Health, Consumption, and Inequality

Jay H. Hong   Josep Pijoan-Mas   José Víctor Ríos-Rull

SNU   CEMFI   UPenn and UCL

PIER Conference Special Event, April 2019

Work in Progress (still)

Motivation

- Inequality is one of the themes of our time.
  - Large body of literature documenting inequality in labor earnings, income, and wealth across countries and over time
    Katz, Murphy (QJE 1992); Krueger *et al* (RED 2010); Piketty (2014)
    Kuhn, Ríos-Rull (QR 2016); Khun *et al* (2017)

- We also know of large socio-economic gradients in health outcomes
  - In mortality
    Kitagawa, Hauser (1973); Pijoan-Mas, Rios-Rull (Demography 2014)
    De Nardi *et al* (ARE 2016); Chetty *et al* (JAMA 2016)
  - In many other health outcomes
    Marmot *et al* (L 1991); Smith (JEP 1999)
    Bohacek, Bueren, Crespo, Mira, Pijoan-Mas (2018)

▷ We want to *compare* and *relate* *inequality in health outcomes* to pure *economic inequality*.

The project

1. Write a model of consumption, saving and health choices featuring
   (a) Health-related preferences
   (b) Health technology

2. Use the FOC (only) to estimate (a) and (b)
   - Consumption growth data to estimate how health affects the marginal utility of consumption
   - Standard measures of VSL and HRQL to infer how much value individuals place on their life in different health states
   - Medical health spending, health transitions (and people's valuation of life) to infer health technology

3. Use our estimates to
   - Welfare analysis: compare different groups given their allocations
   - Ask what different groups would do if their resources were different and how much does welfare change
   - Evaluate public policies?

Main empirical challenge

- Theory:
  - Out-of-pocket expenditures improve health
- Data:
  - Cross-section: higher spending leads to better health transitions across groups (education, wealth)
  - Panel: higher spending leads to worse outcomes
    - ▷ unobserved health shocks spur medical spending
- Add explicitly into the model
  - Unobserved shock to health between t and $t + 1$ that shapes
    - probability of health outcomes
    - the returns to health spending
  - Higher expenditure signals higher likelihood of bad health shock

Model

Life-Cycle Model (mostly old-age)

1. Individuals state $\omega \in \Omega \equiv I \times E \times A \times H$ is
   - Age $i \in I \equiv \{50, \dots, 89\}$
   - Education $e \in E \equiv \{\text{HSD}, \text{HSG}, \text{CG}\}$
   - Net wealth $a \in A \equiv [0, \infty)$
   - Overall health condition $h \in H \equiv \{h_g, h_b\}$
2. Choices:
   - Consumption $c \in \mathbb{R}_{++} \rightarrow$ gives utility
   - Medical spending $x \in \mathbb{R}_{+} \rightarrow$ affects health transitions
   - Next period wealth $a' \in A$
3. Shocks:
   - Unobserved health outlook shock η
   - Implementation error ϵ in health spending
4. (Stochastic) Health technology:
   - Health transitions given by $\Gamma^{ei}[h' \mid h, \eta, x\epsilon]$
   - Survival given by $\gamma^{i}(h)$ (note no education or wealth)

Uncertainty and timing of decisions

1. At beginning of period t individual state is $\omega = (i, e, a, h)$
2. Consumption c choice is made
3. *Health outlook shock* $\eta \in \{\eta_1, \eta_2\}$ with probability π_η
4. Health spending decision $x(\omega, \eta)$ is made
5. *Medical treatment implementation shock* $\log \epsilon \sim N\left(-\frac{1}{2}\sigma_\epsilon^2, \sigma_\epsilon^2\right)$
   - Once health spending is made, the shock determines actual treatment obtained $\tilde{x} = x(\omega, \eta)\,\epsilon$
   - Allows for the implementation of the Bayesian updating of who gets the bad health outlook shock

The Bellman equation

The retiree version

- The household chooses c, $x(\eta)$, $y(\eta)$ such that

$$v^{ei}(h,a) = \max_{c,x(\eta),y(\eta)} \Big\{ u^i(c,h) + \beta^e \gamma^i(h) \sum_{h',\eta} \pi_\eta^{ih} \int_\epsilon \Gamma^{ei}[h' \mid h, \eta, x(\eta)\epsilon] \; v^{e,i+1}[h', a'(\eta,\epsilon)] \; f(d\epsilon) \Big\}$$

