Health Shocks, Portfolio Choice and Inequality

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Introduction

- Wealth gap by health starts at young age and becomes large by retirement time
  - Capatina, Keane and Maruyama (2020); De Nardi, Pashchenko and Porapakkarm (2018); Hosseini, Kopecky and Zhao (2021)
- Two operating channels
  - **Health-income channels**: health expenditure, labor productivity, labor supply and savings
  - **Health-longevity channel**: survival rates or longevity
- Missing channel: **health-wealth portfolio channel**
  - Heterogeneous wealth/savings portfolio by health status $\rightarrow$ heterogeneous investment returns
  - Compounding of investment returns $\rightarrow$ larger wealth gap over time

This paper

- Study health-wealth portfolio channel
  - quantify dynamic effects of health shocks on wealth portfolio over lifecycle
- Empirical analysis: data + regression
  - HRS panel data ⇒ long term effect of health at "40" ⇒ wealth composition at retirement
  - Examine long-term effects of **poor health at 45–55** on risky asset share at age 60–70
  - Dynamic (panel) regression models
- Structural analysis: model + counterfactual policies
  - Stochastic lifecycle model of portfolio choice w/ shocks to health, income and longevity
  - Decompose effects of health shocks on portfolio choice and wealth gap
  - Examine the role of health insurance in reducing wealth inequality

Findings

Empirical: HRS

- Statistically significant differences of lifecycle patterns of risky asset share by health at age 45–55
- Health effect primarily via extensive/participation margin (in stock investments)
  - Wealth mobility is low and decreases with age for the unhealthy individuals

Structural: Stochastic lifecycle model

- The health-wealth portfolio channel: important
  - counterfactuals: P90/P50 $\downarrow$ between 51–61%
- Lifetime cost of bad health: considerable
  - annualized average cost: $6,500
- Expansion of either public or private health insurance
  - wealth gap: $\downarrow$ between 15–60%

Mechanism

1. Bad health $\Rightarrow$ income losses and high expenditures $\Rightarrow \downarrow$ stock market participation
2. Heterogeneity in wealth portfolio by health status $\Rightarrow$ heterogeneous investment returns
3. Compounding of investment returns $\Rightarrow$ larger wealth gap over time
4. Expansion of health insurance $\Rightarrow \uparrow$ stock market participation $\Rightarrow \downarrow$ wealth gap

Related literature

- Macro-health economics: Lifecycle health models
  - Capatina, Keane and Maruyama 2020; Hosseini, Kopecky and Zhao 2021; De Nardi, Pashchenko and Porapakkarm 2018; Chen, Feng and Gu 2022; Mahler and Yum 2022
  - Nakajima and Telyukova 2022; Jung and Tran 2022; Jung and Tran 2023
- Household finance: Lifecycle portfolio choice models
  - Seminal works: Samuelson (1969); Merton (1971)
  - Recent related studies: Yogo 2016; Fagereng, Gottlieb and Guiso 2017; Gomes and Smirnova 2021; Campanale, Fugazza and Gomes (2015); Tischbirek (2019)
  - Surveys: Gomes (2020) and Gomes, Haliassos and Ramadorai (2021)

Detailed references

Health-wealth portfolio channel: Empirical evidence

Health & Retirement Study (HRS) 1992–2018

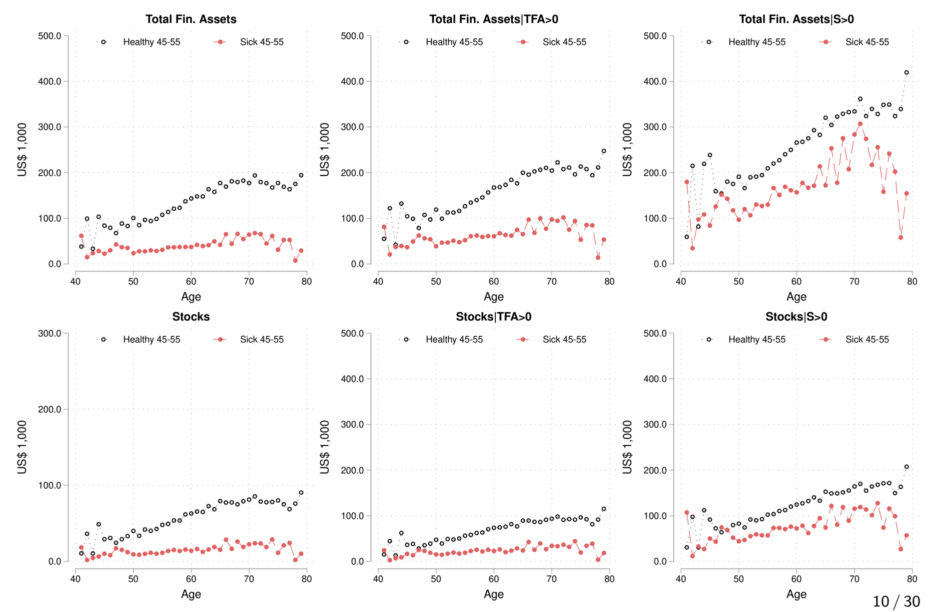
- 20 fin. wealth components: checking/savings accts, CDs, bonds, T-bills, stocks, mutual funds, IRA/Keogh, ...

- Collapse financial assets into 2 classes:
  1. **safe assets** (checking/savings accts, money market funds, CDs, government savings bonds, T-bills, corporate, municipal and foreign bonds, as well as bond funds)
  2. **risky assets** (stocks and mutual funds)
- IRAs limited info $\Rightarrow$ assign 45.8% of holdings to risky assets (Tischbirek, 2019)

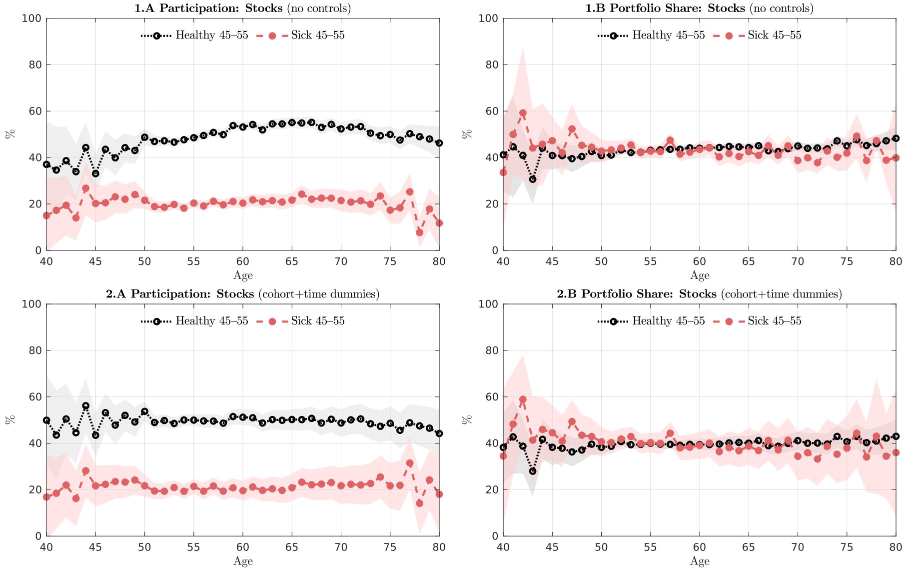
- Health status
  - 1 excellent, 2 very good, 3 good, 4 fair, 5 poor
- Two groups by health status at **age 45–55**
  - **Sick:** 4-fair and 5-poor
  - **Healthy:** 1-excellent, 2-very good, 3-good health

More details

Asset holdings by health status



Health shocks and risky asset holdings



Risky asset (stocks) share

	(1)	(2)	(3)
Sick at 45_55	-0.044***	-0.042***	-0.053***
	(0.005)	(0.007)	(0.008)
Sick × Unemployed at 45_55	-0.001	-0.004	-0.010
	(0.008)	(0.010)	(0.011)
Sick × Uninsured at 45_55	0.035***	0.020**	0.038***
	(0.007)	(0.009)	(0.011)
Observations	24900	24750	24900
R^2	0.239	0.217	
Conditional P(Y>0)	No	No	No
Random Effects	No	No	Yes
Weighted	No	Yes	No

