Health, Consumption, and Inequality

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PRELIMINARY
Motivation

• Inequality (economic 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); Heathcote et al (RED 2010); Piketty (2014); Kuhn, Rios-Rull (QR 2016)

• We also know of large socio-economic gradients in health outcomes

  – In mortality
    
    Kitagawa, Hauser (1973); Pijoan-Mas, Rios-Rull (Demo 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, Crespo, Mira, Pijoan-Mas (2017)

▷ We want to compare and relate inequality in health outcomes to pure economic inequality.
What we do

- We build measures of inequality between socio-economic groups
  - We use the notion of Compensated Variation to compare

- We take into account
  - Differences in Consumption
  - Differences in Health
  - Differences in Mortality
  - The actions that will be taken by the disadvantaged groups to improve health and mortality when given more resources

- In doing so, we develop novel ways of measuring
  a/ Health-related preferences
  b/ Health-improving technology with medical expenditures
The project

(1) Write and calibrate a simple model of consumption and health choices
   – Useful to understand identification from a simple set of statistics

(2) Estimate big quantitative model with over-identifying restrictions
   – Adds more realistic features

▷ Part (2) still preliminary
Stylized Model
Setup

Simple framework to quantify the welfare differences across types

1. Perpetual old: survival and health transitions age-independent

2. Complete markets: annuities and health-contingent securities
   (Guarantees stationarity; allows to ignore financial risks associated to health)

3. Choice of non-medical $c$ vs medical consumption $x$

4. Types $e$ differ in
   - resources $a^e$
   - initial health distribution $\mu^e_h$
   - survival probability $\gamma^e_h$
   - health transitions $\Gamma^e_{hh'}(x)$

5. Instantaneous utility function depends on consumption and health

\[ u(c, h) = \alpha_h + \chi_h \log c \]

6. Let health $h \in \{h_g, h_b\}$
Optimization

- The recursive problem

\[
V^e(a, h) = \max_{x, c, a'_{h'}} \left\{ u(c, h) + \beta \gamma^e_h \sum_{h'} \Gamma^e_{hh'}(x) V^e(a'_{h'}, h') \right\}
\]

s.t.

\[x + c + \gamma^e_h \sum_{h'} q^e_{hh'} a'_{h'} = a(1 + r)\]

- In equilibrium \((1 + r) = \beta^{-1}\) and \(q^e_{hh'} = \Gamma^e_{hh'}\)

- Standard CM result:

\[
\frac{1}{\chi_g} c_g = \frac{1}{\chi_b} c_b \quad \text{and} \quad c_h = c'_h
\]

- And the optimal choice for \(x\) would be

\[
u_c(c_h, h) = \beta \gamma^e_h \sum_{h'} \frac{\partial \Gamma^e_{hh'}(x)}{\partial x} V^e(a', h')
\]
The value of types

- We restrict individuals of the same type $e$ to have all the same resources $a^e_h$
- The attained value in each health state is given by
  \[
  \begin{pmatrix}
  V^e_g \\
  V^e_b
  \end{pmatrix}
  = A
  \begin{pmatrix}
  \alpha_g + \chi_g \log c^e_g \\
  \alpha_b + \chi_b \log \frac{\chi_b}{\chi_g} c^e_g
  \end{pmatrix}
  \]

  where
  \[
  A = \left[ I - \beta \begin{pmatrix}
  \gamma^e_g & 0 \\
  0 & \gamma^e_b
  \end{pmatrix} \begin{pmatrix}
  \Gamma^e_{gg}(X^e_g) & 1 - \Gamma^e_{gg}(X^e_g) \\
  \Gamma^e_{bg}(X^e_g) & 1 - \Gamma^e_{bg}(X^e_g)
  \end{pmatrix} \right]^{-1}
  \]

- And the unconditional value of the average person of type $e$ is given by
  \[
  V^e = \mu^e_g V^e_g + (1 - \mu^e_g) V^e_b
  \]
Welfare comparisons

1. Holding $x$ constant

$$V(c^c_g; \mu^c_h, \Gamma^c_h, \gamma^c_h, \alpha_h, \chi_h) = V([1 + \Delta_c] c^d_g; \mu^d_h, \Gamma^d_h, \gamma^d_h, \alpha_h, \chi_h)$$

