Perceived Income Risks

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Outline

Motivation

- Risks matter for individual decisions
  - precautionary saving
  - stock market participation
  - portfolio choice
- Risks matter for macroeconomic outcomes
  - since idiosyncratic risks are not perfectly insured
    - $\rightarrow$ income/wealth inequality
    - $\rightarrow$ heterogeneous MPCs
    - $\rightarrow$ distributional channel of macroeconomic policies
    - $\rightarrow$ business cycle fluctuations
- Income risks are central inputs of any incomplete-market model
- My question: perceptions $\approx$ estimates $\approx$ “the truth”?

Some macro facts

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

Preview of the findings

1. **Empirics:** subjective risk profiles from a density survey
   - Heterogeneity: sizable difference across/within groups
   - Superior information: on average lower than standard parameterizations used by economists
   - State-dependence: negative correlation with recent/past labor market conditions
   - Extrapolation: correlated with negative labor outcomes
   - History-dependence: positive correlation with experienced volatility/unemployment
   - Decisions: spending plans react to risk perceptions

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   - Decisions: spending plans react to risk perceptions
2. **Model**:
   - a survey-informed subjective OLG / incomplete-market GE model
     - Lower PR $\rightarrow$ lower savings
     - State-dependence/extrapolation $\rightarrow$ higher savings
     - Heterogeneity in PR $\rightarrow$ 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)
- 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)

Log income process

$$\underbrace{y_{i,c,t}}_{\text{idiosyncratic log earning}} = \underbrace{z_{i,c,t}}_{\text{predictable component}} + \underbrace{e_{i,c,t}}_{\text{stochastic component}}$$

- individual i at time t
- group c: share income process/risks $\sigma^2_{c,t}$
  - i.e. education/year of birth/gender/age
- $e_{i,c,t}$: to be specified later

Perceived risks (PR)

- Income growth

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

- To the agent: **expected volatility** under FIRE

$$Var^{*}_{i,c,t}(\Delta y_{i,c,t+1}) = \sigma^2_{c,t+1|t}$$

- To econometricians: **volatility**

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

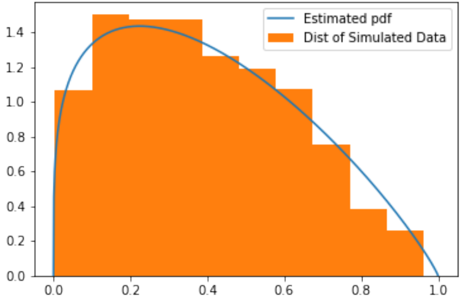
Data and sample

- Density survey: SCE
  - 2013M6-2020M4 (monthly)
  - 1300 households
  - 12-month panel
- Income panel: PSID
  - 1970-1996 (annual), 1997-2017 (biennial)
  - approximately 5000 males/females
  - variable: wage/earning of household heads
  - stay in the sample for 11+ years
  - CPI adjusted
  - age 20-59
- Income Panel: SIPP
  - 2014M1-2019M12 (monthly)
  - earning from the primary job
  - 900-2700 respondents
  - CPI adjusted
  - age 20-59

Survey question

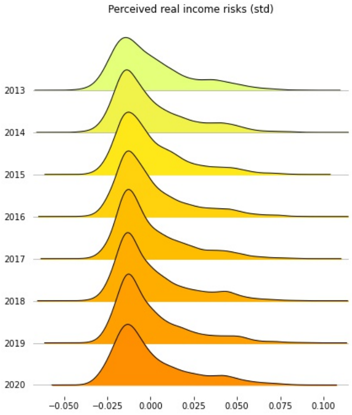
- Individual-specific bin-based forecast on $\Delta y_{i,t+1}$
  - earning growth of the same job/position/hours
  - exl. endogenous labor supply changes/promotion/demotion/separation
- Measurement of PR:
  - variance: $\overline{Var}_{i,t}(\Delta y_{i,t+1})$
- density estimation following Engelberg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

An illustration of the density forecast estimation



- case 1. 3+ intervals with positive probs, to be fitted with a generalized beta distribution
- case 2. exactly 2 adjacent intervals with positive probs, to be fitted with a triangle distribution
- case 3. one interval only, to be fitted with a uniform distribution