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

More details

Stochastic lifecycle model

Lifecycle model: portfolio choice, health & HI

- A stochastic lifecycle model of portfolio choice
  - Lifespan: Age 40–94
  - Three educ. levels: No HS, HS and College
  - Two assets: Risky (stock) and safe (bond) assets
- Four idiosyncratic shocks
  1. Health
  2. Health insurance/employer type
  3. Labor
  4. Longevity (also health-dependent)
- Health insurance (HI)
  - Public HI: Medicaid & Medicare (w/ eligibility criteria)
  - Private HI: Employer HI (w/ community rating and tax deduct. premium)
- Government
  - Progressive inc. tax, payroll taxes, capital taxes (dividend, cap. gains & interest)
  - Soc. Security, Medicaid, Medicare, min. consumption program

Model details

Worker problem

- State vec: $x_j = \left\{\vartheta, a_{j,}, \epsilon_j^{incP}, \epsilon_j^h, \epsilon_j^{\text{ehi}}\right\} \in \{1,2,3\} \times R \times \{1,2,3,4\} \times \{1,2,3,4,5\} \times \{0,1\}$
- Expectation $\Rightarrow \mathbb{E}_{\epsilon_{j+1}^{incP}, \epsilon_{j+1}^h, \epsilon_{j+1}^{\text{ehi}}, \epsilon_{j+1}^s | \epsilon_j^{incP}, \epsilon_j^h, \epsilon_j^{\text{ehi}}}$

$$V(x_j) = \max_{\{c_j, \ell_j, \alpha_j\}} \left\{ u(c_j, \ell_j) + \beta \mathbb{E}\left[\overbrace{\pi_j\left(h\left(\epsilon_j^h\right)\right)}^{\text{Health surv. channel}} V(x_{j+1}) + \overbrace{\left(1 - \pi_j\left(h\left(\epsilon_j^h\right)\right)\right)}^{\text{Health surv. channel}} u^{\text{beq}}(a_{j+1}) \right] \right.$$

s.t.

$$a_{j+1} = \tilde{R}_{j+1} \left(\begin{array}{c} a_j + \overbrace{y_j\left(\ell_j, \vartheta, \epsilon_j^{incP}, \epsilon_j^h\right)}^{\text{Health income channel}} + \text{tr}_j^{\text{si}} - \overbrace{o_j\left(m_j, \epsilon_{j,\vartheta}^{\text{ehi}}, y_j^{\text{agi}}, a_j\right)}^{\text{Health spend. channel}} \\ \underbrace{-1_{\left[\epsilon_j^{\text{ehi}}=1\right]} \text{prem}_j^{\text{ehi}}}_{\text{HI channel}} \quad \underbrace{-\text{tax}_j}_{\text{Health tax channel}} \quad - (1 + \tau^c) c_j - 1_{[\alpha_j > 0]} q \end{array} \right)$$

$$\tilde{R}_{j+1} = \alpha_j \left(1 + \tilde{r}_{net,j+1}^s\right) + (1 - \alpha_j) \left(1 + \bar{r}_{net}^b\right)$$

$$\text{tax}_j = \text{tax}^y\left(y_j^{\text{tax}}\right) + \text{tax}^{\text{ss}}\left(y_j^{\text{ss}}; \bar{y}^{\text{ss}}\right) + \text{tax}^{\text{mcare}}\left(y_j^{\text{ss}}\right)$$

More Details

Retiree problem

- State vector: $x_j = \left\{\vartheta, a_j, \epsilon_j^h\right\} \in \{1,2,3\} \times R \times \{1,2,3,4,5\}$
- Expectation $\Rightarrow \mathbb{E}_{\epsilon_{j+1}^h, \epsilon_{j+1}^s | \epsilon_j^h}$

$$V(x_j) = \max_{\{c_j, \alpha_j\}} \left\{ u(c_j) + \beta \mathbb{E} \left[\overbrace{\pi_j\left(h\left(\epsilon_j^h\right)\right)}^{\text{Health surv. channel}} V(x_{j+1}) + \overbrace{\left(1 - \pi_j\left(h\left(\epsilon_j^h\right)\right)\right)}^{\text{Health surv. channel}} u^{\text{beq}}(a_{j+1}) \right] \right\}$$

s.t.

$$a_{j+1} = \tilde{R}_{j+1} \left(\begin{array}{c} a_j + \text{tr}_j^{\text{ss}}\left(\bar{y}^{\vartheta}\right) + \text{tr}_j^{\text{si}} - \overbrace{o_j\left(m_j, \epsilon_{j,\vartheta}^{\text{ehi}}, y_j^{\text{agi}}, a_j\right)}^{\text{Health spend. channel}} \\ -\text{prem}^{\text{mcare}} \underbrace{-\text{tax}^y\left(y_j^{\text{tax}}\right)}_{\text{Health tax channel}} - (1+\tau^c)\, c_j - 1_{[\alpha_j > 0]}\, q \end{array} \right)$$

$$\tilde{R}_{j+1} = \left(\alpha_j \left(1 + \tilde{r}_{net,j+1}^s\right) + (1 - \alpha_j)\left(1 + \bar{r}^b\right)\right)$$

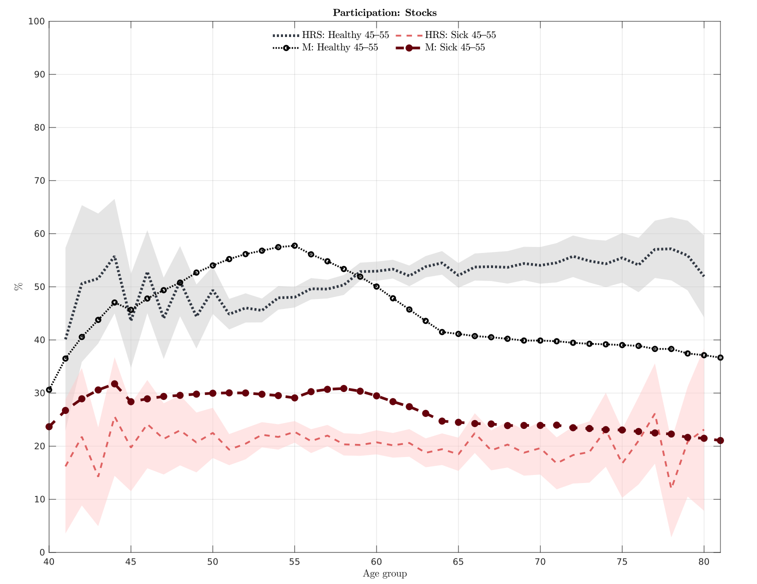
More Details

Calibration

Parameterization and calibration

- Data sources:
  - RAND-HRS for asset profiles, initial asset distribution
  - MEPS: labor supply, health shocks, health expenditures, coinsurance rates
  - Previous studies: income process, labor shocks

Target risky asset participation

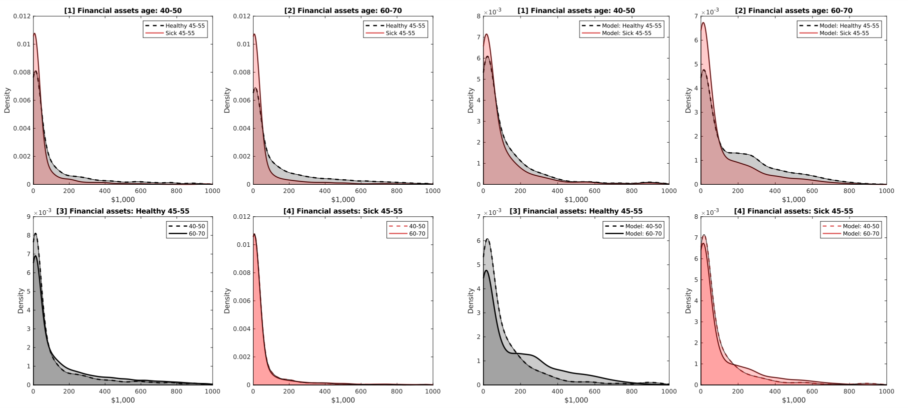


More calibration details
Model performance details

Quantitative Analysis (Preliminary results)

Model replicates wealth mobility patterns

Data　　　　　　　　　　　　　　　　Model



Model: Risky assets by health at age 45–55

	Healthy at 45–55	Sick at 45–55
- Risky asset share α (at 65)	40%	24%
- Stock part. (at 40)	31%	24%
- Stock part. (at 65)	41%	25%
- Wealth-to-inc (at 65)	5.65	3.59