2. Allowing $x$ to be chosen optimally

$$V(c^c_g; \mu^c_h, \Lambda^c, \gamma^c_h, \alpha_h, \chi_h) = V(c^d_g([1 + \Delta_a] a, .); \mu^d_h, \Lambda^d, \gamma^d_h, \alpha_h, \chi_h)$$

(Where $\Lambda^c$ and $\Lambda^d$ are the vector of parameters determining health transitions)

- Then we report $[1 + \Delta_{(x+c)}]$
Data
Expenditure data

- Consumption data:
  - PSID 2005-2013, white males aged 50-88
  a/ Non-durable goods and services \textit{(excluding education and medical)}
  b/ Out of Pocket Medical Expenditures
    - hospital / nursing home
    - doctors
    - prescriptions / in-home medical care / other services
    - health insurance premia

- Obtain \textit{(equivalized)} life-cycle profiles by education and health

- Annuitize the life-cycle profiles to produce \(c^e_h\) and \(x^e_h\)

- Scale them up to match 2005 NIPA per capita figures
  \((x/c \text{ is 0.18 in NIPA, 0.14 in PSID})\)
Measuring health modifiers

- In bad health: around 15% consumption loss for both types

\[
\frac{\chi_b}{\chi_g} = \frac{c^c(h_b)}{c^c(h_g)} = 0.82 \quad \text{and} \quad \frac{\chi_b}{\chi_g} = \frac{c^d(h_b)}{c^d(h_g)} = 0.88
\]

- We set
  - \(\chi_g = 1\) (normalization) and \(\chi_b = 0.85\)

▶ Health and consumption are complements

  - Finkelstein, Luttmer, Notowidigdo (JEEA 2012)
  - Koijen, Van Nieuwerburgh, Yogo (JF 2016)

▶ Footnote: fully-fledged model with incomplete markets and life cycle delivers similar \(\chi_b\)
Measuring health distributions

- We use all waves in HRS, white males aged 50-88
- Health stock measured by self-rated health
  - $h = h_g$ if $h = 1, 2, 3$
  - $h = h_b$ if $h = 4, 5$
- At age 50, college graduates are in better health than HS dropouts
  - $\mu_g^c = 0.94$
  - $\mu_g^d = 0.59$
Measuring survival

1. Estimate health-dependent survival probabilities at each age

\textit{(Pijoan-Mas, Ríos-Rull (2014) show that education does not matter)}

2. Aggregate them into life expectancies (at age 50)

\[ e_g = 33.1 \quad \text{Life expectancy if always in good health} \]
\[ e_b = 19.3 \quad \text{Life expectancy if always in bad health} \]

3. Obtain the age-independent survival rates \( \gamma_h \) consistent with these
Measuring health transitions

1. Estimate health transitions for each type $e$ at each age

2. Aggregate them into average duration (at age 50) of each health state conditional on survival

   ▶ Large differences by education

   $e^c(h_g) = 20.5$  
   Duration good health, college grad

   $e^d(h_g) = 9.6$  
   Duration good health, dropout

   $e^c(h_b) = 2.6$  
   Duration bad health, college grad

   $e^d(h_b) = 8.0$  
   Duration bad health, dropout

3. Obtain the age-independent health transitions consistent with these

   ▶ College health transitions are better

   \[
   \Gamma^c_{gg} - \Gamma^d_{gg} = 0.056 \quad \text{College are better at remaining in good health}
   \]

   \[
   \Gamma^c_{bg} - \Gamma^d_{bg} = 0.261 \quad \text{and even better at recovering good health}
   \]
Measuring value of life in good and bad health

*The idea*

We use standard measures in clinical analysis to obtain $\alpha_g$ and $\alpha_b$

1. **Value of Statistical Life (VSL)**
   - From wage compensation of risky jobs
   - 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 and consumption 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*
The value of life across health states

*The data*

- HUI3 is a health-related quality of life scoring used in clinical analysis

- It measures quality of Vision, Hearing, Speech, Ambulation, Dexterity, Emotion, Cognition, Pain up to 6 levels