- s.t. the budget constraint and the law of motion for cash-in-hand

$$\begin{aligned} c + x(\eta) + y(\eta) &= a \\ a'(\eta,\epsilon) &= [y(\eta) - (\epsilon - 1)\, x(\eta)]R + w^e \end{aligned}$$

- The FOC give:
  - One Euler equation for consumption c
  - One Euler equation for health investments at each state η

FOC for consumption

- Optimal choice of consumption for individuals of type ω
- Standard Euler equation for consumption w/ sophisticated expectation
  (Over survival, health tomorrow h', outlook shock η, and implementation shock ϵ)

$$u_c^i[h, c(\omega)] = \beta^e \gamma^i(h)\, R \sum_{h'\eta} \pi_\eta^{ih} \int_\epsilon \Gamma^{ei}[h' \mid h, \eta, x(\omega, \eta)\epsilon] \quad u_c^{i+1}\left[h', c\left(\omega, \eta, h', \epsilon\right)\right] f\left(d\epsilon\right)$$

- Timing assumptions $\Rightarrow$ consumption independent from shocks η, ϵ
- Then, it is easy to estimate w/o other parts of the model:
  - *expected transitions are the same for all individuals of same type* ω

FOC for health spending

- Individuals of type ω make different health spending choices $x(\omega, \eta)$ depending on their realized η
- The FOC for individual of type ω is η-specific:

$$\sum_{h'} \int_{\epsilon} \underbrace{\epsilon\, \Gamma_x^{ei}[h' \mid h, \eta, x(\omega,\eta)\epsilon]}_{\text{improvement in health transition}} \; \underbrace{v^{e,i+1}\{h', a'(\omega,\eta,\epsilon)\}}_{\text{value of life tomorrow}} \; f(d\epsilon) =$$

$$\underbrace{R \sum_{h'} \int_{\epsilon} \epsilon\, \Gamma^{ei}[h' \mid h, \eta, x(\omega,\eta)\epsilon] \; u_c^{i+1}[h', c(\omega,\eta,h',\epsilon)] \; f(d\epsilon)}_{\text{Expected utility cost of forgone consumption}}$$

- In order to use this for estimation we need to
  - Allocate individuals to some realization for η
  - Compute the value function

Estimation

Preliminaries

- We group wealth data a_j into quintiles $p_j \in P \equiv \{p_1, \dots, p_5\}$
  - State space is the countable set $\widehat{\Omega} \equiv E \times I \times H \times P$
- Functional forms
  - Utility function

$$u^i(h, c) = \alpha_h + \chi_h^i \frac{c^{1-\sigma_c}}{1-\sigma_c}$$

  - Health transitions

$$\Gamma^{ie}(g|h, \eta, x) = \lambda_{0\eta}^{ieh} + \lambda_{1\eta}^{h} \frac{x^{1-\nu^h}}{1-\nu^h}$$

- Estimate several transitions in HRS data
  - Survival rates $\widetilde{\gamma}_h^i$
  - Health transitions $\widetilde{\Gamma}(h_g|\omega)$
  - Health transitions conditional on health spending $\widetilde{\varphi}(h_g|\omega, \tilde{x})$
  - Joint health and wealth transitions $\widetilde{\Gamma}(h', p'|\omega)$

General strategy

- Estimate vector of parameters θ by GMM without solving the model
  - → Use the restrictions imposed by the FOC
  - → Need to compute value functions with observed choices and transitions

- Two types of parameters

1/ Preferences: $\theta_1 = \{\beta^e, \sigma_c, \chi_h^i, \alpha_h\}$

- Can be estimated independently from other parameters
- Use consumption Euler equation to obtain $\beta^e, \sigma_c, \chi_h^i$
- Use VSL and HRQL conditions to estimate α_h

2/ Health technology: $\theta_2 = \{\lambda_{0\eta}^{ieh}, \lambda_{1\eta}^{h}, \nu^h, \pi_\eta, \sigma_\epsilon^2\}$

