The Lifetime Costs of Bad Health

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Facing Demographic Change in a Challenging Economic Environment

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Why bad health is bad?

#A. People in bad health

i. Work less + Earn less if working

ii. Face higher medical expenses

iii. Have lower life expectancy

#B. Over the life cycle, the \textit{accumulated} effects of bad health

- Depend on how long the sickness lasts
- Can be substantial when health is persistent and markets are incomplete

#A is well documented and studied while #B is still not
Is the *accumulated* effect important?


- good health $\in \{\text{excellent, very good, good}\}$; bad health $\in \{\text{fair, poor}\}$
- net worth: controlled for year effects and family sizes

▶ The difference is large even among a relatively homogeneous group
Our stand on health and economic outcomes

How do economists think about health and economic outcomes?

Ch.1 Health is *exogenous*: health $\Rightarrow$ economic outcomes

Ch.2 Health is *endogenous*: economic outcomes $\Rightarrow$ health

Ch.3 People differ in *characteristics/factors affecting both their health and economic outcomes* (eg. childhood development can affect both health outcomes and economic behaviors in adulthood)

This paper

$\Rightarrow$ focus on Ch.1 and 3

$\Rightarrow$ quantify effects of health uncertainty under incomplete markets
What we do? The big picture

1st Part: Why is health status persistent?

- Document long-term dynamics of health status in the data
- Estimate a parsimonious health shock process that is consistent with the empirical facts (both cross-sectional and dynamic aspects)
- Identify two different sources of health persistence
  1. Duration-dependence: the longer an unhealthy spell, the lower the chance of recovering
  2. Fixed health type: people are different, eg. lifestyle, genes
What we do? The big picture (cont.)

2\textsuperscript{nd} Part: How does bad health affect individuals over life cycle?

- Estimate a life cycle model augmented with the health shock that captures
  
  1. Effects of bad health on life expectancy and medical spending
  2. Income-health gradient
  3. Wealth-health gradient

- And answer the following questions

  i. How much is the monetary loss due to bad health over life cycle?
  
  ii. Why being in good health is valuable?
  
  iii. How much does health uncertainty contribute to lifetime inequality?
Data

1. Health and Retirement Study (HRS: 1994-2012)

2. Panel Study of Income Dynamics (PSID)
   - Annual data (1984-1997); bi-annual (1997-2012)

Outline of the presentation

- Health process estimation
- Life-cycle model
- Model estimation (MSM)
- Results
Health status data (PSID)

Panel A: % unhealthy people by ages

Panel B1: % transition bad → good
Transition from bad to good health in consecutive years (conditional on survival)

Panel B2: % transition good → bad
Transition from good to bad health in consecutive years (conditional on survival)
Dynamics of health status data (PSID)

Duration-dependent profile by health status (30-54 years old)

**Panel C1:** % Transition from bad to good health
(30–54 age-group)

**Panel C2:** % Transition from good to bad health
(30–54 age-group)

Long duration-dependence

Not much duration-dependence

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Lifetime Cost of Bad Health
Conditional on surviving to the next period,

- **Probability to be healthy if unhealthy for** $\tau_B$ yrs: $\pi_i^{BG}(\tau_B|age)$

\[
\text{logit}\left(\pi_i^{BG}(\tau_B|age)\right) = \left(a^B_11_{\{\tau_B=1\}} + a^B_21_{\{\tau_B\geq2\}}\right) + \left(b^B_1 age + b^B_2 age^2\right) + \eta_i
\]

- **Duration dependence**

- **Health type**

- **Probability to be unhealthy if healthy for** $\tau_G$ yrs: $\pi_i^{GB}(\tau_G|age)$

\[
\text{logit}\left(\pi_i^{GB}(\tau_G|age)\right) = \left(a^G_11_{\{\tau_G=1\}} + a^G_21_{\{\tau_G\geq2\}}\right) + \left(b^G_1 age + b^G_2 age^2\right) + b^G_3 \times \eta_i
\]

$\eta_i \sim \text{uniform distribution over 5 points symmetric around zero}$
Introduction

Health shock process

lifecycle model

calibration

results

Dynamics of health status: model vs PSID

% High school males in bad health

Transition from bad to good health in consecutive years (conditional on survival)

Transition from good to bad health in consecutive years (conditional on survival)

(30–54 age-group)

(55–69 age-group)

(75+ age-group)

% unhealthy

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Lifetime Cost of Bad Health
Estimated health shock process