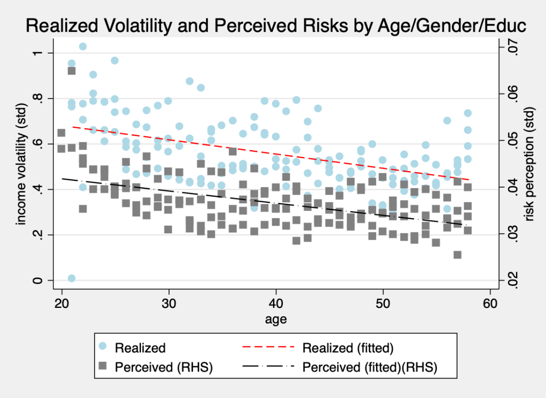
Within-group dispersion in perceived income risks



- residuals controlling for observables + time FE ($R^2 = 0.07$)
- average PR: 3.5% in std; 10/90 IQR: 5.2% in std nominal

skewness

By age/gender/education



- e.g. a male high school graduate aged 30 growth by age by age/education by 5-yr of birth/education/gender
- consistent with Moffitt and Gottschalk (2002), Sabelhaus and Song (2010)

Time series structure of income shocks

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

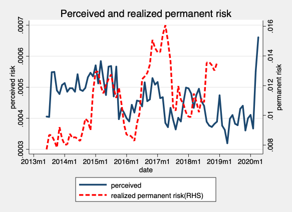
$$log(p_{i,c,t+1}) = log(p_{i,c,t}) + log(\psi_{i,c,t+1})$$

$$log(\psi_{i,c,t}) \sim N(\frac{-\sigma^2_{c,t,\psi}}{2}, \sigma^2_{c,t,\psi})$$

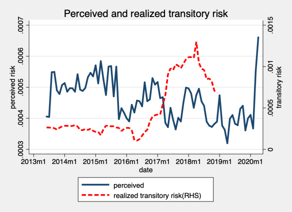
$$log(\theta_{i,c,t}) \sim N(\frac{-\sigma^2_{c,t,\theta}}{2}, \sigma^2_{c,t,\theta})$$

Permanent versus transitory risks (from monthly earning data)

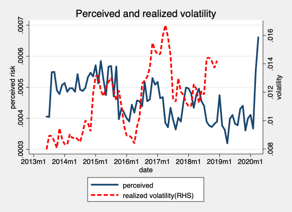
(a) permanent



(b) transitory



(c) volatility



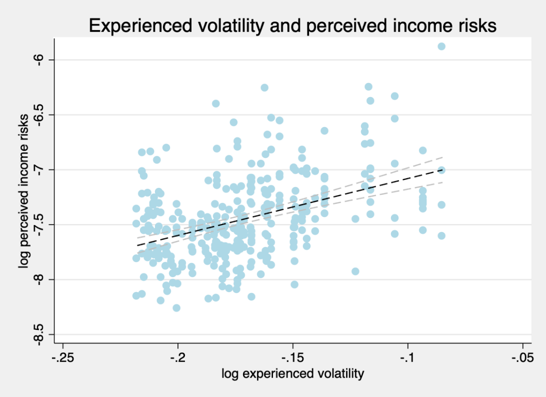
- i.e. one-year-ahead perceived risk at 2014m1 v.s. realized risk over the same period
- monthly wage rate: earning per hour of work
- estimated monthly risks aggregated into annual frequency