- Requires θ_1 as input
- Use medical spending Euler equations plus health transitions
- Problem: we observe neither η_j nor ϵ_j
- Need to recover posterior probability of η_j from observed health spending $\tilde{x}_j$

Data: various sources

1. HRS
   - White males aged 50-88
   - Health stock measured by self-rated health (2 states)
   - ▷ Obtain the objects $\widetilde{\gamma}_h^i$, $\widetilde{\Gamma}(h_g|\omega)$, $\widetilde{\varphi}(h_g|\omega,\tilde{x})$, $\widetilde{\Gamma}(h',p'|\omega)$
2. PSID (1999+) gives
   - Households headed by white males aged 50-88
   - Non-durable consumption
   - Out of Pocket medical expenditures
3. Standard data in clinical analysis
   - Outside estimates of the value of a statistical life (VSL)
   - Health Related Quality of Life (HRQL) scoring data from HRS

Preliminary Estimates: Preferences

Marginal utility of consumption

Consumption Euler equation

- We use the sample average for all individuals j of the same type ω as a proxy for the expectation over η, h', and ϵ

$$\beta^e R \, \tilde{\gamma}_h^i \frac{1}{N_\omega} \sum_j \mathbf{I}_{\omega_j = \omega} \frac{\chi_{h'_j}^{i+1}}{\chi_h^i} \left(\frac{c'_j}{c_j} \right)^{-\sigma} = 1 \qquad \forall \omega \in \widetilde{\Omega}$$

  – Normalize $\chi_g^i = 1$ and parameterize $\chi_b^i = \chi_b^0 \left(1 + \chi_b^1\right)^{(i-50)}$

  – Use cons growth from PSID by educ, health, wealth quintiles

- We obtain

  1. Health and consumption are complements
     Finkelstein et al (JEEA 2012), Koijen et al (JF 2016)
  2. More so for older people
  3. Uneducated are NOT more impatient: they have worse health outlook

Marginal utility of consumption

Results

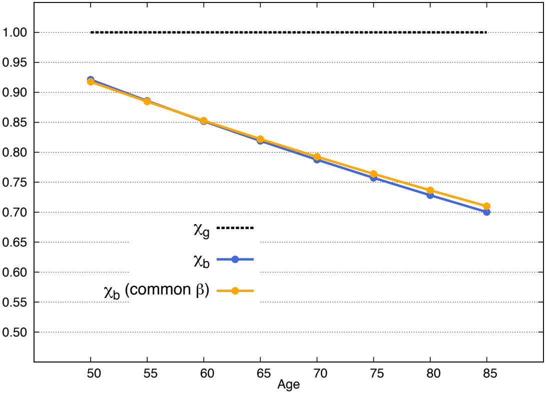
Men sample (with $r = 4.04\%$)

	β edu specific		β common	
σ	1.5		1.5	
β^d (s.e.)	0.8861	(0.0175)	0.8720	(0.0064)
β^h (s.e.)	0.8755	(0.0092)	0.8720	(0.0064)
β^c (s.e.)	0.8634	(0.0100)	0.8720	(0.0064)
χ_b^0 (s.e.)	0.9211	(0.0575)	0.9176	(0.0570)
χ_b^1 (s.e.)	-0.0078	(0.0035)	-0.0073	(0.0035)
observations	15,432		15,432	
moment conditions	240		240	
parameters	5		3	

Notes: estimation with biennial data. Annual interest rate of 2%, annual β: 0.9413, 0.9357, 0.9292 in first column and 0.9338 in the second one.

Marginal utility of consumption

Results



$$\frac{c_g}{c_b} = \left(\frac{\chi_g}{\chi_b}\right)^{1/\sigma} = \begin{cases} 1.057 & \text{at age 50} \\ 1.268 & \text{at age 85} \end{cases}$$

Value of life in good and bad health

We use standard measures in clinical analysis to obtain α_g and α_b

1. Value of Statistical Life (VSL)
   - From wage compensation of risky jobs Viscusi, Aldy (2003)
   - Range of numbers: \$4.0M–\$7.5M to save one statistical life
   - This translates into \$100,000 per year of life saved
   - ▷ Calibrate the model to deliver same MRS between survival probability & cons flow Becker, Philipson, Soares (AER 2005); Jones, Klenow (AER 2016)