**bad ⇒ good**

Probability to be *healthy* if being unhealthy for $\tau_B$ yrs

$$\logit \left( \pi^B_i \left( \tau_B | \text{age} \right) \right) = \left( a_1^B 1_{\{\tau_B = 1\}} + a_2^B 1_{\{\tau_B \geq 2\}} \right) + (b_1^B \text{age} + b_2^B \text{age}^2) + \eta_i$$

$\rightarrow$ Most of duration dependence is due to fixed health type

**good ⇒ bad**

Probability to be *unhealthy* if being healthy for $\tau_G$ yrs

$$\logit \left( \pi^G_i \left( \tau_G | \text{age} \right) \right) = \left( a_1^G 1_{\{\tau_G = 1\}} + a_2^G 1_{\{\tau_G \geq 2\}} \right) + (b_1^G \text{age} + b_2^G \text{age}^2) + \left( b_3^G \eta_i \right)$$

$\rightarrow$ No effect of fixed health type
Distribution of unhealthy periods between 57-65: Model vs HRS

*(Additional validation)*

HRS: balanced panel of *healthy* individuals at 55 (N=828 individuals)
How should we think about health type?

- **Model:** People with bad health type experience multiple periods being unhealthy

- **HRS:** Characteristics of people by #periods being unhealthy

<table>
<thead>
<tr>
<th># unhealthy periods (57-65)</th>
<th>% $\eta_1 + \eta_2$ (model)</th>
<th>% smoking</th>
<th>BMI*</th>
<th>% parent alive father</th>
<th>% parent alive mother</th>
<th>parents’ educ (yrs) father</th>
<th>parents’ educ (yrs) mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>26.9</td>
<td>23.2</td>
<td>27</td>
<td>21.2</td>
<td>49.5</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>2-3</td>
<td>39.7</td>
<td>25.9</td>
<td>28</td>
<td>20.2</td>
<td>46.7</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>4-5</td>
<td>71.1</td>
<td>43.5</td>
<td>30</td>
<td>15.2</td>
<td>36.9</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Individuals are healthy at 55

* BMI = body mass index (median)
Outline

- Health process estimation
- Life-cycle model
- Model estimation (MSM)
- Results
Key mechanisms

- The observed correlation between health and life-cycle outcomes is generated by two mechanisms

1. Causal effects of bad health:
   a. Decreases productivity and increases disutility from work
   b. Increases OOP medical spending
   c. Lowers life expectancy

2. Composition effect:
   - Fixed and heterogeneous health types ($\eta_i$)
   - Fixed and heterogeneous patience ($\beta_i$)
   - $\eta_i$ and $\beta_i$ can be correlated.
Life-cycle model

- 20-64→work, 65-99→retired
  - health type: \( \eta_i \in \{\eta_1, \ldots, \eta_5\} \) and discount factor: \( \beta_i \in \{\beta_{\text{low}}, \beta_{\text{high}}\} \)

\[
0 \leq \Pr(\beta_j|\eta_m) \leq 1; j \in \{\text{low, high}\}, m \in \{1, 2, \ldots, 5\}
\]

- People face productivity, health, medical expenses, and survival uncertainty

- Retired people receive Social Security benefits and are covered by Medicare
A working-age individual

health condition \((h_{t-1}, h_t)\)
labor productivity \((z_{i,t}^h)\)
ESI offer \((g_t^{h,z})\)

OOP medical shock: \(x_t^h \left( 1 - \text{cvg} \left( x_t^h, i_H \right) \right)\)
(Some receives gov transfer \(T^{SI}(\bar{c})\))

\[ u(c_t, l_t, h_t) = \frac{c_t^{1-\rho}}{1-\rho} - \phi W 1\{l_t>0\} - \phi B 1\{h_t=B, l_t>0\} + \bar{b} \]
Outline

- Health process estimation
- Life-cycle model
- Model estimation (*MSM*)
  - wealth profile
  - employment profile + average labor income profile
- Results
### Parameters taken/estimated outside model

