# Social Security, Medicare and Health Capital in A Recursive General Equilibrium Model

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# Introduction

- Main Issue
  - Fast growing numbers of old population in the U.S. incurs huge fiscal pressures, in particular, on Social Security and Medicare
- This paper tries to include explicitly
  - changing demographic structure of population
  - health status of households, respectively, single and couple
  - labor, consumption and medical expenditure decisions affected through idiosyncratic health shocks
- Model features are
  - Heterogeneous Agents in terms of age, education, health, marriage status
  - CGE(Computable General Equilibrium)
  - OLG(Overlapping generation)

# What's new?

- Explicitly include health capital accumulation depending on household formation
- Comprehensively consider health insurance market structure
- Calibrate the current U.S. Economy and simulate it until 2080
- Compare the baseline model with some counterfactural experiments
- Quantify the effect of demographic changes and health cost inflation on Social Security and Medicare in a general setting

# Overview of Results

- Calibration with parameters and simulation with a baseline scenario,
  - Baseline model: dependency ratio [1] from 20% to 32.2% + 60% increase in health care cost
    - capital-output ratio: 3.0 $\rightarrow$ 3.15
    - Social Security benefit/output: 4.5% $\rightarrow$ 7.0%
    - social assistance program/output: 1% $\rightarrow$ 5%
    - labor taxation: 23% $\rightarrow$ 36%
    - average hours worked: 12% increase
    - when Social Security benefit is fixed at 4.5%, labor taxation:23% $\rightarrow$ 32%

[1] $\frac{\text{\# of population aged 65 and over}}{\text{\# between 20-64}}$

# Literature Review

- Social Security
  - Auerbach and Kotlikoff(1987): first paper of social security in OLG
  - Huggett and Ventura(1999): heterogeneous agent model
  - Domeiji and Floden(2006): to model international capital flows
- Medicare
  - Finkelstein(2007): to model the supply of health services
  - French and Jones(2007): to include health shocks and medical costs in a life cycle model
  - Attanasio, Kitao, Violante(2008): how to finance Medicare
- Health in utility function
  - Suen(2006): consider technological progress in medical industry
  - Borgor et al.(2008): representative model and many details in health conditions
  - Jung and Tran(2011): HSA(Health saving account)

# Economic Environment

- Demographics
  - $J$ overlapping generations with growth rate $g$
  - $j$: age
  - working starts at age $j = 1$ and retire at $j = j_R$
  - $e$: educational attainment, $\eta_e$: fraction of type $e$ in each cohort
  - $h$: health capital
  - $\varepsilon_{e,j}\omega_e(h)$: labor productivity

# Health Capital Formation

- Single

$$h' = \zeta(m) + (1 - \delta_h)h + u$$

- $\zeta$: health production function
- $m$: medical spending
- $\delta_h$: health depreciation rate
- $u$: idiosyncratic health shock
- $\overline{\Theta}_{e,j}(u)$: distribution, $\Theta_{e,j}(u', u)$: transition probability
- $\overline{\Lambda}^h_{e,j}(h)$: distribution, $\Lambda^h_{e,j}(h', h)$: transition probability
- $\prod_{e,j}(h)$: survival rate, $\mathbf{h} = \{h_1, \ldots, h_{j-1}\}$: health history, $\prod_{e,j}(\mathbf{h})$: probability of surviving until age $j$ for a new born of type $e$