2. Quality Adjusted Life Years (QALY)
   - Trade-off between years of life under different health conditions
   - From patient/individual/household surveys: no *revealed preference*
   - Use HUI3 data from a subsample of 1,156 respondents in 2000 HRS
   - Average score for $h = h_g$ is 0.85 and for $h = h_b$ is 0.60
   - ▷ Calibrate the model to deliver same relative valuation of period utilities in good and bad health

The value functions

- The value achieved by an individual of type ω is given by

$$
\begin{aligned}
v^{ei}(h,a) &= u^{i}(c(\omega),h) \\
&+ \beta^{e}\gamma^{i}(h)\sum_{h'\eta}\pi_{\eta}^{ih}\int_{\epsilon}\Gamma^{ei}\left[h'|h,\eta,x(\omega,\eta)\,\epsilon\right]v^{ei+1}\left(h',a'(\omega,\eta,\epsilon)\right)f^{x}(d\epsilon)
\end{aligned}
$$

with

$$a'(\omega,\eta,\epsilon) = \big(a - c(\omega) - \epsilon\, x(\omega,\eta)\big)(1+r) + w^{e}$$

- We can compute the value function from observed choices and transitions *without solving for the whole model* by rewriting the value function in terms of wealth percentiles $p \in P$:

$$v^{ei}(h,p) = \frac{1}{N_{\omega}}\sum_{j}\mathbf{I}_{\omega_j=\omega}\, u^{i}(c_j,h_j) + \beta^{e}\widetilde{\gamma}_{h}^{i}\sum_{h',p'}\widetilde{\Gamma}\left[h',p'|\omega\right]v^{ei+1}(h',p')$$

where we have replaced the expectation over η and ϵ by the joint transition probability of assets and health, $\widetilde{\Gamma}\left[h',p'|\omega\right]$

Preliminary Estimates: health technology

The moment conditions: Preview

- For each $\omega = (i, e, h, p)$, we have four distinct moment conditions.
  - (M1) Health spending EE for η_g
  - (M2) Health spending EE for η_b
  - (M3) Average Health transitions for $x >$ median(x_ω)
  - (M4) Average Health transitions for $x <$ median(x_ω)

- We have $210 \times 4 = 840$ moment conditions
  - e: 3 edu groups= {HSD, HSG, CG}
  - i: 8 age groups= {50-54,55-59,60-64,65-69,70-74,75-79,80-84,85-89}
  - h: 2 health groups= $\{h_g, h_b\}$
  - p: 5 wealth groups
  - ▷ This gives 240 cells in ω
  - But there are 30 cells that are empty (20 in age 85+, 5 in age 80-84)

The Problem

- Key problem: how to deal with unobserved health shock η
  - Needed to evaluate the moment conditions (M1) to (M4)
- We construct the posterior probability of η given observed health investment $\tilde{x}_j$ and the individual state ω_j

$$Pr\left[\eta_g|\omega_j,\widetilde{x}_j\right]=\frac{Pr\left[\widetilde{x}_j|\omega_j,\eta_g\right]Pr\left[\eta_g|\omega_j\right]}{Pr\left[\widetilde{x}_j|\omega_j\right]}$$

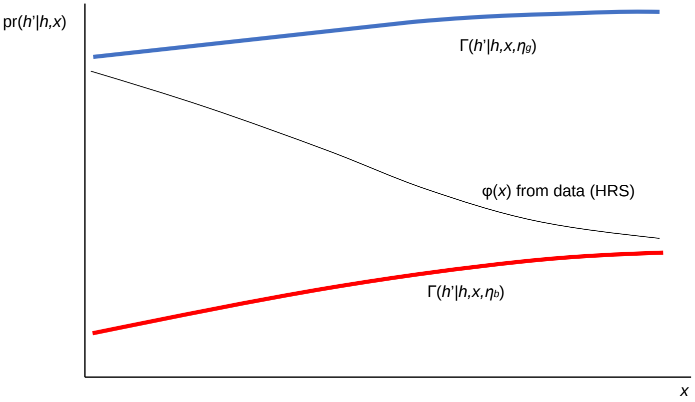
  - where $Pr\left[\widetilde{x}_j|\omega_j,\eta_g\right]$ is the density of $\epsilon_j=\widetilde{x}_j/x\left(\omega_j,\eta_g\right)$
  - where $Pr\left[\eta_g|\omega_j\right]=\pi_{\eta_g}$
  - where $Pr\left[\widetilde{x}_j|\omega_j\right]=\sum_\eta Pr\left[\widetilde{x}_j|\omega_j,\eta\right]Pr\left[\eta|\omega_j\right]$
- We weight every individual observation by this probability