<table>
<thead>
<tr>
<th>parameters</th>
<th>sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival probability by health: $\zeta^h_t$</td>
<td>HRS</td>
</tr>
<tr>
<td>Health transition probability: $\pi_{i,t}^{B\hat{G}}(\tau_B)$, $\pi_{i,t}^{G\hat{B}}(\tau_G)$</td>
<td>PSID</td>
</tr>
<tr>
<td>Labor productivity shock: $z^h_{i,t}$</td>
<td>PSID</td>
</tr>
<tr>
<td>Health-dependent medical expenses: $x^h_t$</td>
<td>MEPS</td>
</tr>
<tr>
<td>ESI offer probability (logit): $g^{h,z}_{t}$</td>
<td>MEPS</td>
</tr>
<tr>
<td>Insurance coverage: $cvg(x^h_t, i_H)$</td>
<td>MEPS</td>
</tr>
<tr>
<td>Risk aversion: $\rho = 3.0$</td>
<td>common values $\in [1, 5]$</td>
</tr>
</tbody>
</table>
Stochastic processes estimated outside the model

- Health-dependent labor income process \( (z_t^h) \)

\[
\begin{align*}
z_{i,t}^h &= \lambda_t^h + \gamma_i + y_{i,t} \\
y_{i,t} &= \rho_y y_{i,t-1} + \epsilon_{i,t}; \quad \epsilon_{i,t} \sim iid \ N\left(0, \sigma_\epsilon^2\right)
\end{align*}
\]

- From PSID:  \( \rho_y = 0.9275, \sigma_\epsilon^2 = 0.0209, \sigma_\gamma^2 = 0.042 \)

- \( \lambda_t^h \) is used to match average labor income among healthy and unhealthy workers
### Parameters estimated inside model

<table>
<thead>
<tr>
<th>parameters</th>
<th>value</th>
<th>targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>({\beta_{\text{low}}, \beta_{\text{high}}})</td>
<td>({0.904, 0.995})</td>
<td>&quot;</td>
</tr>
<tr>
<td>(Pr(\beta_{\text{low}}</td>
<td>\eta_i))</td>
<td>(\eta_1) (\eta_2) (\eta_3) (\eta_4) (\eta_5)</td>
</tr>
<tr>
<td></td>
<td>0.89</td>
<td>0.81</td>
</tr>
</tbody>
</table>

**consumption floor:** \(\bar{c}\)  
$3,593$ (or $5,484$ in 2010)

**value of life:** \(\bar{b}\)  
\[
\frac{\bar{c}^{1-\rho}}{1-\rho}
\]

positive utility flow

* \(\eta_1\) has the lowest probability to recover

> Compensation for adding 1 death among 10,000 adults: **$6.0M USD**  
( Empirical Value of Statistical Life = $2-9M USD )
Targeted moments: model vs PSID

- Wealth profiles by health status

![Wealth profile (25 percentile)](image1)

![Wealth profile (50 percentile)](image2)

![Wealth profile (75 percentile)](image3)
Results

R0. The importance of compositional difference between the heathy and unhealthy

R1. The monetary cost of bad health during the working period

R2. The value of being in good health

R3. The contribution of health to lifetime inequality
R0. The importance of compositional difference

Wealth difference between healthy and unhealthy people at ages 60-64.

<table>
<thead>
<tr>
<th>Wealth difference by health</th>
<th>PSID</th>
<th>Baseline</th>
<th>No ((\beta_{\text{low}}, \eta_i)) correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>25\textsuperscript{th} pct</td>
<td>41,225</td>
<td>54,157</td>
<td>32,497</td>
</tr>
<tr>
<td>50\textsuperscript{th} pct</td>
<td>97,142</td>
<td>101,094</td>
<td>39,715</td>
</tr>
<tr>
<td>75\textsuperscript{th} pct</td>
<td>156,824</td>
<td>146,225</td>
<td>70,404</td>
</tr>
</tbody>
</table>

R0. - No correlation between types and patience misses health-wealth gradient

- Income-health gradient does not imply wealth-health gradient
R1. The monetary cost of bad health

Exp#1:

- Everyone always draws good health
- Consider those surviving to age 64 in baseline
- Monetary costs$_{it}$ of bad health $=$

$$earnings\ loss_{it} + medical\ costs_{it} \ (during\ 20\ to\ 64)$$
R1. The monetary cost of bad health

- Average loss (per year) over 20-64

*avg labor income* = $36,105

- Increases steeply with the number of unhealthy years
- Health insurance covers a non-trivial portion of the cost
- Earning loss is much larger than OOP medical loss
R1. The monetary cost of bad health

- Average loss (per year) over 20-64

- $\text{avg labor income} = $36,105$

- Varies a lot by health type
R1. The monetary loss due to bad health

- Distribution of lifetime cost of bad health

<table>
<thead>
<tr>
<th></th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>top 5%</td>
</tr>
<tr>
<td>earning loss + total medical loss</td>
<td>28%</td>
</tr>
<tr>
<td>earning loss + OOP loss</td>
<td>27%</td>
</tr>
</tbody>
</table>