- It aggregates them into utility values to compare years of life under different health conditions
  - Score of 1 reflects perfect health (all levels at its maximum)
  - Score of 0 reflects dead
  - A score of 0.75 means that a person values 4 years under his current health equal to 3 years in perfect health

- We use data on *Health Utility Index Mark 3* (HUI3) from a subsample of 1,156 respondents in the 2000 HRS
Measuring difference in value of life across health states

Mapping into the model

- In the data we find that
  - Average score for $h = h_g$ is 0.85 and for $h = h_b$ is 0.60

- Imagine an hypothetical state of perfect health $\bar{h}$. Then,
  \[
  u(c^e_g, h_g) = 0.85 \ u(\bar{c}^e, \bar{h})
  \]
  \[
  u(c^e_b, h_b) = 0.60 \ u(\bar{c}^e, \bar{h})
  \]

- Therefore,
  \[
  \frac{u(c^e_g, h_g)}{u(c^e_b, h_b)} = \frac{\alpha_g + \chi_g \log c^e_g}{\alpha_b + \chi_b \log c^e_b} = \frac{0.85}{0.60}
  \]
Results
## Welfare differences without endogenous health

### Welfare of different types

<table>
<thead>
<tr>
<th></th>
<th>CG</th>
<th>HSG</th>
<th>HSD</th>
<th>CG-HSG</th>
<th>CG-HSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cons while in Good Health</td>
<td>$41,348</td>
<td>$31,817</td>
<td>$23,621</td>
<td>30%</td>
<td>75%</td>
</tr>
<tr>
<td>Expected Longevity</td>
<td>30.8</td>
<td>28.5</td>
<td>25.2</td>
<td>2.3</td>
<td>5.6</td>
</tr>
<tr>
<td>Expected Good Health Duration</td>
<td>27.5</td>
<td>22.2</td>
<td>14.3</td>
<td>5.3</td>
<td>12.2</td>
</tr>
<tr>
<td>Compensated variation (cons)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>health diff: none</td>
<td></td>
<td></td>
<td></td>
<td>1.30</td>
<td>1.75</td>
</tr>
<tr>
<td>health diff: quantity of life</td>
<td></td>
<td></td>
<td></td>
<td>2.05</td>
<td>6.37</td>
</tr>
<tr>
<td>health diff: quality of life</td>
<td></td>
<td></td>
<td></td>
<td>2.05</td>
<td>6.63</td>
</tr>
<tr>
<td>health diff: both</td>
<td></td>
<td></td>
<td></td>
<td>3.21</td>
<td>24.95</td>
</tr>
</tbody>
</table>
Welfare differences

Comments

- Welfare differences due to quality and quantity of life are huge

- Question

  *If health is so important, why low types do not give up consumption to buy better health?*

- Our answer

  *By revealed preference, it must be that out-of-pocket health spending is not too useful in improving health after age 50*
The life extending technology

Functional form

- Assume the following functional forms:

\[
\Gamma_{eg}(x) = \lambda_{0,g} + \lambda_{1,g} \frac{x^{1-\nu_g}}{1-\nu_g}
\]

\[
\Gamma_{bg}(x) = \lambda_{0,b} + \lambda_{1,b} \frac{x^{1-\nu_b}}{1-\nu_b}
\]

- This form is flexible:
  - it can impute all the advantage as being *intrinsic* to the type \((\lambda_{1,h} = 0)\)
    
    *(It could also be the result of different non-monetary investments, which we will ignore.)*
  - or as being the result of having *more resources* \((\lambda_{0,h} = 0)\)
  - or somethings in between.