# Health Capital Formation

- Couple

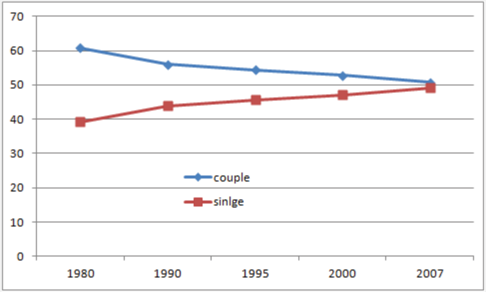
$$h' = f(h'_h, h'_w)$$

$$h'_c = \mathbf{Z_c} m_c + (1 - \mathbf{D_c}) h_c + u_c$$

  - $h_c$: household health status vector consisting of husband($h_h$ and wife($h_w$)
  - $m_c$: medical spending vector
  - $\mathbf{Z_c}$: health production matrix
  - $\mathbf{D_c}$: health depreciation matrix
  - $u_c$: idiosyncratic health shock vector
  - $\overline{\boldsymbol{\Theta}}_{\mathbf{c}e,j}(u_c)$: variance-covariance matrix with non-zero covariances
  - $\boldsymbol{\Theta}_{\mathbf{c}e,j}(u'_c, u_c)$: transition probability

# Family Structure

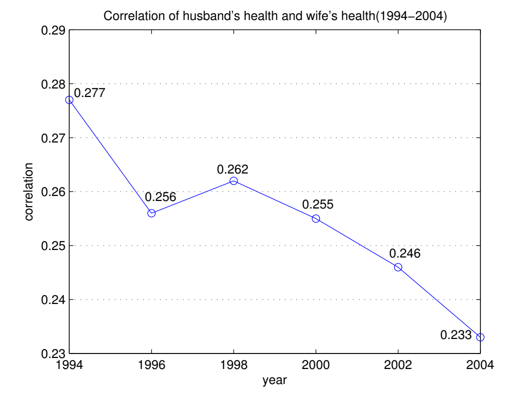
- Couple households have decreased 10% since 1980 and vise versa are single households




U.S. Census 2010

# Health Correlation Between Couples

- Correlation decreases as period of living together lasts




HRS(Health Retirement Survey)

# Preference

- Household Utility

$$U = \mathbb{E}_0 \sum_{j=1}^{J} \prod_{j}^{e} (\mathbf{h}) \beta^{j-1} u(c_j, 1 - n_j)$$

$\beta$: the discount factor, $c$: consumption, $n$ hours worked.

# Health Insurance(1)

$m$: medical expenditure, $q$: relative price of medical services to consumption,

- Private Insurance
  - $\kappa^{\omega}$: a fraction of working age medical expenditure covered by ESHI(Employer-Sponsored Health Insurance)
  - $\kappa^{ret}$: a fraction of retirement age medical expenditure covered by ESHI
  - premium

$$\begin{cases} 0 & \text{if no insurance, } i = 0 \\ p^{\omega} & \text{if ESHI only working stage, } i = 1 \\ p^{\omega} + \xi^{\omega} p^{ret} \text{ working stage ,} & \\ (1 - \bar{\xi}^{ret}) p^{ret} \text{ retirement} & \text{if ESHI throughout life, } i = 2 \end{cases}$$

$\xi^{\omega}$: firm's fraction in working and $\xi^{\bar{ret}}$: firm's fraction in retirement

# Health Insurance(2)

- Medicare
  - $\kappa^{med}$: coverage by Medicare
  - $p^{med}$: premium
  - $\phi^{med}$: administrative cost by Medicare
- Social Assistance Programs: Medicaid, Supplemental Security Income
  - $\bar{c}$: minimum consumption level
  - $tr$: transfer when disposal asset fall below $\bar{c}$

# Commodities, goods and input markets

Three markets are competitive

- Final goods used for private consumption, public consumption, and investments
- Medical services
- Labor services

# Technology

Aggregate production function

$$Y = ZF(K, N)$$

Resource constraint

$$Y = C + K' - (1 - \delta)K + qM + G$$

$M$: aggregate expenditures on medical services (including administrative costs associated with employer based health insurance and Medicare)

# Fiscal Policy

Five types of government fiscal policies: general public consumption $G$, Medicare expenses, Social assistance payments, Social security benefits, and services to public debt

- Social Security

$$b_e = \rho_e \frac{1}{j_R - 1} \sum_{j=1}^{j_R - 1} \bar{y}_e(j)$$

  $\bar{y}_e(j)$: average earnings of households of type $e$ and age $j$, $\rho_e$: benefit fraction of the average earnings of type $e$ in the cohort

- Government supplies one-period risk-free debt $D$ which carry the return $r$ as physical capital.