The Problem

- To obtain the posterior distributions we need to estimate
  - the contingent health spending rule, $x(\omega, \eta)$
  - the variance of the medical implementation error, σ_ϵ^2
  - the probability distribution of health outlooks sock, π_{η_g}
- We identify all these objects through the observed health transitions $\widetilde{\varphi}(h_g|\omega, \tilde{x})$ as function of the state ω and health spending $\tilde{x}$

$$\underbrace{Pr[h_g|\omega, \widetilde{x}]}_{observed\ \ in\ \ the\ \ data} = \Gamma[h_g \mid \omega, \eta_g, \widetilde{x}]\underbrace{Pr[\eta_g|\omega, \widetilde{x}]}_{posterior} + \Gamma[h_g \mid \omega, \eta_b, \widetilde{x}]\underbrace{(1 - Pr[\eta_g|\omega, \widetilde{x}])}_{posterior}$$

The Problem



Moment conditions

Health Spending Euler Equation

- Moment conditions (M1) to (M2) identify the curvature ν^h and slope $\lambda^h_{1\eta}$ of the health technology
- $\forall \omega \in \widetilde{\Omega}$ and $\forall \eta \in \{\eta_g, \eta_b\}$ we have

$$\frac{1}{M_{\omega\eta}} \sum_j 1_{\omega_j=\omega}\ \tilde{x}_j\, \Gamma_x^{e_j i_j}[h_g|h_j, \eta, \tilde{x}_j] \left[v^{e_j, i_{j+1}}(h_g, p'_j) - v^{e_j, i_{j+1}}(h_b, p'_j)\right] \Pr[\eta|\omega_j, \tilde{x}_j] =$$

$$R \frac{1}{M_{\omega\eta}} \sum_j 1_{\omega_j=\omega}\ \tilde{x}_j \left(\sum_{h'} \Gamma^{e_j i_j}[h'|h_j, \eta, \tilde{x}_j]\, \chi^{i_j+1}(h')\ \left[c^{e_j, i_{j+1}}(h', p'_j)\right]^{-\sigma_c} \right) \Pr[\eta|\omega_j, \tilde{x}_j]$$

where $M_{\omega\eta} = \sum_j 1_{\omega_j=\omega} \Pr[\eta|\omega_j, \tilde{x}_j]$

- Note we use $c^{e,i}(h,p)$ (a group average consumption) and $v^{e,i}(h,p)$

Moment conditions

Average Health Transitions

- Moment conditions (M3) to (M4) identify the $\lambda^{ie}_{0\eta}$
- $\forall\omega$ and $X \in \{X_{L(\omega)}, X_{H(\omega)}\}$ we have

$$\widetilde{\Gamma}(h_g|\omega, X) = \sum_{\eta} \frac{1}{M_{\omega\eta X}} \sum_{j} 1_{\omega_j=\omega, \tilde{x}_j \in X} \left[\lambda^{ieh}_{0\eta} + \lambda^{ih}_{1\eta} \frac{\tilde{x}_j^{1-\nu^h} - 1}{1-\nu^h}\right] \Pr[\eta|\omega_j, \tilde{x}_j]$$

where

- $M_{\omega\eta X} = \sum_j 1_{\omega_j=\omega, \tilde{x}_j \in X} \Pr[\eta|\omega_j, \tilde{x}_j]$
- $X_{L(\omega)} = \{x <= \tilde{x}_{\text{med}}(\omega)\}$
- $X_{H(\omega)} = \{x > \tilde{x}_{\text{med}}(\omega)\}$

