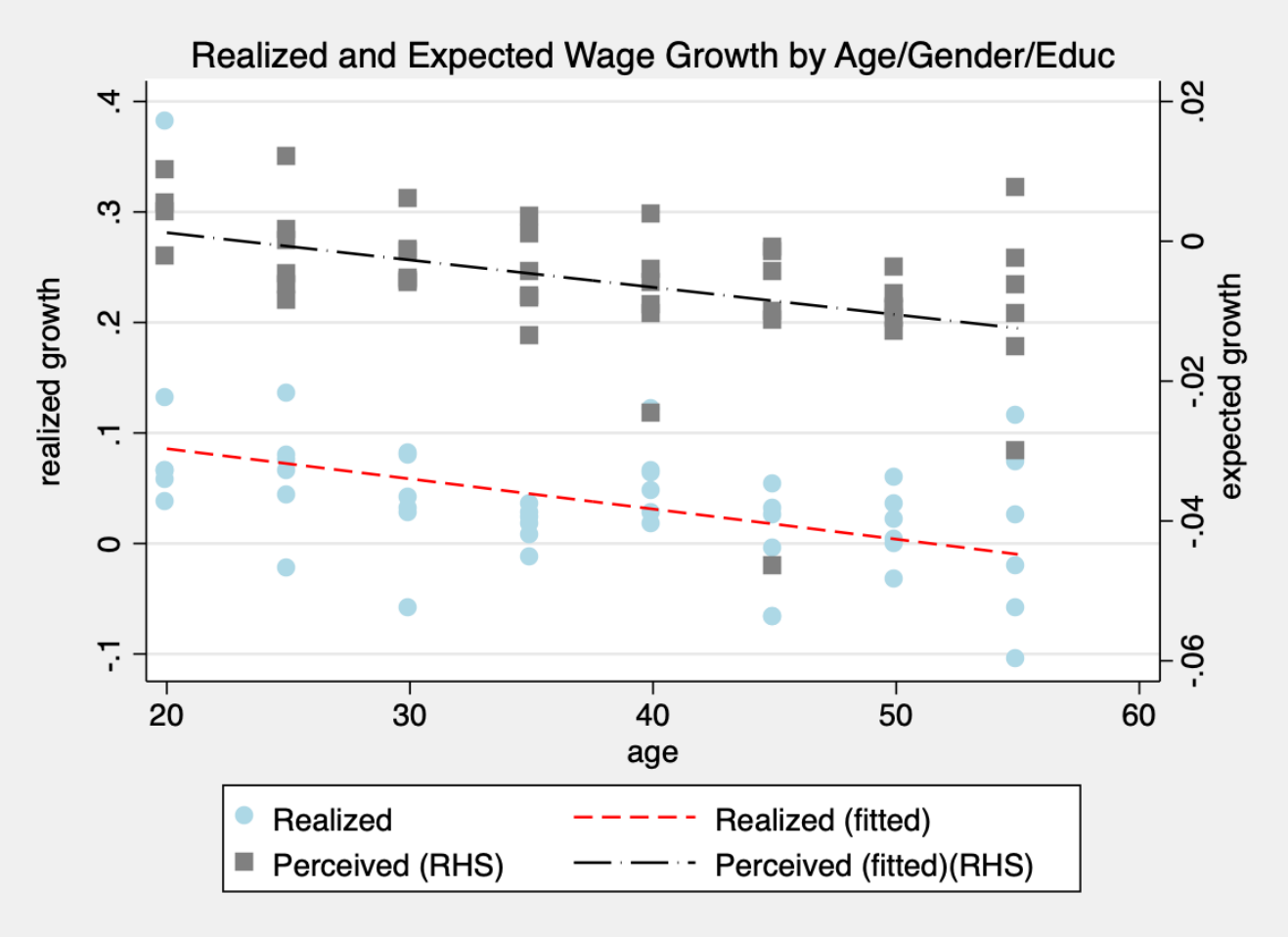
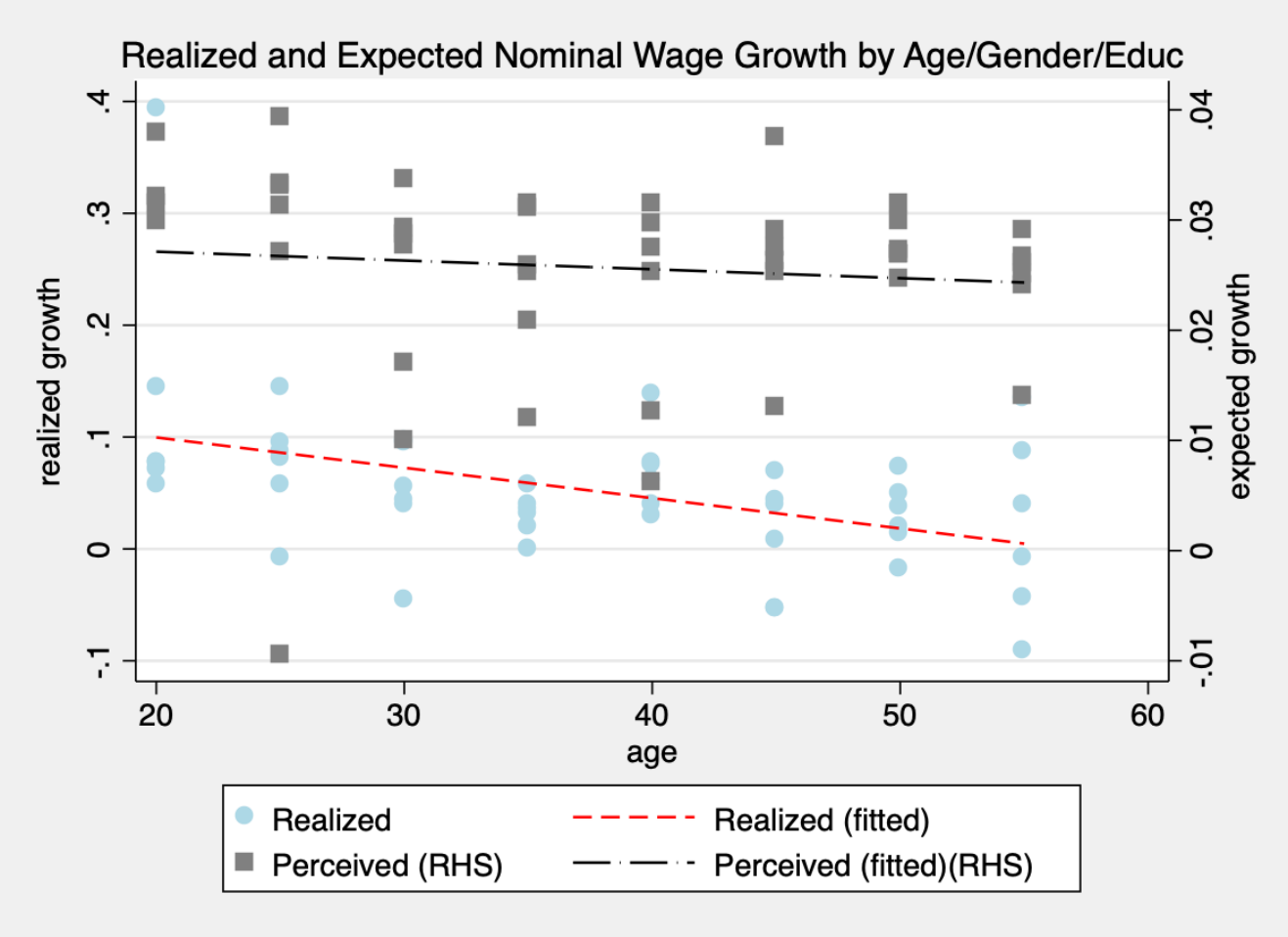
Appendix: expected growth by age