# Fiscal Policy(revenues)

Revenues

- $\tau^{\omega}$: labor income tax
- $\tau^{c}$: consumption tax
- $\tau^{r}$: capital tax
- $p^{med}$: Medicare premium
- accidental bequest

$(\tau^{c}, \tau^{r}, p^{med}, \rho_e, D, G)$: are parameters, letting $\tau^{\omega}$ determined in the model

# Working stage

$$V(e,i,j,h,x) = \max_{c,n}\{u(c,1-n) + \beta \prod_{e,j}(h)\mathbb{E}V(e,i,j+1,h',x')\}$$

subject to

$$\begin{aligned}
x' &= [1+(1-\tau^r)r][x-(1+\tau^c)c+tr] \\
&\quad +(1-\tau^\omega)[\omega\varepsilon_{e,j}\omega_e(h)n - d(i)] - (1-\kappa^\omega \cdot I_{\{i>0\}})qm \\
d &= \begin{cases} 0 & \text{if } i=0 \\ p^\omega & \text{if } i=1 \\ p^\omega + \varepsilon^\omega p^{ret} & \text{if } i=2 \end{cases} \\
tr &= \max\{0,(1+\tau^c)\bar{c}-x\} \\
c &\leq \frac{x+tr}{1+\tau^c} \\
h' &\sim \Lambda^h_{e,j}(h',h) \text{ and } m \sim \Lambda^m_{j,h}(m)
\end{aligned}$$

# Working stage

- $x$: disposable resources
- $I_{\{\cdot\}}$: indicator function
- $d(i)$: health insurance premium
- $a \equiv x - (1 - \tau^c)c + tr$: household's asset holdings

# Retirement stage

$$V_r(e,i,j,h,x) = \max_c \{u(c,1) + \beta \prod_{e,j}(h)\mathbb{E}V_r(e,i,j+1,h',x')\}$$

subject to

$$\begin{aligned}
x' &= [1+(1-\tau^r)r][x-(1+\tau^c)c+tr] \\
&\quad +b_e - [1-\kappa^{med}-\kappa^{ret}\cdot I_{\{i=2\}}]qm \\
&\quad -p^{med} - (1-\bar{\xi}^{ret})p^{ret}\cdot I_{\{i=2\}} \\
tr &= \max\{0,(1+\tau^c)\bar{c}-x\} \\
c &\leq \frac{x+tr}{1+\tau^c} \\
h' &\sim \Lambda^h_{e,j}(h',h) \text{ and } m \sim \Lambda^m_{j,h}(m)
\end{aligned}$$

# A Recursive Competitive General Equilibrium

- Given survival rates $\{\prod_{e,j}(h)\}$,
- Fiscal variables $\{G, D, \rho_e, \tau^c, \tau^r, tr(s)\}$, and
- Relative price of medical services $q$,

A *recursive competitive equilibrium* is a set of:

1. value function $V(s)$,
2. decision rules for the households $\{c(s), n(s)\}$
3. firm choices $\{K, N\}$,
4. insurance premia $\{p^{\omega}, p^{ret}\}$,
5. labor income tax rate $\tau^{\omega}$, and
6. a measure of households $\mu$ such that:

# Households, Firms, and Labor Markets

1. Working households choose optimally consumption and labor supply by solving problem, and retired households choose optimally consumption by solving problem
2. Firms maximizing profits by setting their marginal productivity equal to factor prices

$$\begin{aligned} w &= ZF_N(K, N) \\ r + \delta &= ZF_K(K, N) \end{aligned}$$

3. The labor market clears

$$N = \int_{\mathcal{S}|j<j_R} \varepsilon_{e,j} \omega_e(h) n(s) d\mu$$

# Asset, Health Insurance Markets

4. The asset market clears

$$K + D = \int_{\mathcal{S}} a(s) d\mu$$

5. The private insurance market for working households, and retired households clears

$$\begin{aligned} p^{\omega} \int_{\mathcal{S}|j<j_R, i\in\{1,2\}} d\mu &= (1+\phi)\kappa^{\omega} q \int_{\mathcal{S}|j<j_R, i\in\{1,2\}} m\lambda^{m}_{j,h}(m) d\mu \\ p^{ret} \int_{\mathcal{S}|j\geq j_R, i=2} d\mu &= (1+\phi)\kappa^{ret} q \int_{\mathcal{S}|j\geq j_R, i=2} m\lambda^{m}_{j,h}(m) d\mu \end{aligned}$$

with all insurance companies making zero profits for the two separate pools

# Final Good Market

6. The final good market clears

$$ZF(K,N) = C + \delta K + qM + G$$

where

$$C = \int_{\mathcal{S}} c(s) d\mu \text{ and } M = \int_{\mathcal{S}} m(s) d\mu + \Phi$$

and $\Phi$ represents the total administrative costs associated with the employer-based insurance and Medicare.

# Government Budget Constraint

7. The government budget constraint satisfies

$$\begin{aligned} & \tau^c C + \tau^\omega \omega N + \tau^r r \int_{\mathcal{S}} a(s) d\mu + p^{med} \int_{\mathcal{S}|j \geq j_R} d\mu + \int_{\mathcal{S}} [1 - \prod_{e,j} (h)] x d\mu \\ = \quad & G + rD + \int_{\mathcal{S}} tr(x) d\mu + (1 - \phi^{med}) \kappa^{med} q \int_{\mathcal{S}|j \geq j_R} m \lambda^m_{j,h}(m) d\mu + \int_{\mathcal{S}|j \geq j_R} b_e d\mu \end{aligned}$$

# Measure and Transition Function

8. For all sets $\mathsf{S} \equiv (\mathsf{E} \times \mathsf{I} \times \mathsf{J} \times \mathsf{H} \times \mathsf{X}) \in \Sigma_{\mathcal{S}}$, the measure $\mu$ satisfies

$$\mu(\mathsf{S}) = \int_{\mathcal{S}} Q(s, \mathsf{S}) d\mu$$

where, for $j > 1$, the transition function $Q$ is defined as

$$Q(s, \mathsf{S}) = I\{e \in \mathsf{E}, i \in \mathsf{I}, j+1 \in \mathsf{J}\} \Lambda^{h}_{e,j}(h' \in \mathsf{H}, h) \Pr\{x' \in \mathsf{X} | s\} \prod_{e,j}(h)$$

# Demographics

- Household enter at age 20($j = 1$)
- die at age 100($j = 81$) or less than health standard
- $e = 1$: high education, $e = 0$: low education, $\eta_e$: 0.30
- mandatory retirement at age 65($j_R = 46$)
- survival rate by SSA

# Survival Rate

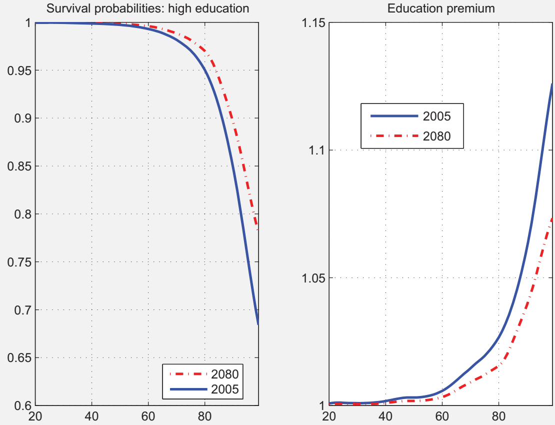



Figure 1: Left-panel: survival rates by age for the college graduates in 2005 (data) and 2080 (projected). Right panel: Ratio of survival rates of college graduates to non college graduates by age in 2005 and 2080.