Estimates of ν and λ_1

- Less curvature in health production than in consumption

  ⇒ *ceteris paribus*, health expenditure shares increase with income
  (As in Hall, Jones (QJE 2007), but completely different identification)

  – But: in the cross-sectional data health expenditure shares unrelated to income

    - Poorer individuals have larger gains to leave bad health state

- Bad health outlook shock η_b increases return to money
  (especially so in good health state)

parameter	with $\pi = 0.5$
$\nu(h_g)$	1.2325 (0.022)
$\nu(h_b)$	0.8204 (0.034)
$\lambda_1(h_g, \eta_g)$	0.0466 (0.0087)
$\lambda_1(h_g, \eta_b)$	0.0912 (0.0169)
$\lambda_1(h_b, \eta_g)$	0.0019 (0.0006)
$\lambda_1(h_b, \eta_b)$	0.0022 (0.0007)

Estimates of λ_0: Take 1

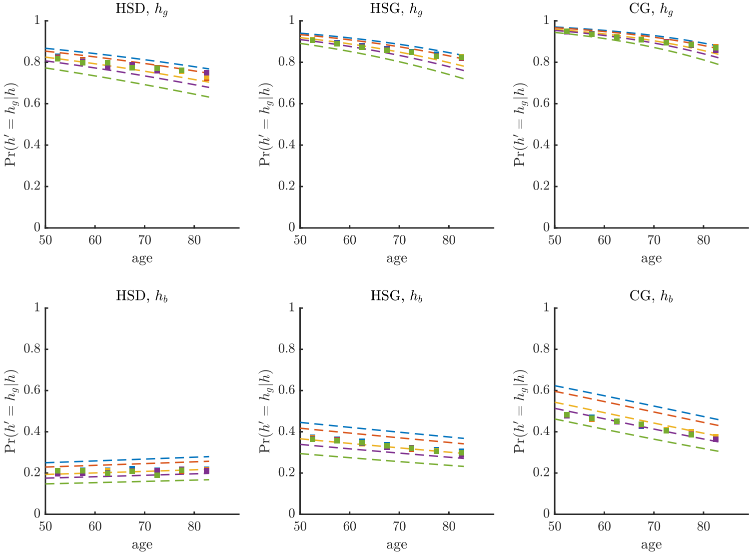
- Our estimates generate health transitions that are consistent with
  - More educated have better transitions
  - Older have worse transitions
  - Useful medical spending predicts worse transitions in the panel

▷ BUT: *not enough separation of health transitions by wealth*

- Given our estimates of λ_1 and ν, observed differences of OOP medical spending across wealth types are too small

Health transitions: Wealth Matters in Data not in Model

Data dashed and model dot each wealth quintile



Estimates of λ_0: Take 2

- Let's allow the λ_0 to depend on wealth
- We parameterize the age and wealth dependence of $\lambda_{0\eta}^{iehp}$ as follows

$$\lambda_{0\eta}^{iehp} = \frac{\exp(L_\eta^{iehp})}{1+\exp(L_\eta^{iehp})}$$

where $L_\eta^{iehp} = \mathtt{a}_\eta^{eh} + \mathtt{ap}_\eta^{eh} \times (p-3) + \mathtt{b}_\eta^{eh} \times (i-50)$

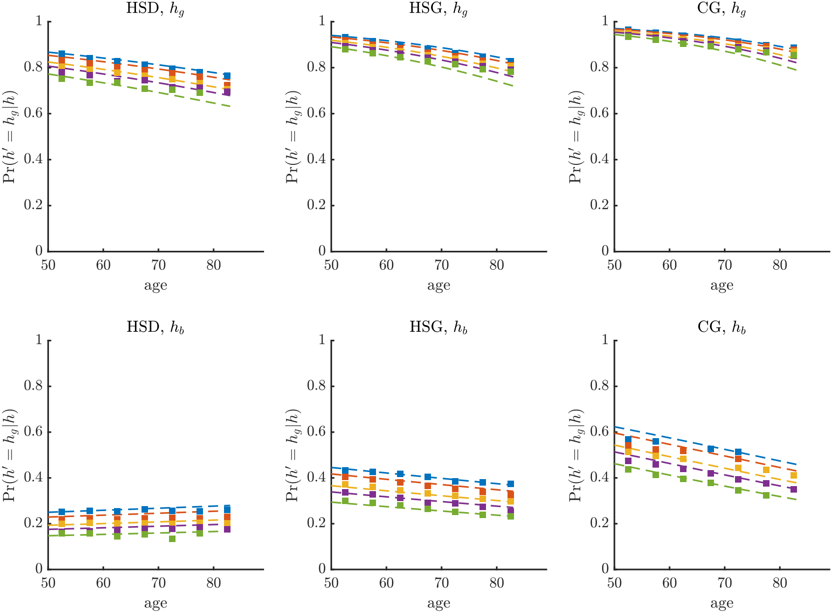
- We normalize $\pi_\eta = 1/2$ and estimate

