Health Care Financing over the Life Cycle, Universal Medical Vouchers and Welfare: Supplementary Documentation

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Abstract

This is supplementary document accompanies Jung and Tran (2009) and covers material that is not included in the paper due to space constraints.

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1 Solutions to simple two period model

We assume that old agents have additive preferences between consumption and health as $u(c^o, h) = \frac{(c^o)^{1-\sigma}}{1-\sigma} + \chi \frac{h^{1-\sigma}}{1-\sigma}$, health production function is linear in medical spending $h(m) = zm$, and health is an investment good as $e = h^\theta$.

1.0.1 Old agents

We have two types of agents.

Insured agent. The insured agent solves the following utility maximization problem

$$
\begin{aligned}
V^I(s,z) &= \max_{c^o,m,h} \left\{ \frac{(c^o)^{1-\sigma}}{1-\sigma} + \chi \frac{h^{1-\sigma}}{1-\sigma} \right\} \\
& \quad s.t \\
(1+\tau^c) c^o + \rho p_m m &= Rs + \left(1-\tau^L\right) w_i^o e - \tau, \\
h &= zm, \\
e &= h^\theta.
\end{aligned}
$$

For simplification we set $\theta = 1$ and solve the model. The Lagrangian is

$$
L = \max_{c^o,m} \left\{ \frac{(c^o)^{1-\sigma}}{1-\sigma} + \chi \frac{h^{1-\sigma}}{1-\sigma} + \lambda \left[Rs + \left(1-\tau^L\right) w_i^o h - \tau - p_c c^o - p_h^I h \right] \right\},
$$

where

$$
p_c = \left(1+\tau^C\right) \text{ and } p_h^I(z) = \frac{\rho p_m}{z} = p_h^I.
$$

We suppress the state variable z from the price of health. This is a well-defined utility maximization problem with two types of goods: consumption and health. Note that the price of consumption is determined by the consumption tax and the price of health is affected by the realization of the health shock. To solve the problem we derive FOCs and have

$$
\partial c \; : \; (c^o)^{-\sigma} = \lambda p_c
$$

$$
\partial h \; : \; \chi h^{-\sigma} = \lambda \left[p_h^I - \left(1-\tau^L\right) w_i^o \right]
$$

$$
\begin{aligned}
\frac{u_c}{u_h} &= \frac{p_c}{p_h^I}, \\
\frac{(c^o)^{-\sigma}}{\chi h^{-\sigma}} &= \frac{p_c}{\left[p_h^I - (1-\tau^L) w_i^o\right]}, \\
h &= \left(\chi \frac{p_c}{p_h^I - (1-\tau^L) w_i^o} \right)^{\frac{1}{\sigma}} c^o.
\end{aligned}
$$

$$
\begin{aligned}
p_c c^o + p_h^I \left(\chi \frac{p_c}{p_h^I - (1-\tau^L)\, w_i^o}\right)^{\frac{1}{\sigma}} c^o &= Rs + \left(1-\tau^L\right) w_i^o \left(\chi \frac{p_c}{p_h^I - (1-\tau^L)\, w_i^o}\right)^{\frac{1}{\sigma}} c^o - \tau, \\
c^o &= \frac{Rs-\tau}{p_c + p_h^I \left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}} - \left(1-\tau^L\right) w_i \left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}, \\
c^o &= \frac{Rs-\tau}{p_c + \left[p_h^I - \left(1-\tau^L\right) w_i^o\right] \left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}.
\end{aligned}
$$

The optimal allocation is given by

$$
\begin{aligned}
c^o &= \left(\frac{1}{p_c + \left[p_h^I - \left(1-\tau^L\right) w_i^o\right] \left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i}\right)^{\frac{1}{\sigma}}}\right)(Rs-\tau) \\
h &= \left(\frac{\left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i}\right)^{\frac{1}{\sigma}}}{p_c + \left[p_h^I - \left(1-\tau^L\right) w_i^o\right] \left(\theta \frac{p_c}{p_h^I-(1-\tau^L) w_i}\right)^{\frac{1}{\sigma}}}\right)(Rs-\tau) \\
m &= \frac{1}{z}\left(\frac{\left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}{p_c + \left[p_h^I - \left(1-\tau^L\right) w_i^o\right] \left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}\right)(Rs-\tau).
\end{aligned}
$$

After plugging the optimal allocation in the maximization problem we obtain the value function for the insured old as

$$
V^I(s,z) = \left(\begin{array}{c}
\left(\frac{1}{p_c+\left[p_h^I-(1-\tau^L) w_i^o\right]\left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}\right)^{1-\sigma} \\
+\chi \left(\frac{\left(\chi \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}{p_c+\left[p_h^I-(1-\tau^L) w_i^o\right]\left(\theta \frac{p_c}{p_h^I-(1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}\right)^{1-\sigma}
\end{array}\right) \frac{(Rs-\tau)^{1-\sigma}}{1-\sigma},
$$