Counter factual: Health-wealth portfolio channel

	Benchmark	No risky assets	No bad health	No stocks & No bad health
Wealth Gap				
All ages				
- P90/P50	8.67	4.40 (↓ 49%)	5.40 (↓ 38%)	3.45 (↓ 61%)
- P50/P25	7.71	3.65 (↓ 53%)	6.22 (↓ 19%)	3.03 (↓ 61%)
At 65				
- P90/P50	9.01	4.40 (↓ 51%)	5.06 (↓ 44%)	3.55 (↓ 61%)
- P50/P25	10.78	6.67 (↓ 49%)	5.91 (↓ 45%)	3.82 (↓ 65%)

Counter factual: Cost of bad health

- Counterfactual
  1. Everybody draws good health (surprise shock)
  2. Everybody at age 45–55 draws good health
- Policy functions are not affected!
- Calculate lifetime cost of bad health (annual averages) following De Nardi, Pashchenko and Porapakkarm (2018)

$$\overline{\text{cost}}_i = \left(\frac{1}{\sum_{j=1}^{J} 1_{\text{alive}_j}}\right) \sum_{j=1}^{J} 1_{\text{alive}_j} \times \left(\overbrace{\left(y_{ij}^{**} - oop_{ij}^{**}\right)}^{\substack{\text{net of med expens.} \\ \text{always healthy}}} - \overbrace{\left(y_{ij}^{*} - oop_{ij}^{*}\right)}^{\substack{\text{net of med expens.} \\ \text{benchmark}}} \right)$$

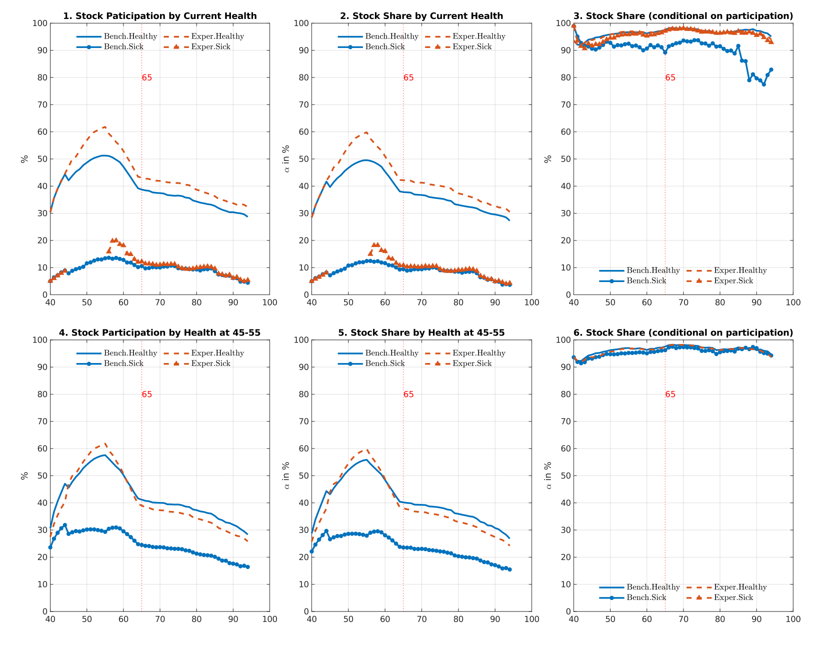
Counter factual: Cost bad health

	All	no HS	HS	College
Cost of bad health (40–death)				
Income loss+medical cost	\$6,535	\$8,666	\$6,165	\$4,484
Percent of time in bad health	16.58%	23.41%	15.37%	10.07%
Welfare cost	–	–	–	–
Cost of bad health (at 45–55)				
Income loss+medical cost	\$3,537	\$4,300	\$3,386	\$2,845
Percent of time in bad health	8.91%	12.63%	8.15%	5.59%
Welfare cost	–	–	–	–

Counter factual: Cost bad health

	Bench.	Good hlth (always)	Good hlth (45–55)
Assets	100	122.5	111.3
Healthy at 45–55			
- α at 65	40%	53%	41%
- Stock part. at 40	31%	35%	27%
- Stock part. at 65	41%	55%	42%
- Wealth-to-inc at 65	5.65	6.01	5.47
Sick at 45–55			
- α at 65	24%	–	–
- Stock part. at 40	24%	–	–
- Stock part. at 65	24%	–	–
- Wlth-to-inc at 65	3.58	–	–
Consumption	100	103.8	101.8
Labor part.	49.5%	68%	67.7%
Hours (workers)	42.7	43.4	42.9

Good health at age 45–55



Health insurance policy experiments

	Bench.	Medicare (for all)	EHI (for all)
Assets	100	103.6	102.9
Healthy at 45–55			
- α at 65	40%	43%	43%
- Stock part. at 65	41%	44%	44%
- Wealth-to-inc at 65	5.65	5.83	5.84
Sick at 45–55			
- α at 65	24%	24%	23%
- Stock part. at 65	24%	25%	24%
- Wlth-to-inc at 65	3.58	3.83	3.74
Wealth gap			
- All age: P90/P50	8.67	6.94 ($\downarrow$ 20.0%)	7.32 ($\downarrow$ 10.5%)
- All age: P50/P25	7.71	5.37 ($\downarrow$ 31.1%)	5.66 ($\downarrow$ 30.6%)
- At 65: P90/P50	9.01	7.64 ($\downarrow$ 15.2%)	7.64 ($\downarrow$ 15.2%)
- At 65: P50/P25	10.78	4.39 ($\downarrow$ 59.2%)	5.97 ($\downarrow$ 44.6%)

Policy experiments details

Conclusion

Conclusion

- Study dynamic effects of health shocks on savings, portfolio choice and wealth accumulation over lifecycle

- Empirical
  - Use HRS panel data to investigate health shocks $\Rightarrow$ savings portfolio
  - Dynamic (panel) regression models

- Computational model
  - Lifecycle model w/ savings (portfolio) decisions, health shocks and health insurance
  - Quantify long-run effects of bad health on portfolio choice and wealth gaps
  - Examine effects of health insurance reforms on wealth inequality at retirement

Supplementary material

Related literature I

- Lifecycle portfolio investment literature starting with Samuelson (1969); Merton (1971) and recent surveys in Gomes (2020) and Gomes, Haliassos and Ramadorai (2021)
- Health and wealth inequality
  - Medical expenditures and access to health insurance: De Nardi, French and Jones (2010); Nakajima and Telyukova (2022); Chen, Feng and Gu (2022); De Nardi, Pashchenko and Porapakkarm (2018)
  - Health on labor supply and productivity: Prados (2018); Capatina, Keane and Maruyama (2020); Hosseini, Kopecky and Zhao (2021)
  - Lifestyle behaviors: Mahler and Yum (2022)
- Wealth on proportion of risky assets has mixed results
  - positive effect: Wachter and Yogo (2010)
  - minor effect: Brunnermeier and Nagel (2008)
  - negative effect: Liu, Liu and Cai (2021)
- Additional channels
  - stock market entry/adjustment costs: Alan (2006); Bonaparte, Cooper and Zhu (2012); Fagereng, Gottlieb and Guiso (2017)
  - education: Cocco, Gomes and Maenhout (2005); Cooper and Zhu (2016)

Related literature II

- unemployment: Bagliano, Fugazza and Nicodano (2014); Bagliano, Fugazza and Nicodano (2019)
- household composition: Inkmann, Michaelides and Zhang (2022)
- demographics and composition of 401k: Egan, MacKay and Yang (2021)
- introduction of Pension Protection Act of 2006: Parker et al. (2022)
- longevity annuities: Zhou, Li and Zhou (2022)
- reverse mortgages: Nakajima and Telyukova (2017); Hambel, Kraft and Meyer-Wehmann (2022)
- cyclicality of skewness of income shocks: Catherine (2022)

- Estimated structural lifecycle models of portfolio choice and retirement: Yogo (2016); Fagereng, Gottlieb and Guiso (2017); Gomes and Smirnova (2021)
- Calibrated lifecycle models with liquidity costs of stocks and long-term bonds: Campanale, Fugazza and Gomes (2015) and Tischbirek (2019)
- Empirical lit. of **health spending** and **health insurance** on portfolio choice of **elderly:** Goldman and Maestas (2013); Ayyagari and He (2016)
  - Early life health status: Böckerman, Conlin and Svento (2021)
  - Current health status: Rosen and Wu (2004)
  - Subjective health status: Bressan, Pace and Pelizzon (2014)
  - Expected future health shocks: Edwards (2008)