# Preference and Technology

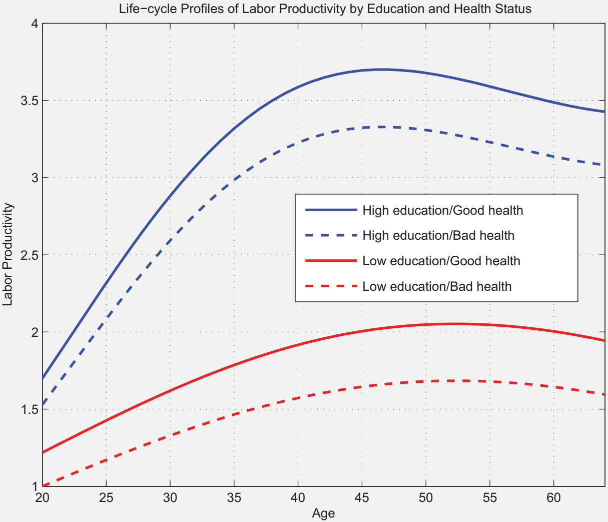
$$u(c, 1-n) = \frac{c^{1-\gamma}}{1-\gamma} + \chi \frac{(1-n)^{1-\theta}}{1-\theta}$$

- $\gamma = 2$ (Attanasio(1999)), $\chi = 2.028$, market work=0.33
- $((1-n)/n)/\theta = 0.5$: intertemporal labor supply elasticity implies $\theta = 4$(Browning, Hansen, and Heckman (1999))
- $\beta = 0.9955$ so that wealth to GDP ratio: 3.4

$$Y_t = ZK_t^{\alpha} L_t^{1-\alpha}$$

- $\alpha = 0.33$
- $\delta = 0.06$

# Labor productivity



# Health Status

Medical Expenditure Panel Survey(MEPS)

| | Low Education | | | High Education | | |
|---|---|---|---|---|---|---|
| | | good | bad | | good | bad |
| 20-29 | good | 0.95 | 0.04 | good | 0.98 | 0.01 |
| | bad | 0.41 | 0.58 | bad | 0.58 | 0.42 |
| 30-39 | good | 0.94 | 0.05 | good | 0.97 | 0.02 |
| | bad | 0.32 | 0.67 | bad | 0.31 | 0.68 |
| 40-49 | good | 0.92 | 0.07 | good | 0.95 | 0.04 |
| | bad | 0.20 | 0.79 | bad | 0.29 | 0.70 |
| 50-64 | good | 0.87 | 0.12 | good | 0.94 | 0.53 |
| | bad | 0.16 | 0.83 | bad | 0.22 | 0.77 |
| 65+ | good | 0.86 | 0.13 | good | 0.89 | 0.10 |
| | bad | 0.13 | 0.86 | bad | 0.20 | 0.79 |

# Medical Expenditure

MEPS($ in 2004)

| | good health | | | |
|---|---|---|---|---|
| | 1-60% | 61-95% | 96-100% | average |
| 20-29 | 153 | 1,875 | 10,192 | 1,253 |
| 30-39 | 321 | 2,762 | 13,482 | 1,833 |
| 40-49 | 453 | 2,928 | 19,606 | 2,277 |
| 50-65 | 1,002 | 5,124 | 22,609 | 3,525 |
| 65+ | 2,047 | 8,990 | 33,190 | 6,034 |
| | bad health | | | |
| | 1-60% | 61-95% | 96-100% | average |
| 20-29 | 484 | 4,453 | 23,484 | 3,023 |
| 30-39 | 758 | 6,027 | 40,605 | 4,595 |
| 40-49 | 1,262 | 8,243 | 42,861 | 5,785 |
| 50-65 | 2,363 | 12,399 | 59,730 | 8,744 |
| 65+ | 3,946 | 16,194 | 60,556 | 11,063 |