More details | PSID

Perceptions versus economists' estimates

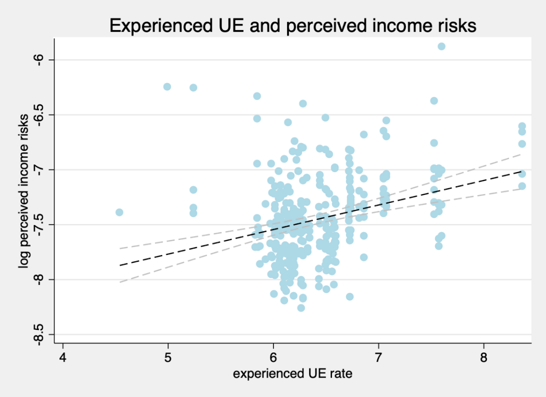
	PerceivedRisk	PerceivedRisk(median)	RealizedGroupVolatility	RealizedPRisk	RealizedTRisk
full sample (100%)	0.029	0.021	0.090	0.101	0.016
gender					
1 (50%)	0.030	0.022	0.091	0.102	0.016
2 (49%)	0.028	0.022	0.089	0.101	0.016
education					
HS dropout (0%)	0.036	0.022	0.051	0.100	0.016
HS graduate (42%)	0.030	0.022	0.085	0.101	0.016
College/above (56%)	0.028	0.021	0.094	0.101	0.016
5-year age					
20 (2%)	0.037	0.031	0.072	0.102	0.015
25 (12%)	0.032	0.027	0.115	0.102	0.016
30 (12%)	0.030	0.023	0.091	0.101	0.016
35 (13%)	0.029	0.021	0.098	0.101	0.016
40 (13%)	0.028	0.020	0.084	0.101	0.016
45 (14%)	0.028	0.020	0.065	0.101	0.016
50 (15%)	0.027	0.019	0.078	0.101	0.016
55 (15%)	0.027	0.018	0.105	0.100	0.016

Experienced income volatility and perceived risks



- 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

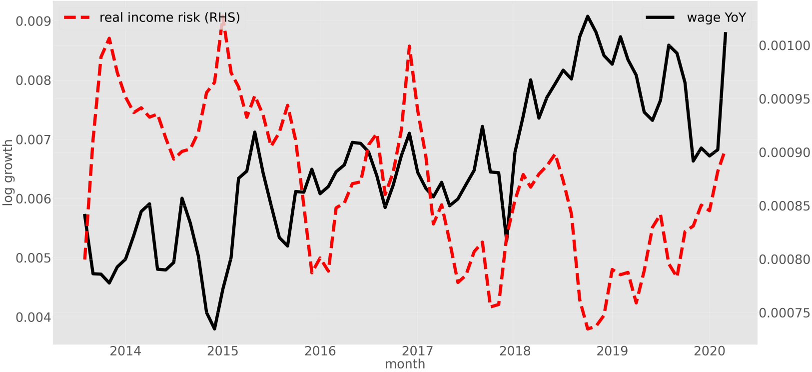
Extrapolation from individual experiences

- 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

Perceived risks and recent (past) wage growth

- $\overline{\text{var}_t}$: average perceived risk across individuals
- $log(\text{wage}_t) - log(\text{wage}_{t-1/4})$: quarterly growth in average hourly wage



Perceived risks and current labor market condition

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

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

	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*

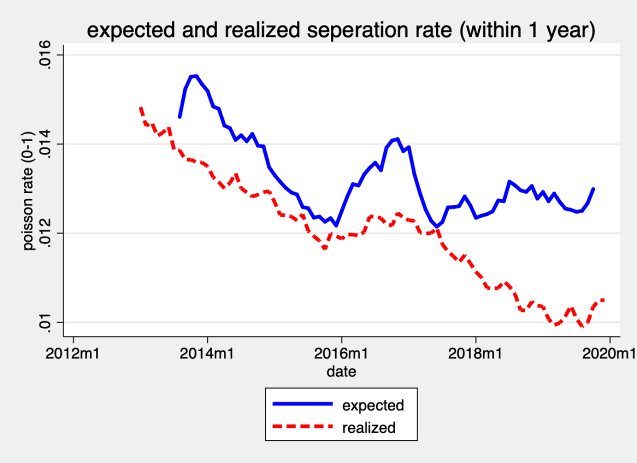
- Counter-cyclical income risks: Storesletten et al. (2004), Guvenen et al. (2014), Bayer et al. (2019)

Perceived risks 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

Perceived unemployment risk and realized job separation rate



- realized job separation rate is computed from CPS survey

Perceived risks and household spending

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

	(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.