Related literature III

- Empirical **financial literacy**
  - Cognitive abilities and investment decisions: Christelis, Jappelli and Padula (2010); Agarwal and Mazumder (2013); Gamble et al. (2015); Lindeboom and Melnychuk (2015); Mazzonna and Peracchi (2020); Shimizutani and Yamada (2020)
  - Role of financial advising: Rossi and Utkus (2020, 2021)

Back to literature

Health & Retirement Study (RAND-HRS) 1992–2018

- Health and Retirement Study (RAND-HRS) - panel data survey
- The majority of them are between 51–61 years
- Limit sample to heads of households and age group of 40–80 with wealth info
- In regressions we use reduced sample of 60–70 year olds
- Variables: labor market behavior, educational attainment, family background, government program participation, family life, health issues, assets, and income

HRS summary statistics I

	(1) w/H.Info Age:40-80	(2) Sick 45-55 A:40-80	(3) Alive60-70 A:40-80	(4) All A:60-70	(5) w/H.Info A:60-70	(6) Sick 45-55 A:60-70	(7) HlimWrk A:60-70
Sick at 45_55	0.30	1.00	0.27	0.27	0.27	1.00	0.65
Health Limits Work at 45_55	0.27	0.62	0.25	0.24	0.24	0.60	1.00
Health Limits Work	0.30	0.58	0.30	0.33	0.33	0.63	0.71
Spouse: Health Limits Work	0.24	0.32	0.24	0.26	0.26	0.36	0.34
Unemployed at 45_55	0.30	0.56	0.28	0.27	0.27	0.53	0.67
Uninsured at 45_55	0.29	0.35	0.28	0.27	0.27	0.34	0.32
P(Stocks)	0.42	0.20	0.45	0.45	0.45	0.22	0.28
P(Safe Assets)	0.79	0.62	0.81	0.81	0.82	0.65	0.70
Risky Assets ($1,000)	91.09	20.66	103.20	107.80	128.11	27.98	41.23
Safe Assets ($1,000)	95.04	30.30	104.61	110.00	127.84	40.95	52.74
Risky Asset Share	0.18	0.09	0.20	0.19	0.20	0.09	0.12
Safe Asset Share	0.61	0.53	0.62	0.62	0.62	0.56	0.58
Debt ($1,000)	7.03	7.26	6.68	5.27	5.83	5.31	5.70
Mortgage ($1,000)	48.70	28.30	47.62	36.16	45.81	26.78	29.36
Other home loans ($1,000)	4.42	1.99	4.74	3.73	4.82	2.33	3.32
Income Risk Aversion	3.20	3.26	3.19	3.28	3.24	3.32	3.28
Financial planning horizon	3.13	2.86	3.13	3.05	3.09	2.80	2.89
Prob. live to 75	61.59	48.71	62.32	63.00	62.28	49.39	54.08
Prob. live to 85	41.46	30.98	41.62	42.82	42.48	30.72	34.42
Age	59.91	58.63	61.47	64.64	64.16	63.92	63.98
Female	0.30	0.38	0.28	0.33	0.28	0.38	0.38
Married/Partnered	0.58	0.47	0.59	0.57	0.59	0.45	0.46
Nr. Children Alive	2.90	3.14	2.96	3.18	2.99	3.27	3.14
Black	0.21	0.30	0.20	0.20	0.19	0.28	0.26
Hispanic	0.13	0.21	0.12	0.11	0.11	0.19	0.13
No high school degree	0.25	0.42	0.25	0.29	0.25	0.44	0.36

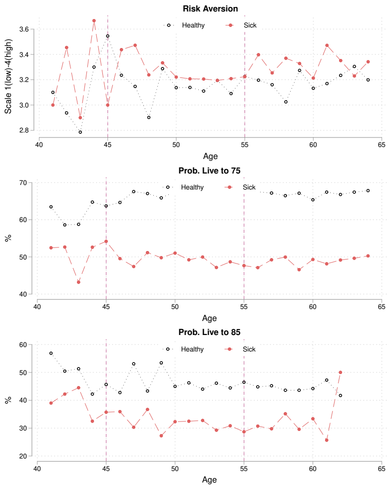
HRS summary statistics II

High school degree	0.52	0.47	0.51	0.49	0.51	0.46	0.50
College or higher	0.24	0.10	0.24	0.22	0.25	0.10	0.13
Labor income ($1,000)	33.80	16.36	32.20	21.20	25.01	10.16	8.73
Pre-govt HH income ($1,000)	85.88	45.48	86.10	74.86	84.15	42.58	48.60
Employed	0.52	0.36	0.48	0.32	0.37	0.21	0.17
Receives Social Security	0.72	0.76	0.84	0.90	0.88	0.91	0.93
Health Excellent	0.12	0.02	0.12	0.11	0.10	0.02	0.04
Health Very Good	0.28	0.07	0.29	0.28	0.29	0.08	0.13
Health Good	0.31	0.23	0.31	0.32	0.33	0.27	0.30
Health Fair	0.20	0.46	0.19	0.21	0.21	0.41	0.34
Health Poor	0.08	0.22	0.08	0.09	0.08	0.21	0.20
Initial Health Excellent	0.21	0.03	0.23	0.20	0.23	0.02	0.07
Initial Health Very Good	0.28	0.06	0.29	0.27	0.28	0.06	0.14
Initial Health Good	0.28	0.16	0.28	0.29	0.28	0.15	0.26
Initial Health Fair	0.16	0.52	0.14	0.16	0.14	0.52	0.29
Initial Health Poor	0.07	0.24	0.07	0.08	0.07	0.25	0.23
Healthy	0.72	0.32	0.73	0.71	0.72	0.37	0.46
Body Mass Index	28.92	30.44	28.77	28.47	28.97	30.48	29.98
Smoker	0.22	0.31	0.21	0.19	0.18	0.24	0.24
OOP health exp. ($1,000)	3.07	3.79	3.17	3.36	3.43	3.88	3.80
Total OOP exp. HH ($1,000)	5.00	5.39	5.22	5.37	5.68	5.68	5.47
Insured	0.84	0.81	0.85	0.88	0.88	0.88	0.90
Uninsured	0.16	0.19	0.15	0.12	0.12	0.12	0.10
Public health insurance	0.31	0.46	0.33	0.42	0.40	0.59	0.62
Private health insurance	0.52	0.34	0.52	0.46	0.48	0.29	0.28
Observations	75526	22387	61107	56374	25686	6819	6261

HRS summary statistics III

Back to HRS variable definitions

Preference/belief differences by type



Unweighted

Back to HRS variable definitions

Safe asset share

	(1)	(2)	(3)
Sick at 45_55	0.015*	0.008	0.008
	(0.009)	(0.010)	(0.012)
Sick × Unemployed at 45_55	-0.050***	-0.049***	-0.045**
	(0.012)	(0.016)	(0.017)
Sick × Uninsured at 45_55	-0.084***	-0.070***	-0.079***
	(0.012)	(0.017)	(0.017)
Observations	24900	24750	24900
R^2	0.057	0.049	
Conditional P(Y>0)	No	No	No
Random Effects	No	No	Yes
Weighted	No	Yes	No

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Back to risky asset share regression

Preferences

- Preferences

$$u\left(c_j, \ell_j; \bar{n}_j\right) = \frac{\left(c_j^{\eta} \times \left[\ell_j - 1_{[0<n_j]} \times \bar{n}_j\right]^{1-\eta}\right)^{1-\sigma}}{1-\sigma} + \bar{u}$$

- Warm-glow bequest

$$u^{\text{beq}}\left(a_j\right) = \theta_1 \frac{\left(a_j + \theta_2\right)^{(1-\sigma)\eta}}{1-\sigma}$$

Health

- Health:
  - 5 idiosyncratic (exogenous) health groups $\epsilon^h \in \{1, 2, 3, 4, 5\}$
  - Age dependent health expenditure $m\left(j, \vartheta, \epsilon^h\right)$
  - Health state:

$$h\left(\epsilon^h\right) = \begin{cases} \text{healthy} & \text{if } \epsilon^h \in \{\text{excellent, very good, good}\}, \\ \text{sick} & \text{if } \epsilon^h \in \{\text{fair, poor}\}. \end{cases}$$

- Survival probability: $\pi\left(h\left(\epsilon^h\right)\right)$

- Health and labor income shocks:

$$\Pr\left(\epsilon^h_{j+1} | \epsilon^h_j\right) \in \Pi^h\left(j, \vartheta\right) \ , \ \Pr\left(\epsilon^{incP}_{j+1} | \epsilon^{incP}_j\right) \in \Pi^{incP}_j$$

