# Endogenous Health Care in Overlapping Generations Model:

## Simulation for Health Care and Economy

**Fiona Fan**

Lightning Talk for OSM Lab
July 19, 2018

# Motivation

- **Health is an overlapping generations thing – Grossman Model (Grossman, 1972)**

$$H_{t+1} = (1 - \delta)(H_t + I_t)$$

- **Key Features of Model**
  - Agents in the model choose health care to consume, in addition to consumption and savings.
  - Consumption of health care at time t boosts labor productivity at time t+1 (consistent with Grossman).
  - Insurance in forms of Medicare (young people pay for old people's health insurance). Other kinda insurance could be added (Hashimoto and Tabata, 2010)
  - Production of health care VS non-health-care good.

# Motivation

- **Health is an overlapping generations thing – Grossman Model (Grossman, 1972)**

$$H_{t+1} = (1 - \delta)(H_t + I_t)$$

- **Key Features of Model**
  - Agents in the model choose health care to consume, in addition to consumption and savings.
  - Consumption of health care at time t boosts labor productivity at time t+1 (consistent with Grossman).
  - Insurance in forms of Medicare (young people pay for old people's health insurance). Other kinda insurance could be added (Hashimoto and Tabata, 2010)
  - Production of health care VS non-health-care good.

**What we can learn from simulation**

- With the repeal of mandate (decreased insurance), what will happen to economic growth/ labor participation rate in healthcare VS non-health-care/ consumption of health care/ consumption of non-health-care, etc?
- What effect of aging/ decreased mortality rate affect health care consumption/ spending?

# Demographics

$$\omega_{1,t+1} = (1-\rho_o)\sum_{s=1}^{E+S} f_s\omega_{s,t} + i_1\omega_{1,t}, \quad \forall t \tag{1}$$

$$\begin{aligned}\omega_{s+1,t+1} &= (1-\rho_s)\omega_{s,t} + i_{s+1}\omega_{s+1,t},\\ &\forall t \quad \text{and} \quad 1 \leq s \leq E+S-1\end{aligned} \tag{2}$$

$$N_t = \sum_{s=1}^{E+S}\omega_{s,t} \qquad \tilde{N}_t = \sum_{s=E+1}^{E+S}\omega_{s,t} \tag{3}$$

$$g_{n,t+1} = \frac{N_{t+1}}{N_t} - 1 \qquad \tilde{g}_{n,t+1} = \frac{\tilde{N}_{t+1}}{\tilde{N}_t} - 1 \tag{4}$$

$$n_{s,t} = \begin{cases} 1, & E+1 \leq s \leq E + round(\frac{2S}{3}) \\ 0.2, & s \geq E + round(\frac{2S}{3}) \end{cases} \tag{5}$$

# Households

- Budget Constraints

$$n_{s,t} = n_s \tag{6}$$

$$c_{s,t} + b_{s+1,t+1} + P_t^H h_{s,t} = (1 + r_t)b_{s,t} + w_t n_{s,t} f(h_{s-1,t-1}) + \frac{BQ_t}{\tilde{N}_t} \tag{7}$$

$$U = \frac{c^{(1-\sigma)}}{1-\sigma} + \frac{h^{(1-\gamma)}}{1-\gamma} \tag{8}$$

# Households

- Budget Constraints

$$n_{s,t} = n_s \tag{6}$$

$$c_{s,t} + b_{s+1,t+1} + P_t^H h_{s,t} = (1 + r_t)b_{s,t} + w_t n_{s,t} f(h_{s-1,t-1}) + \frac{BQ_t}{\tilde{N}_t} \tag{7}$$

$$U = \frac{c^{(1-\sigma)}}{1-\sigma} + \frac{h^{(1-\gamma)}}{1-\gamma} \tag{8}$$