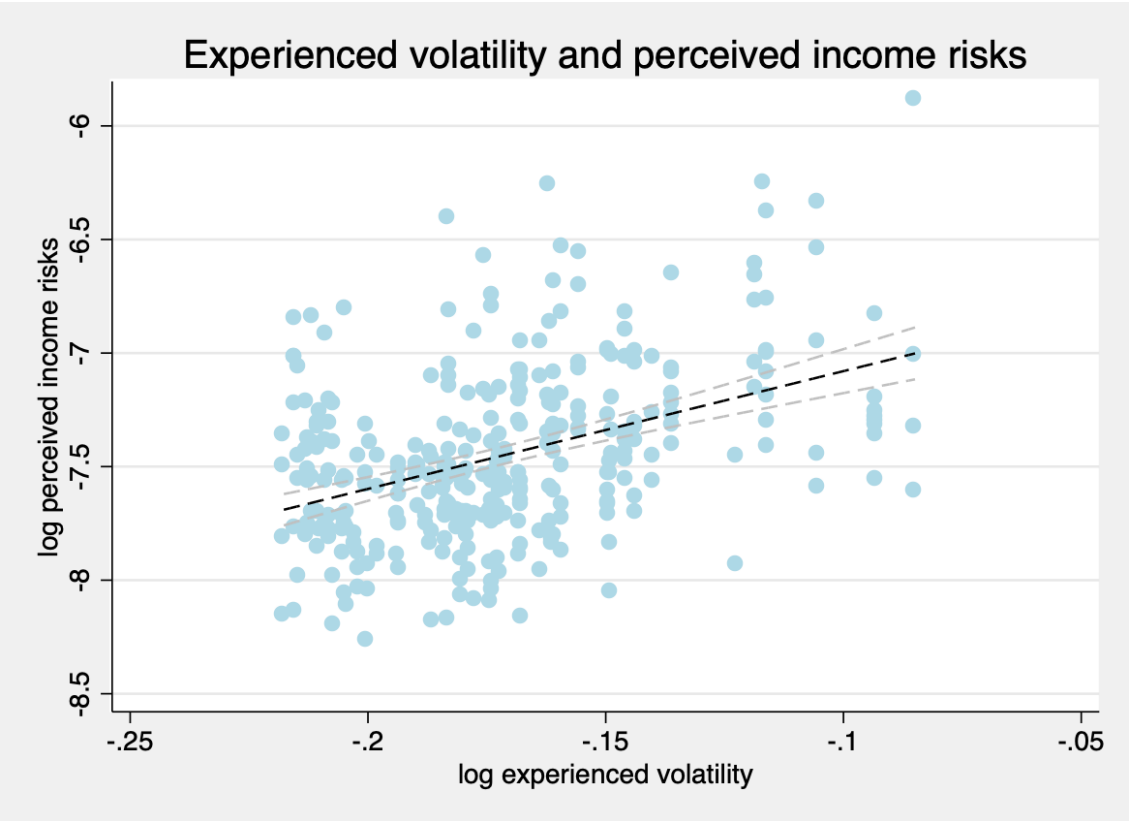
- e.g. a male high school graduate aged 30