Health insurance

- **Workers:** exogenous employer HI

$$\epsilon^{\text{ehi}}_{j,\vartheta} = \begin{cases} 0 & \text{not privately insured,} \\ 1 & \text{privately health insurance,} \end{cases} \quad \text{for } j \leq J_w$$

- $\epsilon^{\text{ehi}}_{j,\vartheta}$ follows Markov process with $P\left(\epsilon^{\text{ehi}}_{j+1,\vartheta} | \epsilon^{\text{ehi}}_{j,\vartheta}\right) \in \Pi^{\text{ehi}}_{j,\vartheta}$
- Coinsurance: γ^{ehi}
- Premium: $\text{prem}^{\text{Ins}}_{j}$

- **Poor:** qualify for Medicaid w/ coinsurance γ^{maid} if $y^{\text{agi}}_{j} < y^{\text{maid}}$ and $a_j < a^{\text{maid}}$

- **Retired** $j > J_1$ have Medicare w/ coinsurance γ^{mcare} and premium $\text{prem}^{\text{mcare}}$

Out-of-pocket health spending

$$o_j\left(m_j, \epsilon^{\text{ehi}}_{j,\vartheta}, y^{\text{agi}}_j, a_j\right) =$$

$$= \begin{cases} \overbrace{1_{[\text{maid-yes}]}\gamma^{\text{maid}}}^{\text{primary HI}} \times m\left(j, \vartheta, \epsilon^h_j\right) & \text{if } \overbrace{\epsilon^{\text{ehi}}_{j,\vartheta} = 0 \wedge j \leq J_w}^{\text{working, no private HI}} \\ \overbrace{1_{[\text{maid-yes}]}\gamma^{\text{maid}}}^{\text{Medicaid is secondary HI}} \times \left(\overbrace{\gamma^{\text{ehi}}}^{\text{primary}} \times m\left(j, \vartheta, \epsilon^h_j\right) \right) & \text{if } \overbrace{\epsilon^{\text{ehi}}_{j,\vartheta} = 1 \wedge j \leq J_w}^{\text{working, with private HI}} \\ \overbrace{1_{[\text{maid-yes}]}\gamma^{\text{maid}}}^{\text{Medicaid is secondary HI}} \left(\times \overbrace{\gamma^{\text{mcare}}}^{\text{primary}} \times m\left(j, \vartheta, \epsilon^h_j\right) \right) & \text{if } \overbrace{j > J_w}^{\text{retired, with Medicare}} \end{cases}$$

Labor income

- Profile by health type: $\bar{e}_j = \bar{e}\left(j, \vartheta, h\left(\epsilon^h\right)\right)$
- Exogenous income shock: $e_j\left(\vartheta, \epsilon^h, \epsilon^{incP}\right) = \bar{e}_j\left(\vartheta,\ h\left(\epsilon^h\right)\right) \times \epsilon^{incP}$
- Labor income: $y_j\left(\ell_j, \vartheta, \epsilon_j^{incP}, \epsilon_j^h\right) = \overbrace{\widehat{w} \times e_j\left(\vartheta, \epsilon_j^{incP}, \epsilon^h\right)}^{\text{Health-dependent income}} \times (1 - \ell_j)$

Savings/Assets

- Two types of assets
  - risk-free bond b w/ real return r^b
  - risky stock s w/ return $\tilde{r}^s = r^b + \mu^s + \epsilon^s$
    and risk premium $\mu_s > 0$, stoch. return $\epsilon^s \sim N\left(0, \sigma^2_{\epsilon^s}\right)$
- Net returns (see Gomes, Michaelides and Polkovnichenko, 2009)

$$\bar{r}^b_{net} = \frac{1 + \left[\left(r^b + 1\right)(1+\pi) - 1\right]\left(1 - \tau^d\right)}{1+\pi} - 1$$

$$\tilde{r}^s_{\text{net}} = \frac{1 + \tilde{g}\left(1 - \tau^g\right) + d\left(1 - \tau^d\right)}{1+\pi} - 1$$

- W/ exogenous parameters
  - d, $\tilde{g}$: dividend vs. capital gains
  - τ^d, τ^g: dividend vs. capital gains tax
  - π inflation
- Borrowing limit $b_{j+1} \geq \underline{b}$, stock holdings $s_{j+1} \geq 0$
- Transaction cost q_ϑ when investing in risky asset

Taxes and transfers

- Taxes
  - Labor income (Benabou 2002; Heathcote, Storesletten and Violante 2017)

$$\mathsf{tax}^{y}(y_j^{\mathsf{tax}}) = \max\left[0,\, y_j^{\mathsf{tax}} - \lambda \times \left(y_j^{\mathsf{tax}}\right)^{(1-\tau)}\right]$$

    - $0 < \tau < 1$ progressivity
    - λ scaling
  - Payroll: $\mathsf{tax}^{ss}\left(y_j^{ss};\, \bar{y}^{ss}\right)$ and $\mathsf{tax}^{mcare}\left(y_j^{ss}\right)$
  - Consumption: τ^c
  - Capital: τ^d on dividends and τ^g on capital gains
- Transfers
  - Social Security: tr^{ss}
  - Medicare, Medicaid
  - Lump-sum transfers tr^{si} to guarantee $c_{\min}$

Back to model overview

Worker Problem I

- State vec: $x_j = \left\{\vartheta, a_{j,}, \epsilon_j^{incP}, \epsilon_j^h, \epsilon_j^{\text{ehi}}\right\} \in \{1,2,3\} \times R \times \{1,2,3,4\} \times \{1,2,3,4,5\} \times \{0,1\}$
- Expectation $\Rightarrow \mathbb{E}_{\epsilon_{j+1}^{incP}, \epsilon_{j+1}^h, \epsilon_{j+1}^{\text{ehi}}, \epsilon_{j+1}^s | \epsilon_j^{incP}, \epsilon_j^h, \epsilon_j^{\text{ehi}}}$

$$V(x_j) = \max_{\{c_j, \ell_j, \alpha_j\}} \left\{ u(c_j, \ell_j) + \beta \mathbb{E} \left[\overbrace{\pi_j\left(h\left(\epsilon_j^h\right)\right)}^{\text{Health surv. channel}} V(x_{j+1}) + \overbrace{\left(1 - \pi_j\left(h\left(\epsilon_j^h\right)\right)\right)}^{\text{Health surv. channel}} u^{\text{beq}}(a_{j+1}) \right] \right.$$

s.t.

$$a_{j+1} = \tilde{R}_{j+1} \left(\begin{array}{c} a_j + \overbrace{y_j\left(\ell_j, \vartheta, \epsilon_j^{incP}, \epsilon_j^h\right)}^{\text{Health income channel}} + \text{tr}_j^{\text{si}} - \overbrace{o_j\left(m_j, \epsilon_{j,\vartheta}^{\text{ehi}}, y_j^{\text{agi}}, a_j\right)}^{\text{Health spend. channel}} \\ \underbrace{-1_{\left[\epsilon_j^{\text{ehi}}=1\right]} \text{prem}_j^{\text{ehi}}}_{\text{HI channel}} \quad \underbrace{-\text{tax}_j}_{\text{Health tax channel}} \quad - (1 + \tau^c) c_j - 1_{[\alpha_j > 0]} q \end{array} \right)$$

$$\tilde{R}_{j+1} = \alpha_j \left(1 + \tilde{r}_{net,j+1}^s\right) + (1 - \alpha_j)\left(1 + \bar{r}_{net}^b\right)$$

$$\text{tax}_j = \text{tax}^y\left(y_j^{\text{tax}}\right) + \text{tax}^{\text{ss}}\left(y_j^{\text{ss}}; \bar{y}^{\text{ss}}\right) + \text{tax}^{\text{mcare}}\left(y_j^{\text{ss}}\right)$$

$$\underline{b} \leq b_{j+1},\ 0 \leq s_{j+1}$$

Worker Problem II

- Total taxable income y_j^{tax} and payroll tax eligible income y_j^{ss}

$$\begin{aligned} y_j^{\text{tax}} &= y_j - 1_{[\text{in}_{j+1}=2]}\text{prem}_j^{\text{ehi}} \\ &\quad - \max\left[0,\ o_j\left(m_j, \epsilon_{j,\vartheta}^{\text{ehi}}, y_j^{\text{agi}}, a_j\right) - 0.075 \times (y_j + r_b \times b_j + r_s \times s_j)\right] \end{aligned}$$

$$y_j^{\text{ss}} = y_j - 1_{[\text{in}_{j+1}=2]}\text{prem}_j^{\text{ehi}}$$

- Taxes

$$\begin{aligned} \text{tax}_j &= \text{tax}^y\left(y_j^{\text{tax}}\right) + \text{tax}^{\text{ss}}\left(y_j^{\text{ss}};\ \bar{y}^{\text{ss}}\right) + \text{tax}^{\text{mcare}}\left(y_j^{\text{ss}}\right) \\ \text{tax}^{ss}\left(y_j^{\text{ss}};\ \bar{y}^{\text{ss}}\right) &= \tau^{ss} \times \min\left[y_j^{\text{ss}};\ \bar{y}^{\text{ss}}\right] \\ \text{tax}^{\text{mcare}}\left(y_j^{\text{ss}}\right) &= \tau^{\text{mcare}} \times y_j^{ss} \end{aligned}$$