$$\theta_2 = \{\underbrace{\mathtt{a}_\eta^{eh}, \mathtt{ap}_\eta^{eh}, \mathtt{b}_\eta^{eh}}_{\lambda_{0\eta}^{iehp}}, \lambda_{1\eta}^{h}, \nu^h, \sigma_\epsilon^2\}$$

(This is 12+12+12+4+2+1 = 43 parameters)

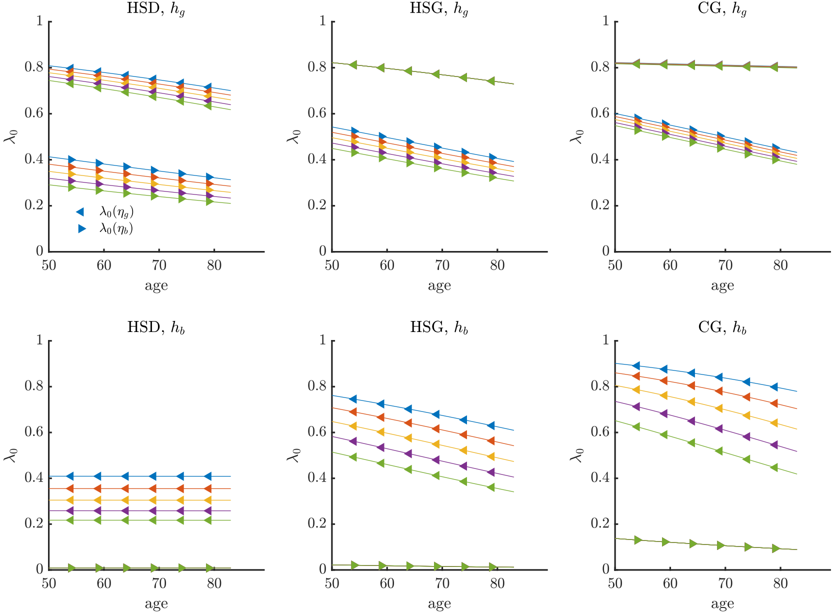
- Now: Wealthier experience better health transitions

Health transition with wealth dependent λ_0^p



Note: Model(square), HRS(dashed). Note this is the old eq26. Not fitted in this estimation directly.

$\lambda_0(\eta, i, e, h, p)$ graphically



So what to do about wealth-dependent transitions?

Two strategies

1. Pose unobserved types: something that increases wealth AND health
   - Bad types dissave (cannot be done without fully solving the model). WHICH KILLS THE BEAUTY OF THE APPROACH!!!
2. Non-linear (concave) pricing: difference in total health spending by wealth types is larger than in OOP
   - In preliminary estimates w/ MEPS data, the price of medical spending:
     - Declines with medical spending ⇒ concave pricing (copayments lower for more severe treatments)
     - Is lower for the less educated individuals (copayments lower in the public system)
     - Is higher in good health (copayments higher for preventive care)
   - But: MEPS lacks data on wealth

Conclusions

Conclusions

- We have identified preferences for health
  - Consumption is complement with health
  - Differential value of good health seems to be increasing with age.
  - Health is very valuable:
    - Back of the envelope calculation says that the better health of college educated than high school dropouts is worth 5 times the consumption of the latter group.

- Health technology
  - Health expenditures matter little
  - Wealth matters beyond health expenditures
    - Perhaps additional type differences
    - Perhaps concave pricing
    - Perhaps differential use of expenditures