- This adds 8 parameters: \(\nu_g, \nu_b, \lambda_{1,g}, \lambda_{1,b}, \lambda_{c,g}, \lambda_{c,b}, \lambda_{d,g}, \lambda_{d,b}\)
The life extending technology

*Identification with only two types*

We have 8 equations to solve for the 8 parameters

1. The 4 FOC of $x$ for each $e$ and $h$

   \[
   \chi_h \frac{1}{C_h^e} = \beta \gamma_h \lambda_{1,h} (\chi^e_h)^{-\nu_h} \left( V^e_g - V^e_b \right)
   \]

   a/ The health spending ratio between education types identifies $\nu_h$

   \[
   \left( \frac{x^c_h}{x^d_h} \right)^{\nu_h} = \frac{c^e_h}{c^d_h} \frac{(V^c_g - V^c_b)}{(V^d_g - V^d_b)} \quad \forall h \in \{g, b\}
   \]

   b/ The health spending level identifies $\lambda_{1,h}$

   \[
   \frac{(x^e_h)^{\nu_h}}{\lambda_{1,h}} = \beta \gamma_h c^e_g (V^e_g - V^e_b) \quad \forall h \in \{g, b\}
   \]

2. The 4 observed health transitions yield the $\lambda^e_{0,h}$ for $e$ and $h \in \{g, b\}$. 
Health technology

Summary

- OOP money matters little (after age 50): 0.3 out of 5.6 years
  - RAND Health Insurance experiment of 1974-1982
    Aron-Dine et al (JEP 2013)
  - Oregon Medicaid Extension lottery of 2008
    Finkelstein et al (QJE 2012)

- We recover small curvature: \( \nu_g = 0.35 \) and \( \nu_b = 0.25 \)
  - Income elasticity of health spending larger than non-medical expenditure
    (consistent with Hall, Jones (QJE 1997) for representative agent)
  - But in the data expenditure share similar between types
    (consistent with Aguiar, Bils (AER 2015) with CEX data)

  - This is because value of good health \((V_g^e - V_b^e)\) higher for dropouts

- We recover small \( \lambda_{1g} \) and \( \lambda_{1b} \)
  - This is because of low ratio of medical to non-medical expenditure (0.18)
## Panel A: Health Transition Parameters

<table>
<thead>
<tr>
<th></th>
<th>$\Gamma_{hg}$</th>
<th>$\lambda^e_{0h}$</th>
<th>$\lambda^e_{1h}$</th>
<th>$\nu_h$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good health</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>0.951</td>
<td>0.935</td>
<td>$3.5 \times 10^{-5}$</td>
<td>0.35</td>
</tr>
<tr>
<td>Dropouts</td>
<td>0.895</td>
<td>0.884</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bad health</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>0.386</td>
<td>0.367</td>
<td>$1.6 \times 10^{-5}$</td>
<td>0.25</td>
</tr>
<tr>
<td>Dropouts</td>
<td>0.125</td>
<td>0.114</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Panel B: Decomposition of the Life Expectancy Gradient

<table>
<thead>
<tr>
<th></th>
<th>$\mu^c$</th>
<th>$\chi^c$</th>
<th>$\lambda^c_{0h}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy</td>
<td>5.6</td>
<td>0.7</td>
<td>4.8</td>
</tr>
<tr>
<td>Healthy life expectancy</td>
<td>12.2</td>
<td>1.8</td>
<td>11.5</td>
</tr>
</tbody>
</table>
Optimal health spending

- Because $\eta_g, \eta_b < 1$ the ratio $x/c$ increases with overall spending
- But at same level of spending, $x/c$ larger for HSD
### Welfare differences with endogenous health

<table>
<thead>
<tr>
<th>Compensated variations (total expenditure)</th>
<th>CG-HSG</th>
<th>CG-HSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>health diff: none</td>
<td>1.25</td>
<td>1.64</td>
</tr>
<tr>
<td>health diff: quantity and quality of life</td>
<td>2.86</td>
<td>21.30</td>
</tr>
<tr>
<td>endogenous health choices</td>
<td>2.26</td>
<td>6.86</td>
</tr>
</tbody>
</table>
Quantitative Model
Why?

- **Theory:**
  - Out of Pocket Expenditures Improve Health

- **Data:**
  - Across (age, educational) groups higher spending leads to better health transitions.
  - But in panel dimension Higher Expenditures lead to Worse outcomes.

- **Resolution:**
  - A (unobserved) shock to health that shapes the health outlook including the returns to investment
Set up

- Add: *life cycle, incomplete markets*
  - The individual state is given by $\omega = (e, i, h, a) \in E \times I \times H \times A \equiv \Omega$.