Worker Problem III

- Transfers

$$\mathrm{tr}_j^{\mathrm{si}} = \max\left[0,\ c_{\mathrm{min}} + o\left(m_j\right) - y_j^{\mathrm{at}} - a_j\right]$$
$$y_j^{\mathrm{at}} = y_j - \mathrm{tax}_j$$

- Average past labor earnings:

$$\bar{y}^{\vartheta} = \int_{j \leq J_r} w \times e\left(x\right) \times n\left(x\right) d\Lambda\left(x_j\left(\vartheta\right)\right)$$

Back to worker problem

Retiree's Dynamic Optimization Problem I

- State vector: $x_j = \left\{\vartheta, a_j, \epsilon_j^h\right\} \in \{1,2,3\} \times R \times \{1,2,3,4,5\}$
- Expectation $\Rightarrow \mathbb{E}_{\epsilon_{j+1}^h, \epsilon_{j+1}^s | \epsilon_j^h}$

$$V(x_j) = \max_{\{c_j, \alpha_j\}} \left\{ u(c_j) + \beta \mathbb{E} \left[\overbrace{\pi_j \left(h \left(\epsilon_j^h \right) \right)}^{\text{Health surv. channel}} V(x_{j+1}) + \overbrace{\left(1 - \pi_j \left(h \left(\epsilon_j^h \right) \right) \right)}^{\text{Health surv. channel}} u^{\text{beq}}(a_{j+1}) \right] \right\}$$

s.t.

$$a_{j+1} = \tilde{R}_{j+1} \left(\begin{array}{c} a_j + \mathrm{tr}_j^{\mathrm{ss}}\left(\bar{y}^{\vartheta}\right) + \mathrm{tr}_j^{\mathrm{si}} - \overbrace{o_j \left(m_j, \epsilon_{j,\vartheta}^{\mathrm{ehi}}, y_j^{\mathrm{agi}}, a_j \right)}^{\text{Health spend. channel}} \\ -\mathrm{prem}_j^{\mathrm{mcare}} \underbrace{-\mathrm{tax}^y\left(y_j^{\mathrm{tax}}\right)}_{\text{Health tax channel}} - (1 + \tau^c) c_j - 1_{[\alpha_j > 0]} q \end{array} \right)$$

$$\tilde{R}_{j+1} = \left(\alpha_j \left(1 + \tilde{r}_{net,j+1}^s \right) + (1 - \alpha_j) \left(1 + \bar{r}^b \right) \right)$$

$$\underline{b} \leq b_{j+1}$$

$$0 \leq s_{j+1}$$

Retiree's Dynamic Optimization Problem II

$$y_j^{\text{tax}} = \text{tr}_j^{\text{ss}} - \max\left[0,\ \left(o_j\left(m_j\right) + \text{prem}^{\text{mcare}}\right) - 0.075 \times \left(r_b \times b_j + r_s \times s_j + \text{tr}_j^{\text{ss}}\right)\right]$$

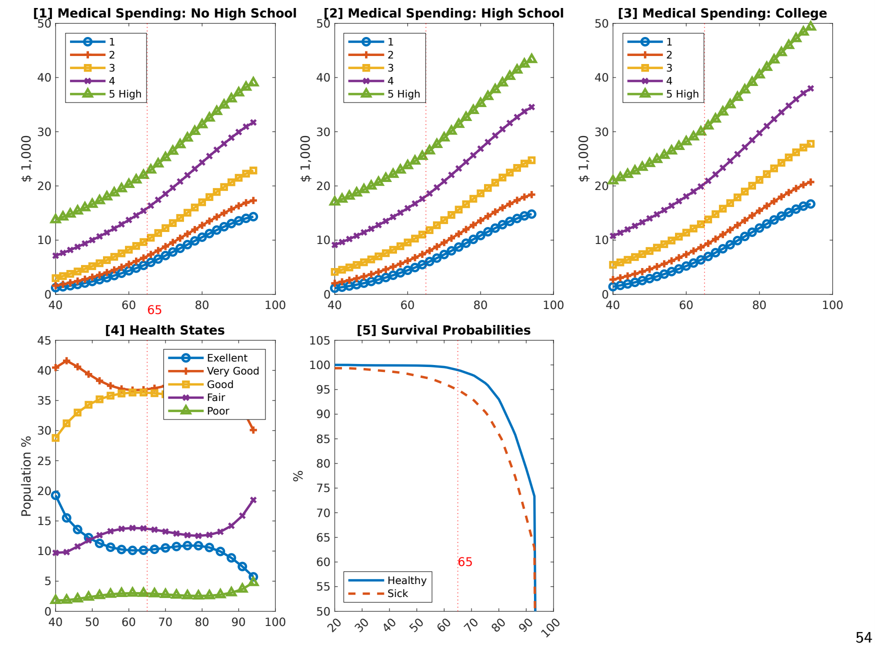
$$\text{tr}_j^{\text{si}} = \max\left[0,\ c_{\min} + o_j\left(m_j\right) + \text{prem}^{\text{mcare}} + \text{tax}^y\left(y_j^{\text{tax}}\right) - a_j - \text{tr}_j^{\text{ss}}\right]$$

Back to retired problem

Exogenous parameters

Parameter description	Parameter values	Source
Periods	$J = 55$	
Work periods	$J_w = 25$	Age 40–64
Years modeled	years $= 55$	Age 40–94
Relative risk aversion	$\sigma = 3$	Standard values between $2.5 - 3.5$
Survival probabilities	$\pi_j \left(h \left(\epsilon^h \right) \right)$ see online appendix	İmrohoroğlu and Kitao (2012)
Health Shocks	ϵ_j^h see online appendix	MEPS 1996–2018
Health transition prob.	Π_j^h see online appendix	MEPS 1996–2018
Persistent labor shock autocor.	$\rho = 0.977$	French (2005)
Variance of transitory labor shock	$\sigma_{\epsilon_1}^2 = 0.0141$	French (2005)
Bias adjusted wage profile	$\bar{e}_j \left(\vartheta, h \left(\epsilon^h \right) \right)$ see online appendix	MEPS 1996–2018
Private employer HI	$\gamma^{\text{ehi}} = 0.31$	MEPS 1996–2018
Medicaid coinsurance	$\gamma^{\text{maid}} = 0.11$	MEPS 1996–2018
Medicare coinsurance	$\gamma^{\text{mcare}} = 0.30$	MEPS 1996–2018
Consumption tax	$\tau^c = 5\%$	IRS
Bequest parameter	$\theta_2 = \$500,000$	De Nardi (2004); French (2005)
Payroll tax Social Security	$\tau^{\text{ss}} = 10.6\%$	IRS
Payroll tax Medicare	$\tau^{\text{mcare}} = 2.9\%$	SSA (2007)
Tax progressivity	τ_1^i =0.053	Guner, Lopez-Daneri and Ventura (2016)
Dividend tax	$\tau^d = 25\%$	Gomes, Michaelides and Polkovnichenko (2009)
Capital gains tax	$\tau^g = 20\%$	Gomes, Michaelides and Polkovnichenko (2009)