- Utility Maximization

$$\max_{\substack{\{c_{s,t+s-1},h_{s,t+s-1}\}_{s=E+1}^{E+S}, \\ \{b_{s+1,t+s}\}_{s=E+1}^{E+S-1}}} \sum_{s=E+1}^{E+S} \beta^{s-E-1}[\Pi_{n=E}^{s-1}(1-\rho_n)]U(c_{s,t+s-E-1}, h_{s,t+s-E-1}) \quad \forall s,$$

$$s.t. \quad 6 \quad \text{and} \quad 7, \quad \text{and} \quad b_{E+1,t}, b_{E+S+1,t} = 0 \quad \forall t \quad \text{and} \quad c_{s,t} \geq 0 \quad \forall s, t$$

# Euler Equations

$$\frac{\partial U(c_{s,t},h_{s,t})}{\partial c_{s,t}} = \beta(1+r_{t+1})(1-\rho_s)\frac{\partial U(c_{s+1,t+1},h_{s+1,t+1})}{\partial c_{s+1,t+1}} \tag{9}$$

$$\beta(1-\rho_s)w_t n_s \frac{\partial f(h_{s,t})}{\partial h_{s,t}}\frac{\partial U(c_{s+1,t+1},h_{s+1,t+1})}{\partial c_{s+1,t+1}} = P_t^H \frac{\partial U(c_{s,t},h_{s,t})}{\partial c_{s,t}} + \frac{\partial U(c_{s,t},h_{s,t})}{\partial h_{s,t}} \tag{10}$$

$$\forall t, \text{ and } E+1 \leq s \leq S-1$$

Each system has $S-1$ Euler equations.

# Firm

$$Y_t^H = A^H(e^{g_y} L_t^H) P_t^H \tag{11}$$

$$Y_t^N = A^N (K_t)^{\alpha} (e^{g_y} L_t^N)^{(1-\alpha)} \tag{12}$$

$$\max_{L_t^H} \quad P_t^H A^H (e^{g_y} L_t^H) - w_t^H L_t^H$$

$$\max_{K_t^N, L_t^N} \quad A_t^N (K_t^N)^{\alpha} (e^{g_y} L_t^N)^{(1-\alpha)} - (r_t^N + \delta) K_t^N - w_t^N L_t^N$$

# Prices

$$r_t = \alpha A_N (\frac{L_t^N}{K_t})^{(1-\alpha)} - \delta \tag{13}$$

$$w_t^H = w_t^N = A_N (1-\alpha)(\frac{K_t}{L_t^N})^{\alpha_N} \tag{14}$$

$$P_t^H = \frac{w_t}{A_H} \tag{15}$$

# Market Clearing

$$K_t = \sum_{s=E+2}^{E+S} (\omega_{s-1,t-1} b_{s,t} + i_s \omega_{s,t-1} b_{s,t}) \tag{16}$$

$$L_t^N + L_t^H = \sum_{s=E+1}^{E+S} \omega_{s,t} n_s f(h_{s-1,t-1}) \tag{17}$$

# Market Clearing

$$K_t = \sum_{s=E+2}^{E+S} \left(\omega_{s-1,t-1} b_{s,t} + i_s \omega_{s,t-1} b_{s,t}\right) \tag{16}$$

$$L_t^N + L_t^H = \sum_{s=E+1}^{E+S} \omega_{s,t} n_s f(h_{s-1,t-1}) \tag{17}$$

$$Y_t^N = C_t + I_t - \sum_{s=E+2}^{E+S} i_s \omega_{s,t} b_{s,t+1} \quad \text{where} \tag{18}$$

$$I_t = K_{t+1} - (1-\delta)K_t \quad \text{and,}$$

$$C_t = \sum_{s=E+1}^{E+S} \omega_{s,t} c_{s,t}$$

$$Y_t^H = \sum_{s=E+1}^{E+S} \omega_{s,t} h_{s,t} \tag{19}$$

$$BQ_t = (1 + r_t) \sum_{s=E+2}^{E+S} \rho_{s-1} \omega_{s-1,t-1} b_{s,t} \tag{20}$$

# Calibration and Simulation

## Calibrations

- $\zeta_s$: OCED data on increase in productivity VS health care spending/capita
- $\rho$, $f$, $i$: US Census data

**Figure: Boost of Productivity by Healthcare over Time in OECD countries**