- Health outlook shock $\eta \in \{\eta_g, \eta_b\}$
  - Changes both the probability of health outcomes next period and the return to health investment (The health transition $\Gamma^{ei}(h' | h, x)$ depends on $\eta$)
  - It happens between $t$ and $t + 1$, after consumption $c$ has been chosen
  - Probabilities of $\eta_g$: $\pi^i h_{\eta_g}$

- Mechanism to account for individual variation in health spending. Alternative to measurement error to maintain implied wealth transitions: Medical treatment implementation shock $\epsilon$
  - Once contingent health spending $x(\omega, \eta)$ has been chosen, shock determines actual treatment $\tilde{x} = x(\omega, \eta) \epsilon$ obtained.
  - Distribution: $\log \epsilon \sim N\left(-\frac{1}{2} \sigma^2_\epsilon, \sigma^2_\epsilon\right)$
The Bellman equation

The retiree version

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

$$v^{ei}(h, a) = \max \left\{ u^i(c, h) + \beta^e \gamma^i(h) \sum h' \eta \int_{\epsilon} \Gamma^{ei}[h' | h, \eta, x(\eta)\epsilon] v^{e,i+1}[h', a'] f(\epsilon) \right\}$$

- Subject to

  - the budget constraint

    $$c + x(\eta) + y(\eta) = a,$$

  - the law of motion for cash in hand

    $$a' = [y(\eta) - (\epsilon - 1) x(\eta)] R + w^e$$
Two FOC

- Consumption

\[
u_i^c[h, c(\omega)] = \beta^e \gamma^i(h)R \sum_{h', \eta} \pi_{\eta}^{ih} \int_{\epsilon} \Gamma_{\epsilon}^{ei}[h' | h, \eta, x(\omega, \eta)\epsilon] u_{c}^{i+1}[h', c(\omega, \eta, h', \epsilon)] f(d\epsilon)
\]

- Health investments at each state \(\eta\):

\[
R \sum_{h'} \int_{\epsilon} \Gamma_{\epsilon}^{ei}[h' | h, \eta, x(\omega, \eta)\epsilon] u_{c}^{i+1}[h', c(\omega, \eta, h', \epsilon)] f(d\epsilon) =
\]

\[
\sum_{h'} \int_{\epsilon} \Gamma_{\epsilon}^{ei}[h' | h, \eta, x(\omega, \eta)\epsilon] v_{e,i+1}^{e,i+1}[h', a'(\omega, \eta, \epsilon)] f(d\epsilon)
\]
Estimation
Preliminaries

- We aggregate wealth data $a_j$ into quintiles $p_j \in P \equiv \{p_1, \ldots, p_5\}$
  - State space is the countable set $\hat{\Omega} \equiv E \times I \times H \times P$

- Need to specify functional forms
  - Utility function
    \[
    u^i(h, c) = \alpha_h + \chi_h \frac{c^{1-\sigma_c}}{1 - \sigma_c}
    \]
  - Health transitions
    \[
    \Gamma^{ie}(g|h, \eta, x) = \lambda_{0\eta}^{ieh} + \lambda_{1\eta}^{ih} \frac{x^{1-\nu^h}}{1 - \nu^h}
    \]

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

- Estimate vector of parameters $\theta$ by GMM without solving the model
  - Use the restrictions imposed by the FOC

- Two types of parameters

  1/ Preferences: $\theta_1 = \{\beta^e, \alpha_h, \chi^i_h, \sigma_c\}$
    - Can be estimated independently from other parameters
    - Uses consumption Euler equation to obtain $\beta^e, \chi^i_h, \sigma_c$
    - Adds VSL and HRQL conditions to estimate $\alpha_h$

  2/ Health technology and shocks $\theta_2 = \{\lambda^{i_{eh}}, \lambda^{i_{eh}}_{1\eta}, \nu^i_h, \pi^i_{\eta}, \sigma^2_{\epsilon}\}$
    - Uses medical spending Euler equation plus several health transitions
    - Uses $\theta_1 = \{\beta^e, \alpha_h, \chi^i_h, \sigma_c\}$ as input
    - We observe neither $\eta_j$ nor $\epsilon_j$: need to recover $x(\omega_j, \eta_j)$ and posterior probability of $\eta_j$ from observed health spending $\tilde{x}_j$
Consumption Euler equation