- Highly concentrated

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Lifetime Cost of Bad Health
R2. The value of being in good health (20-64)

Exp#2:

- Increase the probability of being in good health by 1% from period $t$ to $t + 1$
- Calculate willingness to pay to move from the baseline to the experiment above (among people aged 20-64)
R2. The value of being in good health (20-64)

- **Sources of the gains**
  1. Allow one channel through which health affects individuals
  2. Recompute the remaining gain

<table>
<thead>
<tr>
<th>Baseline economy</th>
<th>$\eta_1 - \eta_5$</th>
<th>$\eta_1$</th>
<th>$\eta_3$</th>
<th>$\eta_5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$%$ of avg labor inc</td>
<td>$3,828$</td>
<td>$5,113$</td>
<td>$3,506$</td>
<td>$3,026$</td>
</tr>
<tr>
<td>$(10.6%)$</td>
<td>$(14.1%)$</td>
<td>$(9.7%)$</td>
<td>$(8.4%)$</td>
<td></td>
</tr>
</tbody>
</table>

Dollar value when only one channel exists

- Survival channel
  - $86\%$ $81\%$ $86\%$ $93\%$
- Labor market channel
  - $18\%$ $26\%$ $16\%$ $9\%$
- Medical expenses channel
  - $2\%$ $3\%$ $2\%$ $1\%$

% is a fraction of willingness to pay in the baseline

- **Survival channel contributes most to the value of being healthy**
R3. Lifetime inequality due to health

- Everyone always draws good health till death
  - **Case 1.** Fix age of death as in Baseline ⇒ exclude survival channel
  - **Case 2.** Allow age of death to increase ⇒ include survival channel

- Define *Lifetime utility*

  \[
  U_i = \sum_{t=20}^{\text{age of death}+1} \beta_i^{t-20} \left( u(c_t, l_t, h_t) \times 1_{\text{alive}_t} + B_{eq_t} \times (1 - 1_{\text{alive}_t}) \right)
  \]

- Variation of \( U_i \) due to health = \( \left(1 - \frac{V(\hat{U}_i)}{V(U_i^B)}\right) \times 100\% \)

  \[
  \hat{U}_i = \text{lifetime utility from } R3
  \]

  \[
  U_i^B = \text{lifetime utility from Baseline}
  \]
R3. Lifetime inequality due to health

Case 1. Exclude survival channels (fixing age of death as in Baseline)

Variation of lifetime utility due to health

<table>
<thead>
<tr>
<th></th>
<th>$\beta_{low}$</th>
<th>$\beta_{high}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>all $\eta_i$</td>
<td>7.35%</td>
<td>0.22%</td>
</tr>
<tr>
<td>$\Rightarrow {\eta_1, \eta_2}$</td>
<td>9.5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>$\Rightarrow {\eta_3, \eta_4, \eta_5}$</td>
<td>2.6%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

* $\eta_1, \eta_2$ have lower probability to recover

Case 2. Include survival channels (allowing age of death to increase)

Variation of lifetime utility due to health

<table>
<thead>
<tr>
<th></th>
<th>$\beta_{low}$</th>
<th>$\beta_{high}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>all $\eta_i$</td>
<td>42.5%</td>
<td>12.8%</td>
</tr>
<tr>
<td>$\Rightarrow {\eta_1, \eta_2}$</td>
<td>47.5%</td>
<td>20.2%</td>
</tr>
<tr>
<td>$\Rightarrow {\eta_3, \eta_4, \eta_5}$</td>
<td>33.3%</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

- Health affects lifetime ineq. mostly through survival channel
- Health affects lifetime ineq. more among those with bad health type ($\eta_1, \eta_2$)
Conclusions

- We quantify the effects of health in a life-cycle model that matches
  - (1) Long-run health dynamics
  - (2) Income-health gradient
  - (3) Wealth-health gradient
- Health type: important for capture (1)
- Compositional difference btw. the healthy and unhealthy: important for (3)
- Implications
  - i. Lifetime costs of bad health are highly concentrated
  - ii. The earning losses due to bad health are the largest component of OOP losses
  - iii. The most valuable aspect of being healthy is a longer life expectancy
  - iv. Health affects lifetime inequality mostly through survival ch.