Taking stock

- People do have some clues
    - consistent with inter-group differences in income volatility
    - other covariates
        - $\downarrow$ with education, household income, being a male
        - $\uparrow$ with numeracy score, self-employed job, perceived individual UE risks, aggregate UE expectations, experienced volatility

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- But huge amount of heterogeneity remains
  - including all above: $R^2 = 0.10$
  - individual fixed effects only: $R^2 = 0.71$
- Possible explanations
  - "superior information"/ unobserved heterogeneity
  - state dependence: aggregate economy conditions matter
  - past dependence: experiences matters Kuchler and Zafar (2019)
  - intrinsic heterogeneity: some are more uncertain than the other Ben-David et al. (2018)

Implications for consumption/saving

- On level of aggregate savings
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  4. $\uparrow$ counter-cyclical risks: amplified business cycle fluctuations Bayer et al. (2019)

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- On wealth inequality
  - $\uparrow$ Direct effect: heterogeneous PR $\rightarrow$ heterogeneity in saving/wealth
  - $\uparrow$ Indirect effect: lower PR $\rightarrow$ lower self-insurance $\rightarrow$ higher ex-post wealth inequality

Model overview

- Overlapping generation
- General equilibrium
- Uninsured idiosyncratic income risks
  - Permanent+ transitory productivity shock
  - Persistent unemployment spells
- No aggregate risk a la Krusell and Smith (1998)
- A blend of Huggett (1996) and Carroll (1997)
- Single one risk-free asset
- Allowing for subjective risk perceptions
  - Individuals swing between low/high risk perceptions

Benchmark model (objective risk perceptions)

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

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

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

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

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

- 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

- income

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

- permanent component

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

- 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 $\nu = e$

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

Objective versus subjective profile

- objective: agents perceive $\underbrace{\Gamma = \{\sigma^2_{\psi}, \sigma^2_{\theta}, \mho, E\}}_{\text{income risk parameters}}$
- subjective with state-dependence: each agent i swings between two subjective risk state $\tilde{\Gamma}_{i,\tau} = \tilde{\Gamma}_l$ and $\tilde{\Gamma}_{i,\tau} = \tilde{\Gamma}_h$, with transition matrix Ω.
  - heterogeneity in risk perceptions
- subjective model with extrapolation: $\tilde{\Gamma}_{i,\tau}$ depends on employment status $\nu_{i,\tau}$, i.e. $\tilde{\Gamma}_{i,\tau}(\nu_{i,\tau} = 0) = \tilde{\Gamma}_l$ and $\tilde{\Gamma}_{i,\tau}(\nu_{i,\tau} = 1) = \tilde{\Gamma}_h$

Why subjective risk perceptions?

- I don't take a stance on if agents perceptions are correct or wrong
- It could be due to unobserved information to economists, or because of psychological reasons
- The subjective risk profile is disciplined by the survey data
- Risk parameters are exogenous to the model, therefore, does not contradict with rational expectation.

Economic environment

- Technology

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

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- Government (balance budget)

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

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

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

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

Economic environment

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$$\mu_{\tau+1} = (1-D)\mu_\tau$$

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- Accidental bequests
  - Newborn starts with a bank-balance equal to $0-1$ fraction of the lump-sum of the accidental deceased's wealth

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:

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

  - $B(X)$: 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:

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

Stationary equilibrium (StE)

- Optimal consumption and saving policies given W, R, λ
- Distribution evolution consistent with optimal c and a policies and exogenous probabilities of income/beliefs
- The factor markets are clearing.

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

$$\sum_{\tau=0}^{T-1} \mu_\tau \Pi^E_\tau = N$$

- Firm optimization under competitive factor markets.

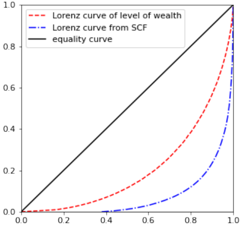
$$W = Z(1-\alpha)(K/N)^\alpha$$

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

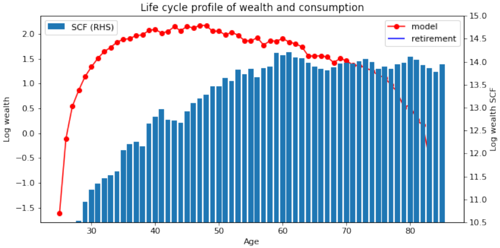
- Newborn's bank balance equal to accidental bequests
- Balanced government budget