Appendix: expected **nominal** growth by age



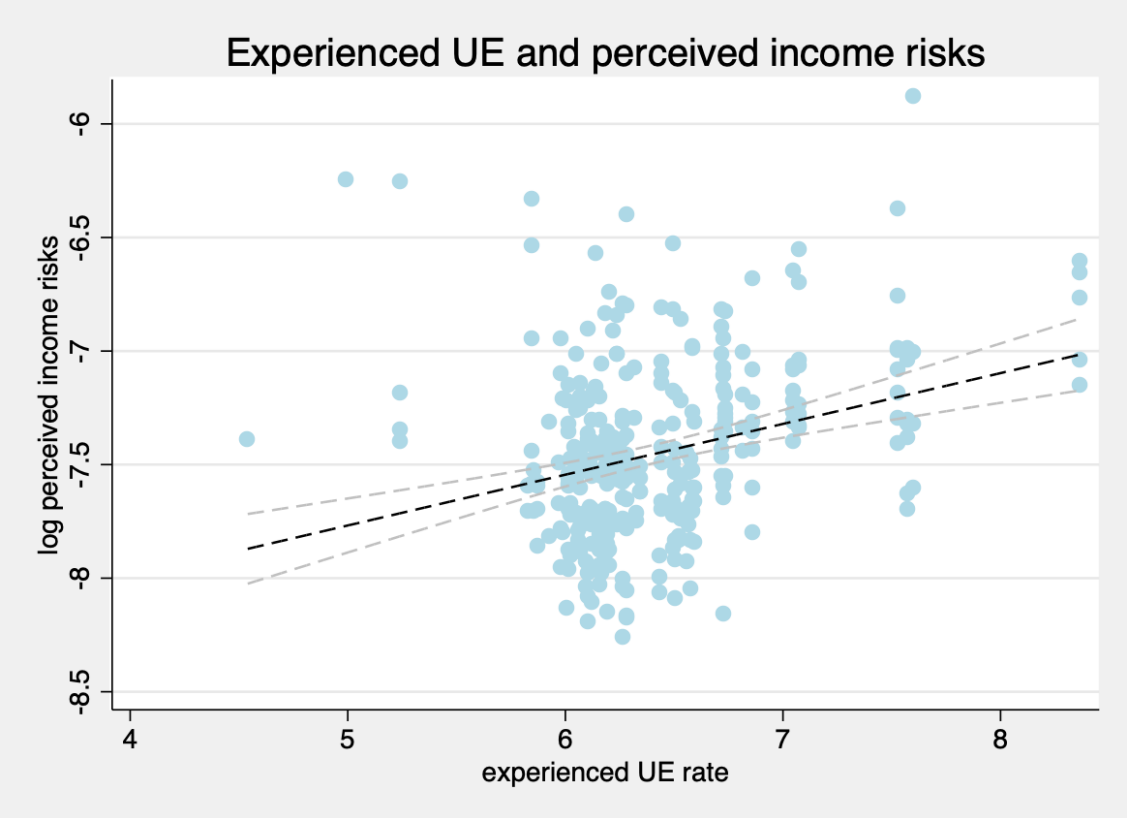
- e.g. a male high school graduate aged 30