- We use the sample average for all individuals $j$ of the same type $\omega$ as a proxy for the expectation over $\eta$, $h'$, and $\epsilon$

$$
\beta^e R \tilde{\gamma}_h^i \frac{1}{N_\omega} \sum_{j} I_{\omega_j = \omega} \frac{\chi_{h_j}^{i+1}}{\chi_h^i} \left( \frac{c_j'}{c_j} \right)^{-\sigma} = 1 \quad \forall \omega \in \tilde{\Omega}
$$

- It has the disadvantage of (implicitly) using the health transitions in the PSID, which may be different from the ones in the HRS

- Alternatively, we can use the functional form for the health transition and the observed health spending
  - But then we cannot separate the estimation in two pieces
Identifying the health technology: The Problem

- Key problem: How to deal with unobserved health shock.

- We have to construct the posterior probability given observed health investment.

- We do so by posing an implementation error.
  - Conditional on type, different households are imputed different probabilities of having had the health shock given their expenditures.
Identifying the health technology: The moment conditions

- Health spending Euler equation: \( \forall \omega \in \tilde{\Omega} \) and \( \forall \eta \in \{\eta_g, \eta_b\} \)

\[
R \sum_{h'} \frac{1}{M_{\omega,h'}} \sum_j I_{\omega=\omega', h_j'=h'} \tilde{x}_j \Gamma^{e_{ij}} [h_j' | h_j, \eta, \tilde{x}_j] \chi^{i+1}(h_j') (c_j')^{-\sigma_c} Pr [\eta | \omega_j, \tilde{x}_j] = \\
\sum_{h'} \frac{1}{M_{\omega,h'}} \sum_j I_{\omega=\omega', h_j'=h'} \tilde{x}_j \Gamma_x^{e_{ij}} [h_j' | h_j, \eta, \tilde{x}_j] \nu^{e_{ij}+1} (h_j', p_j') Pr [\eta | \omega_j, \tilde{x}_j]
\]

- Health transitions: \( \forall \omega \in \tilde{\Omega} \)

\[
\tilde{\Gamma}(h_g | \omega) = \sum_{\eta} \pi_{\eta}^{ih} \left( \lambda^{ih}_{\eta} + \frac{\lambda^{ih}_{1\eta}}{1 - \nu^{ih}} \frac{1}{M_{\omega}} \sum_j I_{\omega=\omega'} \tilde{x}_j^{1-\nu^{ih}} Pr [\eta | \omega_j, \tilde{x}_j] \right)
\]
Preliminary Estimates
Preferences

- Normalize $\chi_i^g = 1$ and parameterize $\chi_i^b = \chi_b^0 (1 + \chi_b^1)^{(i-50)}$
- We obtain
  - consumption expenditure is less valuable in poor health
  - this does not change much with ageing
The uneducated are not more impatient. They just have worse health outlook.
Transitions

Summary

• So far: Fix $\pi_1^{ih} = 0.75$

• Curvatures consistent with simple model

<table>
<thead>
<tr>
<th></th>
<th>Life cycle + IM</th>
<th>Perpetual Old + CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_c$</td>
<td>1.57</td>
<td>1</td>
</tr>
<tr>
<td>$\nu_g$</td>
<td>0.95</td>
<td>0.35</td>
</tr>
<tr>
<td>$\nu_b$</td>
<td>0.21</td>
<td>0.25</td>
</tr>
</tbody>
</table>

• Need to process role of estimated $\lambda_0$, $\lambda_1$
Transitions

$\lambda_0$

![Graphs showing transitions](image-url)
Transitions: $\lambda_1 \times 10^{-5}$

![Graph of Transitions]

- **Good Health**: The transition rate $\eta_1$ is represented by a blue line, while the transition rate $\eta_2$ is represented by a red line. The y-axis represents the transition rate in units of $10^{-5}$, and the x-axis represents age.