StE Distribution of the Objective model (preliminary)

(a) Wealth inequality



(b) Life-cycle wealth distribution



Calibration Partial equilibrium

Estimation of subjective risk profile

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

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

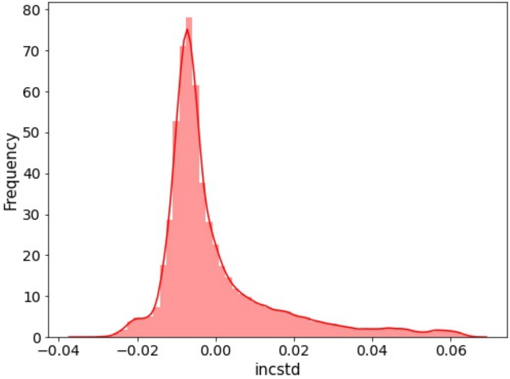
- $J_{i,t} = 0$ for low and $= 1$ for high PR state
- a short time series of $\tilde\Gamma_{i,t}$ for many is observed in the survey
- $\{\tilde\Gamma_l\,\tilde\Gamma_h, \Omega\}$ can be estimated by MLE
- a modified Hamilton (1989) 2-regime-switching model
- $J_{i.t}$ can be also dependent upon business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

More details

Summary

- 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

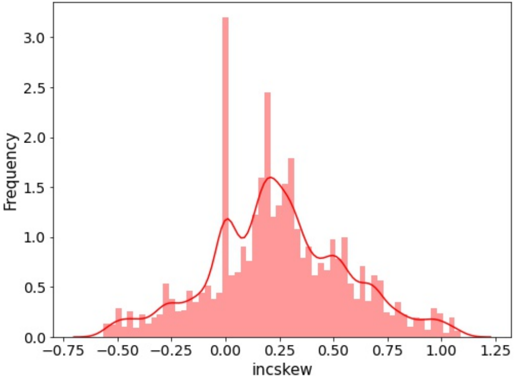
Within-group dispersion in nominal PR