# Health Insurance and Government

- $\kappa^{\omega} = 0.70$, $\kappa^{ret} = 0.30$, $\kappa^{med} = 0.50$: coverage rate
- Medicare cost: 2.4% of GDP
- $p^{med} = 0.0224$: Medicare premium
- $\bar{\xi}^{ret} = 0.6$: retiree's insurance paid by the employer (Buchmueller (2006))
- $\phi^{med} = 0.1$: administrative cost
- $\tau^{r} = 0.4$,(by Mendoza(1994)) $\tau^{c} = 0.057$, $\tau^{\omega} = 0.23$
- social security replacement rate: $\rho_e = 0.4$ for $e = 0$,$\rho_e = 0.3$ for $e = 1$
- $D = 0.4$: public debt to GDP
- $\bar{c} = 0.1$: minimum consumption
- $\delta_h = 0.81$(Suen(2006)),

# Baseline Simulation

- Calibrate and simulate the model in order to analyze basic changes in 2080
  - Baseline model: dependency ratio from 20% to 32.2% + 60% increase in health care cost
    - capital-output ratio: $3.0 \rightarrow 3.15$
    - Social Security benefit/output: $4.5\% \rightarrow 7.0\%$
    - Medicare costs/output: $2.4\% \rightarrow 6.3\%$
    - social assistance program/output: $1\% \rightarrow 5\%$
    - labor taxation: $23\% \rightarrow 36\%$
    - average hours worked: 12% increase
    - when Social Security benefit is fixed at 4.5%, labor taxation:$23\% \rightarrow 32\%$

# Sensitivity Analysis

- Health care cost varies 1.0%, 1.3%, 1.9%
  - 0.1% of excess health care annual inflation leads to a rise of 1% of labor income tax rate
  - saving falls due to lack of self-insurance
  - social assistance doubles when 1.6% $\rightarrow$ 1.9%
- Population growth
  - 0% growth rate=d.r.=41.3%: labor tax 41%
  - 1.4% growth rate=d.r.=25.1%: labor tax 32%

# Limitation and Extension

- Incomplete information+Optimal Taxation
- Sophisticate household structures
  - structure of household formation like # of kids
  - structural changes in single and non-single distribution
- Financial market
- Open market in medical industry or financial market

# Appendix

- $s \equiv \{e, i, j, h, x\}$: the individual state vector
- $e \in \mathcal{E}$, $i \in \mathcal{I} = \{0, 1, 2\}$, $j \in \mathcal{J} = \{1, 2, \ldots, J\}$, $h \in \mathcal{H}$, $x \in \mathcal{X} = [\underline{x}, \overline{x}]$
- $\mathcal{B}_{\mathcal{H}}$, $\mathcal{B}_{\mathcal{X}}$: Borel Sigma-algebras of $\mathcal{H}$ and $\mathcal{X}$
- $P(\mathcal{E})$ $P(\mathcal{I})$ and $P(\mathcal{J})$ be the power set of $\mathcal{E}$, $\mathcal{I}$ and $\mathcal{J}$
- The state space: $\mathcal{S} \equiv \mathcal{E} \times \mathcal{I} \times \mathcal{J} \times \mathcal{H} \times \mathcal{X}$
- $\Sigma_{\mathcal{S}}$: sigma algebra on $\mathcal{S}$ defined
- as $\Sigma_{\mathcal{S}} \equiv P(\mathcal{E}) \otimes P(\mathcal{I}) \otimes P(\mathcal{J}) \otimes \mathcal{B}_{\mathcal{H}} \otimes \mathcal{B}_{\mathcal{X}}$
- $(\mathcal{S}, \Sigma_{\mathcal{S}})$: the corresponding measurable space
- $\mu$: the stationary measure of households on $(\mathcal{S}, \Sigma_{\mathcal{S}})$