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

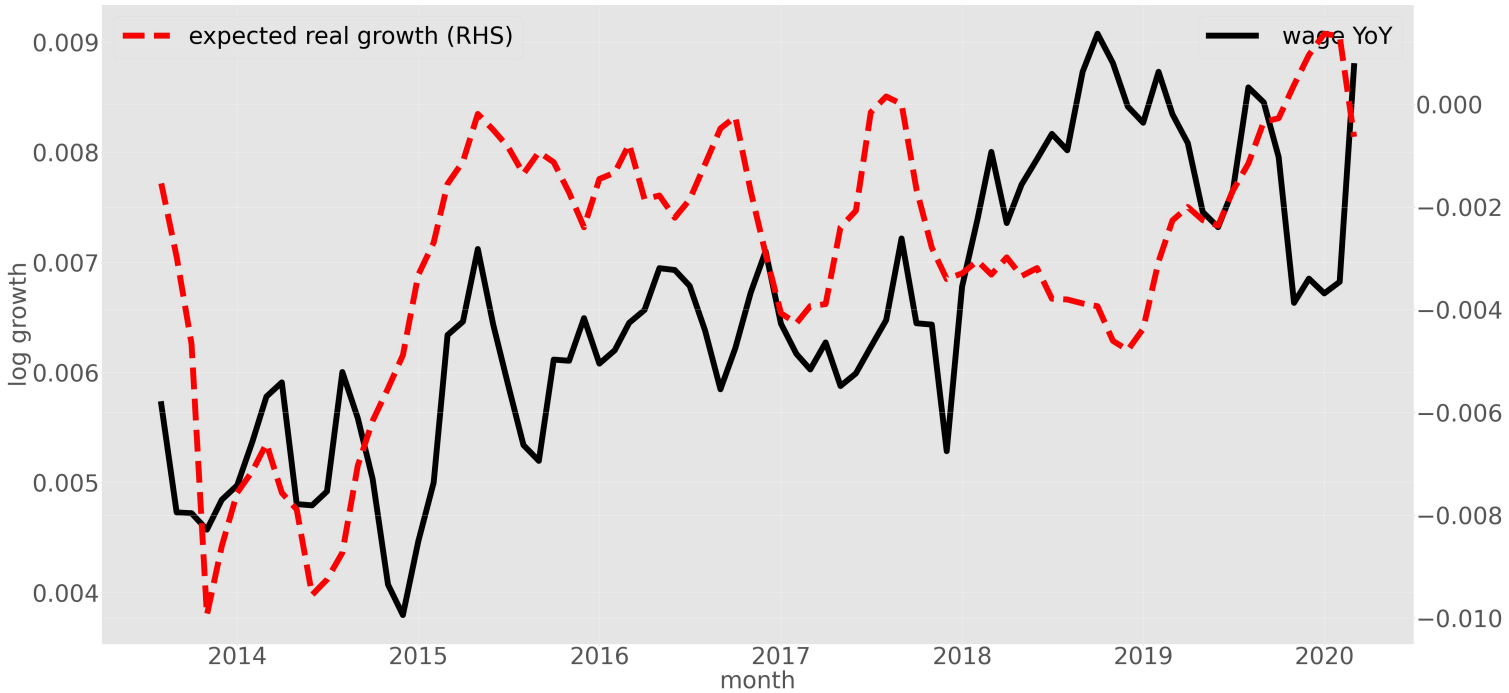
Appendix: Extrapolation from individual experiences