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

Back

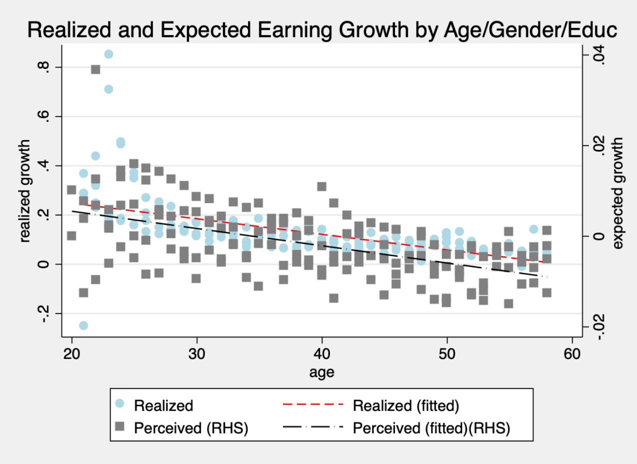
Within-group dispersion in PR skewness



- residuals controlling for observables / time fixed effects

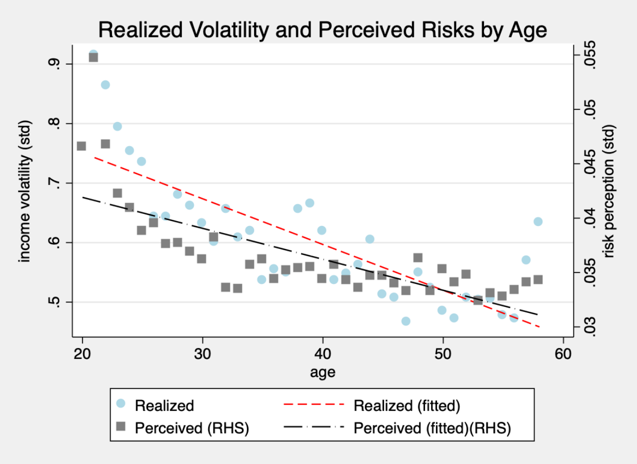
Back

Appendix: expected growth by age



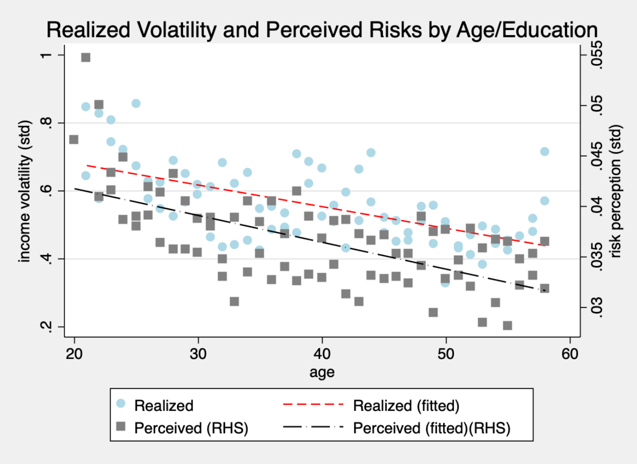
- e.g. a male high school graduate aged 30 Back

Appendix: PR by age



- e.g. a 35-year old Back

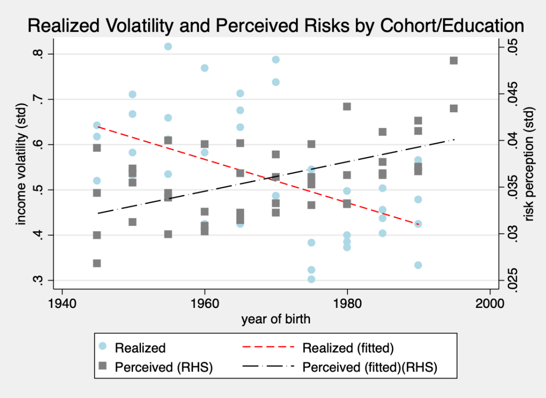
Appendix: PR by age/education



- e.g. a 35-year old high school graduate

Back

Appendix: PR by cohort/education/gender

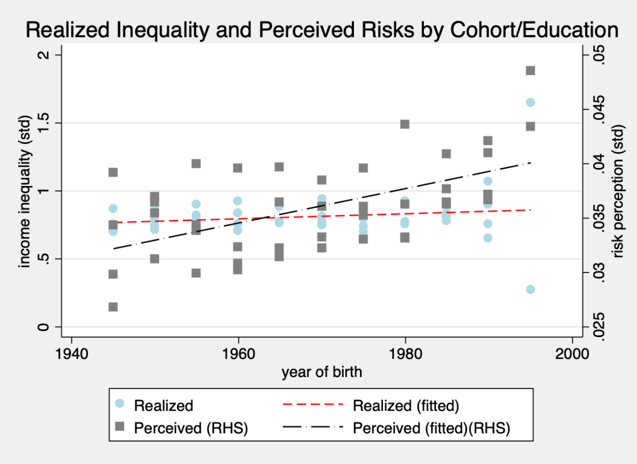


- e.g. a male higher school graduate born between 1990-1995

inequality inequality by 5-year/education 5-year/education Back

- declining income volatlity between 1978-2013 Sabelhaus and Song (2010), Bloom et al. (2018)