Exogenous medical spending



Internal (calibrated) parameters

Parameters	Values	Calibration target	Model	Data	Source
Discount factor	$\beta = 0.99$	Wealth-to-inc. 65	4.79	4.6	HRS 1992–2018
Fixed cost of work	$\bar{n}_{j,\vartheta}$	Avge. work part.	Pan2,Fig.1	Pan2,Fig.1	MEPS 1996–2018
Pref. cons. vs. leis.	$\eta = 0.275$	Avge. hours wrkrs	Pan3,Fig.1	Pan3,Fig.1	MEPS 1996–2018
Cost of investm.	$q_\vartheta \in \left[\underline{q_\vartheta}, \bar{q}_\vartheta\right]$	Risky asset part.	Pan1,Fig.19	Pan1,Fig.19	HRS 1992–2018
Prog. tax scaling	τ_0^i =1.016				Jung and Tran (2022)
Bequest parameter	θ_1	Assets of 90–94	Pan.4,Fig.1	Pan.4,Fig.1	HRS 1992–2018
Medicaid asset test	$\bar{a}^{\text{maid}} = \$75k$	Work. 40–64 on Maid	Pan.2,Fig.2	Pan.2,Fig.2	MEPS 1996–2018
Medicaid inc. test	$\bar{y}^{\text{maid}} = \$5.5k$	Work. 20–39 on Maid	Pan.2,Fig.2	Pan.2,Fig.2	MEPS 1996–2018
Cons. floor	$c_{\min} = \$3.2k$	Frac. net-assts<\$5k	20% (of pop.)	20%	Jeske and Kitao (2009)

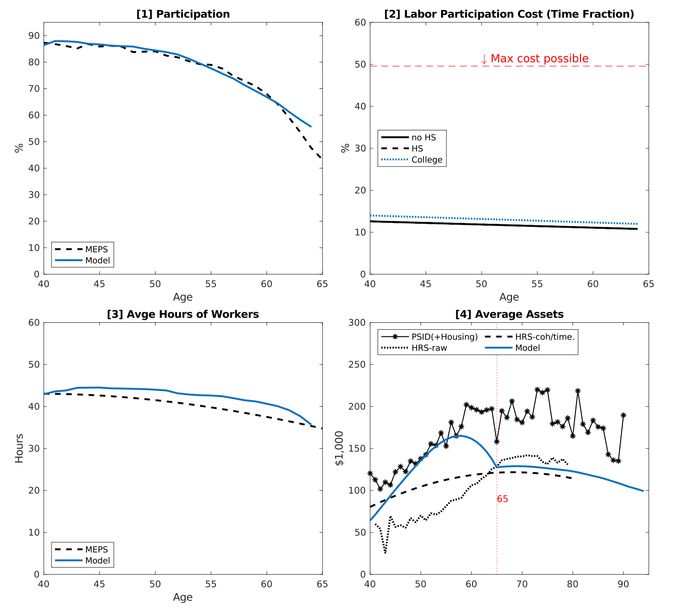


Figure 1: **Calibration targets**

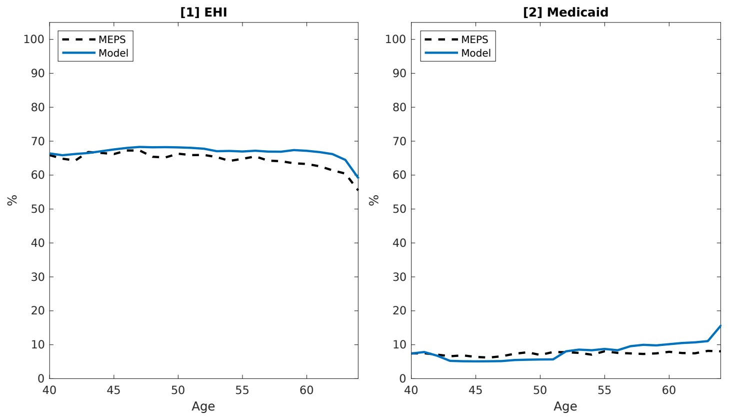


Figure 2: **Calibration targets (only Medicaid is a target)**

Back to calibration

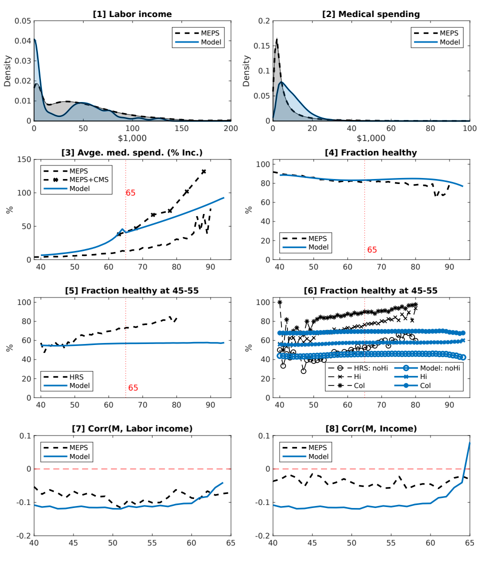


Figure 3: **Model performance (not calibration targets)**

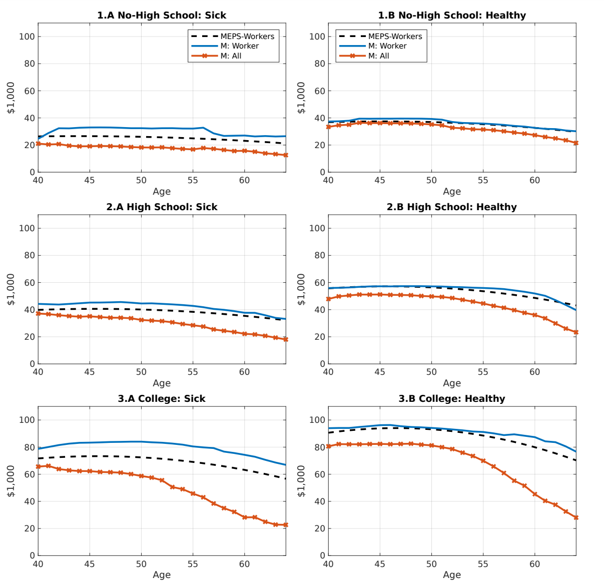


Figure 4: **Model performance: labor income by education and health**

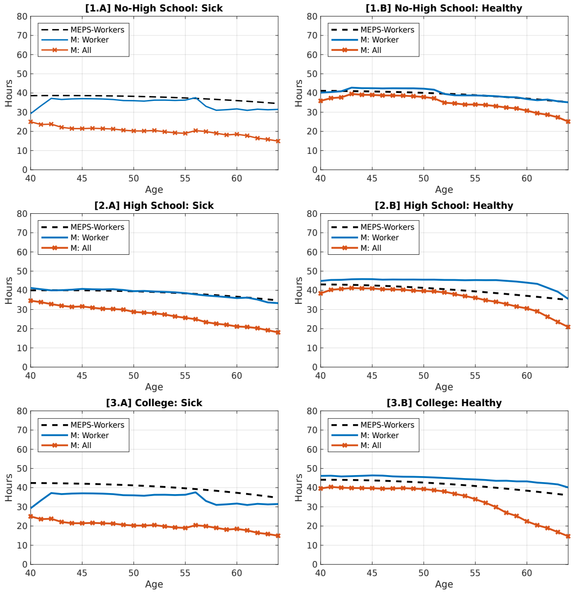


Figure 5: **Model performance: hours worked by education and health**

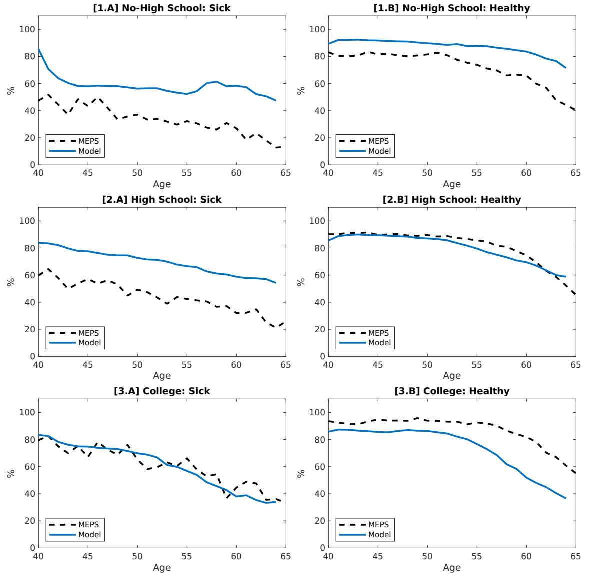


Figure 6: **Model performance: labor force participation by education and health**

Model performance (not targets)