- 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



Appendix: PR and current labor market condition

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

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

	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

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

	(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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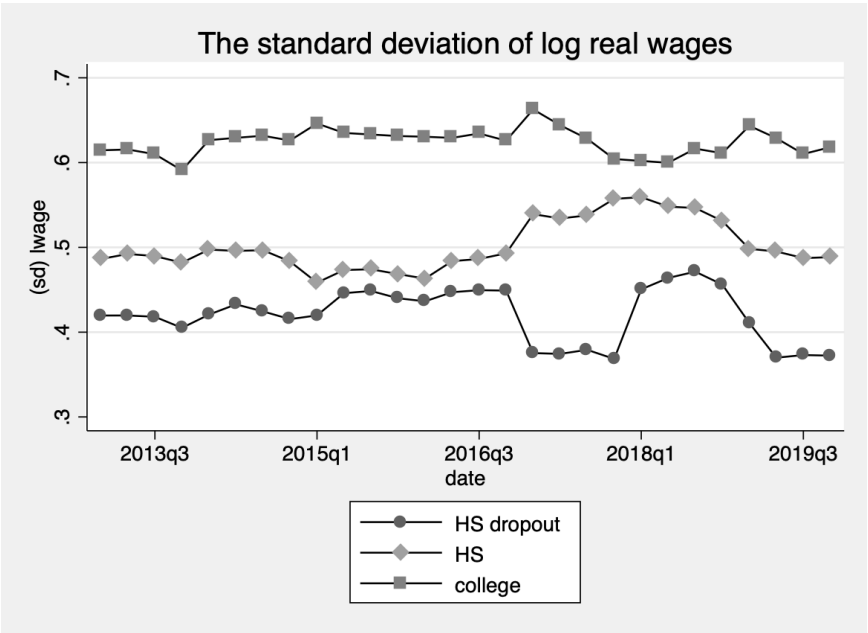
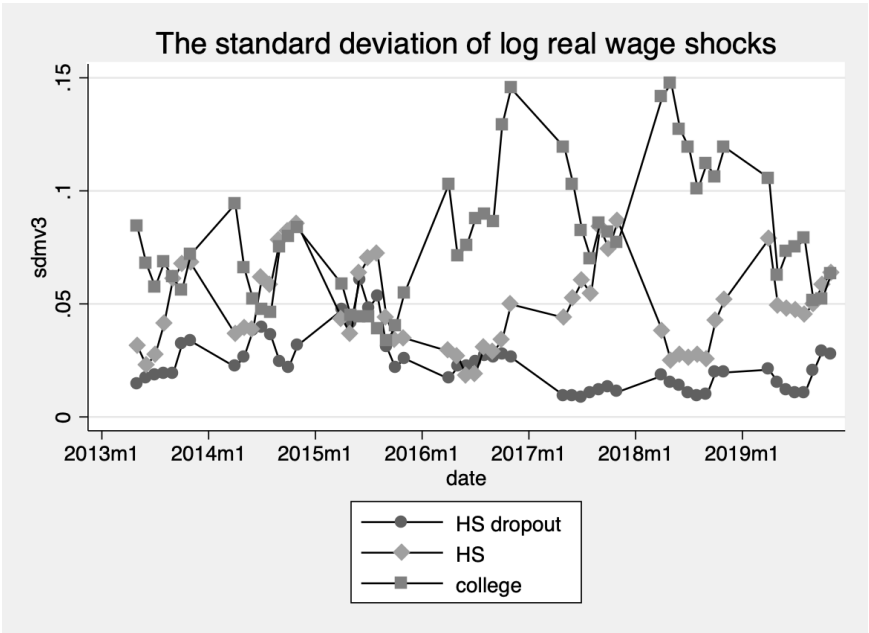
Appendix: monthly earning inequality and volatility

(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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