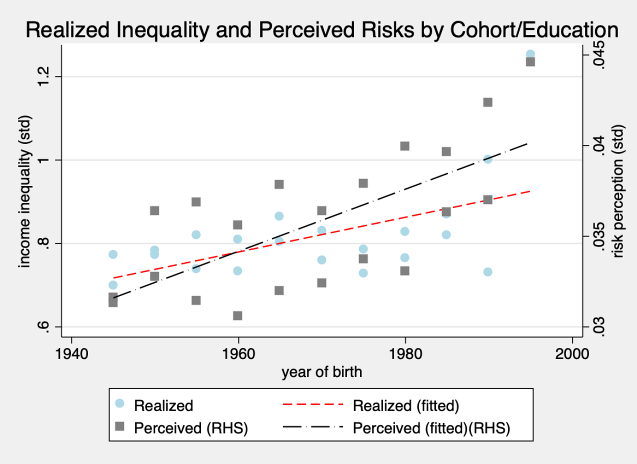
Appendix: PR by cohort



- e.g. a female college graduate born between 1970-1975

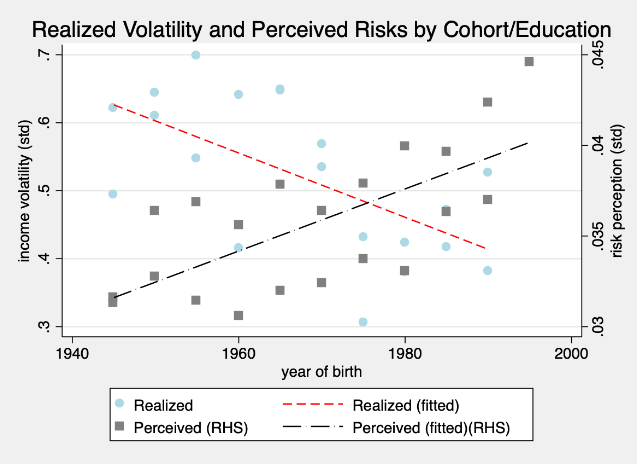
Back

Appendix: PR by cohort/education



- e.g. a high school graduate born between 1985-1990 Back

Appendix: PR by cohort/education

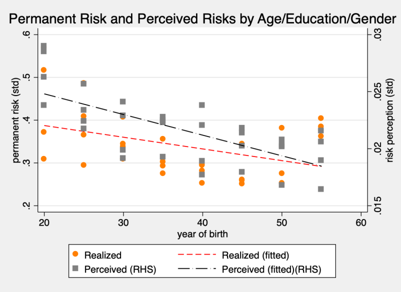


- a college graduate born between 1985-1990

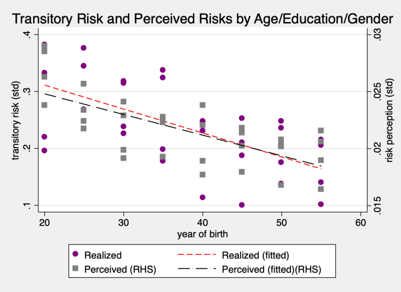
Back

Permanent versus transitory risks

(a) permanent



(b) transitory



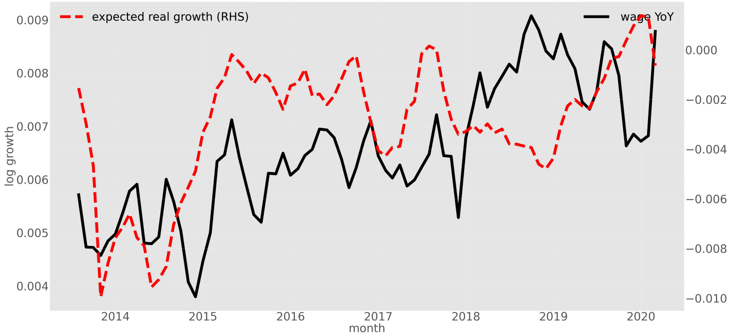
- e.g. a female high school graduate aged 30-35

5-yr cohort/education/gender

Back

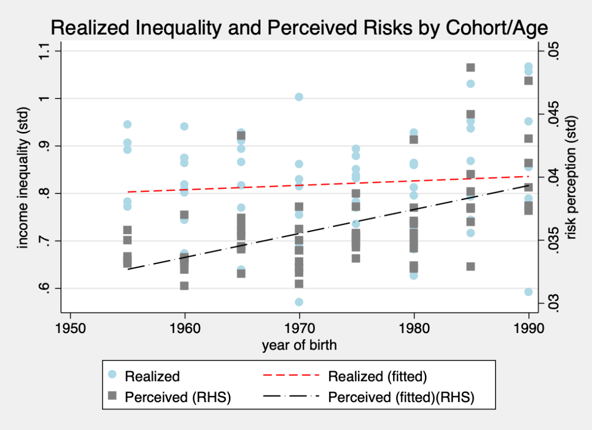
Appendix: expected income growth and recent (past) wage growth