- **Bad Health**: The transition rate is represented by a red line, showing a similar trend as in the good health graph, but with a different scale for the y-axis.
Still to be Processed

- The properties of the investment technology
- The Compensated variation measure of educational inequality
Conclusions
Conclusions

- We have discussed how to measure inequality between types by incorporating
  - differences in consumption
  - differences in life expectancy
  - differences in health

- We have found much larger numbers than those associated to consumption alone.

- We estimate both health preferences and a production function from out of pocket expenditures (in the U.S.)
  - Limited value to out of pocket health investments, especially with bad health.

- We still have to finish
  - Fully-fledged life cycle model without complete markets and trace its welfare implications.
  - So far not that different from calibrated simple version.
Remaining Important Issues

1. Estimation is closely dependant on U.S. features
   - Limited health insurance.
   - Not well defined role of Out of Pocket Expenditures. We are not sure if it means the same things across education groups.

2. Would love to use non U.S. data
Tables
Estimation of logit underlying the $\tilde{\phi}(h_g|\omega, \tilde{x})$

**White males**

<table>
<thead>
<tr>
<th>Term</th>
<th>coeff</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG</td>
<td>2.14</td>
<td>(8.51)</td>
</tr>
<tr>
<td>HSG</td>
<td>1.13</td>
<td>(5.90)</td>
</tr>
<tr>
<td>CG (\times) age</td>
<td>-0.02</td>
<td>(-5.41)</td>
</tr>
<tr>
<td>HSG (\times) age</td>
<td>-0.01</td>
<td>(-3.88)</td>
</tr>
<tr>
<td>Wealth q1</td>
<td>2.22</td>
<td>(7.84)</td>
</tr>
<tr>
<td>Wealth q2</td>
<td>2.02</td>
<td>(7.62)</td>
</tr>
<tr>
<td>Wealth q3</td>
<td>1.64</td>
<td>(6.34)</td>
</tr>
<tr>
<td>Wealth q4</td>
<td>0.92</td>
<td>(3.64)</td>
</tr>
<tr>
<td>Wealth q1 (\times) age</td>
<td>-0.02</td>
<td>(-5.11)</td>
</tr>
<tr>
<td>Wealth q2 (\times) age</td>
<td>-0.02</td>
<td>(-5.31)</td>
</tr>
<tr>
<td>Wealth q3 (\times) age</td>
<td>-0.02</td>
<td>(-4.42)</td>
</tr>
<tr>
<td>Wealth q4 (\times) age</td>
<td>-0.01</td>
<td>(-2.65)</td>
</tr>
<tr>
<td>good health</td>
<td>4.13</td>
<td>(25.19)</td>
</tr>
<tr>
<td>good health (\times) age</td>
<td>-0.02</td>
<td>(-10.29)</td>
</tr>
<tr>
<td>oop med ((in $1,000))</td>
<td>-21.34</td>
<td>(-6.44)</td>
</tr>
<tr>
<td>oop med (\times) age</td>
<td>0.23</td>
<td>(5.11)</td>
</tr>
<tr>
<td>constant</td>
<td>-2.11</td>
<td>(-8.67)</td>
</tr>
<tr>
<td>age</td>
<td>0.01</td>
<td>(2.54)</td>
</tr>
</tbody>
</table>

\(N\) 60761
Evaluation of $\tilde{\varphi}(h_g|\omega, \tilde{x})$ at selected points

Probability of health transition for *white males, 65 year-old, wealth in 3rd quintile* by education, health, and oop medical spending

| $\tilde{x}$  | $\Pr(h' = h_g|h_g, \tilde{x})$ | $\Pr(h' = h_g|h_b, \tilde{x})$ | $\Pr(h' = h_g|h_g, \tilde{x})$ | $\Pr(h' = h_g|h_b, \tilde{x})$ |
|------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| top 10     | 0.909                         | 0.438                         | 0.805                         | 0.245                         |
| top 25     | 0.915                         | 0.457                         | 0.817                         | 0.259                         |
| median     | 0.918                         | 0.466                         | 0.823                         | 0.267                         |
| bottom 25  | 0.919                         | 0.471                         | 0.825                         | 0.270                         |
| bottom 10  | 0.919                         | 0.472                         | 0.826                         | 0.272                         |