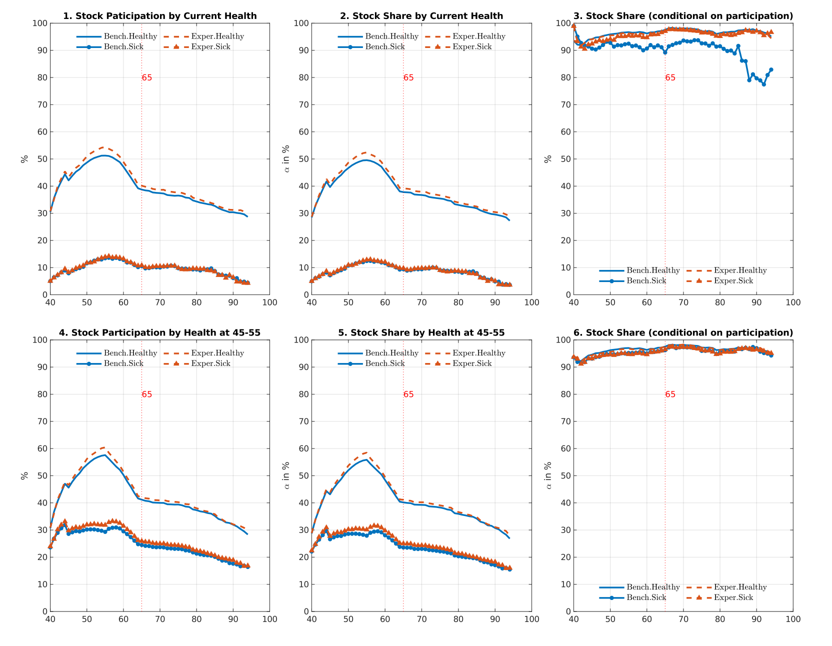
Moments	Model	Data	Sources
Medical exp/income	16.5%	Pan.3,Fig.3	MEPS 1996–2018
Gini medical spending	0.56	0.60	MEPS 1996–2018
Gini gross income	0.40	0.46	MEPS 1996–2018
Gini labor income	0.55	0.54	MEPS 1996–2018
Gini assets	0.58	0.69	HRS 1992–2018
Frisch labor supply elasticities	1.19–1.51	1.1–1.7	Fiorito and Zanella (2012)
Interest rate: r	5.9%	$5.2 - 5.9\%$	Gomme, Ravikumar and Rupert (2011)

Back to calibration

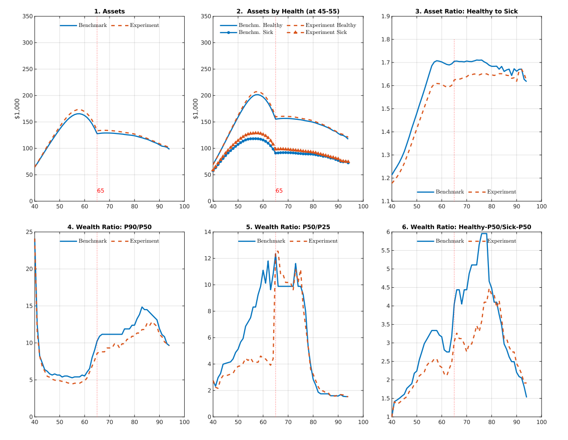
Policy experiments

- Expansion of Medicare to 20–64 year olds (UPHI)
- Expansion of EHI to all workers
- Medicare buy in for 55–64 year olds
- Expansion of Medicaid
- No insurance world

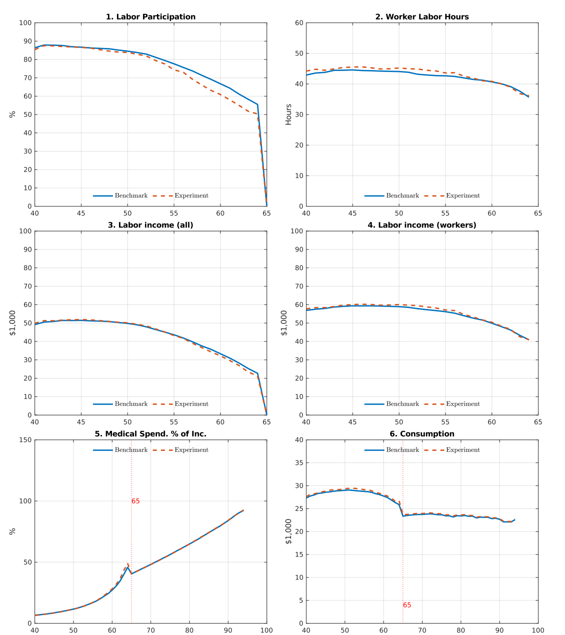
Exp. 1 (Medicare for all): Stock holdings



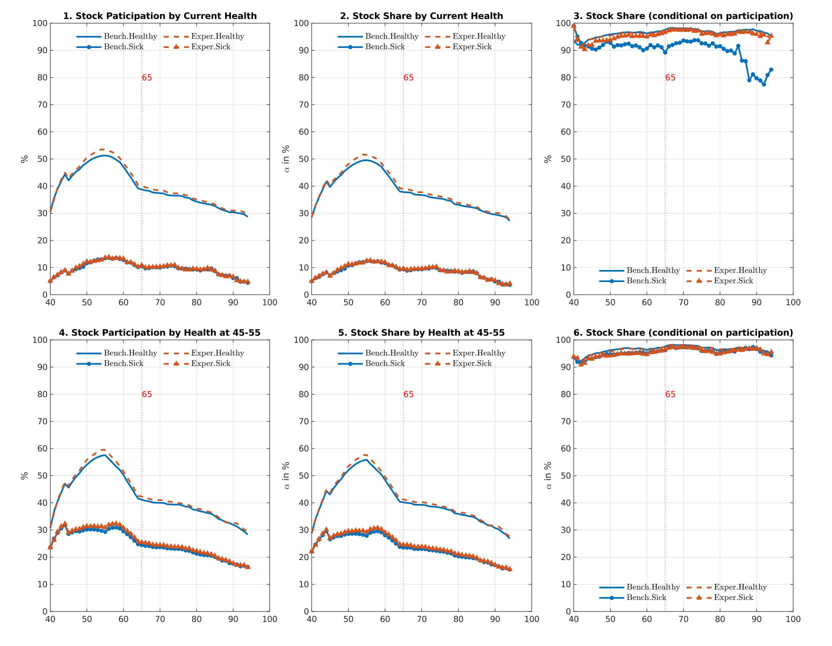
Exp. 1 (Medicare for all): Asset profiles



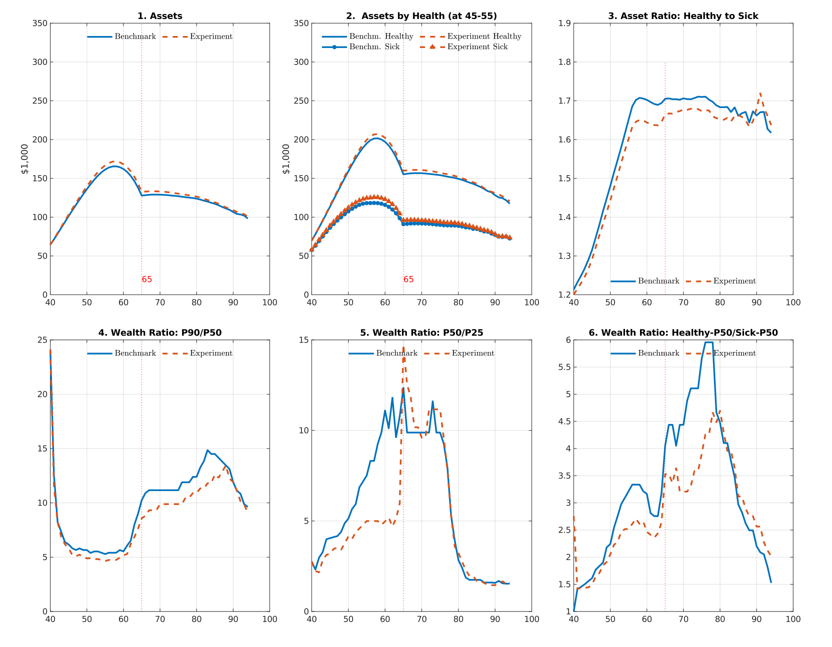
Exp. 1 (Medicare for all): Labor profiles



Exp. 2 (EHI for all workers): Stock holdings



Exp. 2 (EHI for all workers): Asset profiles



Experiments done

Back to results

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