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



Back

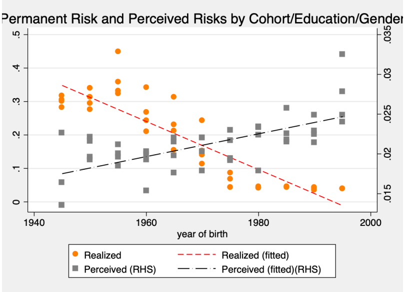
Appendix: by **5-yr of birth/age**



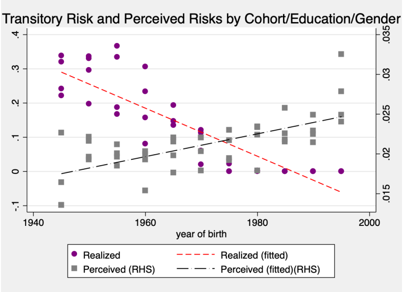
- e.g. a 25-year old born between 1985-1990
- only possible for post-2013 sample Back

Appendix: permanent versus transitory risks

(a) permanent



(b) transitory

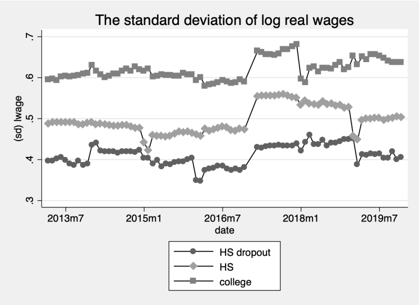


- e.g. a female high school graduate born between 1985-1990

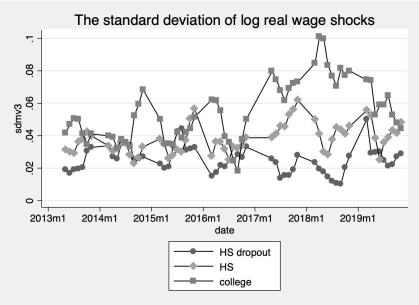
Back

Appendix: monthly earning inequality and volatility

(a) Inequality



(b) Volatility



Back

Appendix: estimation of subjective risk profile

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

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

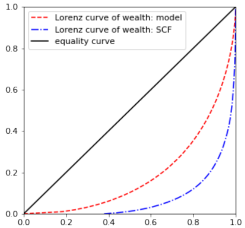
Back

Appendix: calibration of the objective OLG-GE model

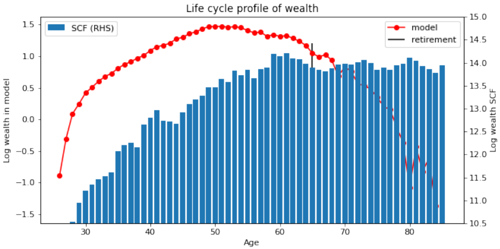
Back

Appendix: distribution in the partial equilibrium

(a) Wealth inequality



(b) Life-cycle wealth distribution



Back

Extensions: additional heterogeneity in MPC

- Heterogeneous time preferences
  - Ex-ante differences in β, a la Krusell and Smith (1998); Carroll et al. (2017); Krueger et al. (2016).
- Costly adjustments

$$
\begin{aligned}
V_{i,\tau}(c_{i,\tau-1}, x_{i,\tau}) &= \max \quad \{V^A_\tau(x_{i,\tau}) - \chi, V^N_\tau(c_{i,\tau-1}, x_{i,\tau})\} \\
V^A_\tau(x_{i,\tau}) &= \max_{\{c_{i,\tau}\}} \quad u(c_{i,\tau}) + (1-D)\beta\mathbb{E}_\tau\left[V_{\tau+1}(x_{i,\tau+1})\right] \\
V^N_\tau(c_{i,\tau-1}, x_{i,\tau}) &= u(c_{i,\tau-1}) + (1-D)\beta\mathbb{E}_\tau\left[V_{\tau+1}(c_{i,\tau}, x_{i,\tau+1})\right]
\end{aligned}
$$

  - Utility cost from adjusting consumption in each period
  - To introduce extensive margin of consumption change and match high MPC from data

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