or

$$
V^I(s,z,w^o) = \Omega^I(z,w_i^o)\,\frac{(Rs+\tau)^{1-\sigma}}{1-\sigma},
$$

where

$$\begin{aligned}\Omega^{I}(z,w^{o}) &= \left(\frac{1}{p_c+\left[p_h^I-\left(1-\tau^L\right)w_i^o\right]\left(\chi\frac{p_c}{p_h^I-(1-\tau^L)w_i^o}\right)^{\frac{1}{\sigma}}}\right)^{1-\sigma}\\ &\quad+\chi\left(\frac{\left(\chi\frac{p_c}{p_h^I-(1-\tau^L)w_i^o}\right)^{\frac{1}{\sigma}}}{p_c+\left[p_h^I-\left(1-\tau^L\right)w_i^o\right]\left(\chi\frac{p_c}{p_h^I-(1-\tau^L)w_i^o}\right)^{\frac{1}{\sigma}}}\right)^{1-\sigma}.\end{aligned}$$

Taking the first derivative with respect to asset holdings/saving we get the marginal value function

$$\frac{\partial V^{I}(s,z)}{s}=\Omega^{I}(z,w^{o})\,R\,(Rs-\tau)^{-\sigma}.$$

Uninsured agent. When the agent does not have health insurance, the solution is identical except for a different price of health $p_h^{NI}=\frac{p_m}{z}$ which results in

$$V^{NI}(s,z)=\Omega^{NI}(z,w^{o})\,\frac{(Rs-\tau)^{1-\sigma}}{1-\sigma},$$

where

$$\begin{aligned}\Omega^{NI}(z,w^{o}) &= \left(\frac{1}{p_c+\left[p_h^{NI}-\left(1-\tau^L\right)w_i^o\right]\left(\chi\frac{p_c}{p_h^{NI}-(1-\tau^L)w_i^o}\right)^{\frac{1}{\sigma}}}\right)^{1-\sigma}\\ &\quad+\chi\left(\frac{\left(\chi\frac{p_c}{p_h^{NI}-(1-\tau^L)w_i^o}\right)^{\frac{1}{\sigma}}}{p_c+\left[p_h^{NI}-\left(1-\tau^L\right)w_i^o\right]\left(\chi\frac{p_c}{p_h^{NI}-(1-\tau^L)w_i^o}\right)^{\frac{1}{\sigma}}}\right)^{1-\sigma}.\end{aligned}$$

When health is not an investment good $\theta=0$, then $\Omega^{I}(z,w^{o})$ and $\Omega^{NI}(z,w^{o})$ are only functions of health shock z, but not of old age income w^{o}.

1.0.2 Young agents

The consumption/savings problem with insurance choice is

$$V=\max_{p}\left\{\max_{\{c^y,s\}}\left\{\frac{(c^y)^{1-\sigma}}{1-\sigma}+\beta EV(s,z):\ s.t.\ (1+\tau^c)\,c^y+s+p=\left(1-\tau^L\right)w^y-\tau\right\}\right\}.$$

This problem can be solved in two steps. First, taking the insurance choice as given, the agent solves for optimal allocation of consumption and savings. Second, the agent compares two value functions to decide the insurance choice.

When the agent decides to buy insurance the optimization problem is

$$V^I = \max_{\{c^y, s\}} \left\{ \frac{(c^y)^{1-\sigma}}{1-\sigma} + \beta EV(s,z) : \ s.t. \ (1+\tau^c) c^y + s + p = \left(1-\tau^L\right) w^y - \tau \right\}.$$

Deriving FOCs results in

$$\begin{aligned}
(c^y)^{-\sigma} &= p_c \beta \frac{\partial EV(s,z)}{\partial s}, \\
(c^y)^{-\sigma} &= p_c \beta R \left[\pi \Omega^{I,B} + (1-\pi) \Omega^{I,G}\right] (Rs)^{-\sigma}, \\
s &= \frac{\left[p_c \beta R \left[\pi \Omega^{I,B} + (1-\pi) \Omega^{I,G}\right]\right]^{\frac{1}{\sigma}}}{R} c^y,
\end{aligned}$$

where $\Omega^{I,B} = \Omega^I \left(z^B\right)$ and $\Omega^{I,G} = \Omega^I \left(z^G\right)$. The optimal allocation for between consumption and savings for the young agent is

$$\begin{aligned}
c^y &= \frac{1}{p_c + \frac{\left[p_c \beta R (\pi \Omega^{I,B} + (1-\pi)\Omega^{I,G})\right]^{\frac{1}{\sigma}}}{R}} \left(\left(1-\tau^L\right) w^y - \tau - p\right), \\
s &= \frac{\frac{\left[p_c \beta R \left(\pi \Omega^{I,B} + (1-\pi)\Omega^{I,G}\right)\right]^{\frac{1}{\sigma}}}{R}}{p_c + \frac{\left[p_c \beta R (\pi \Omega^{I,B} + (1-\pi)\Omega^{I,G})\right]^{\frac{1}{\sigma}}}{R}} \left(\left(1-\tau^L\right) w^y - \tau - p\right).
\end{aligned}$$

When the agent decides not to buy insurance the optimal allocation is

$$\begin{aligned}
c^y &= \frac{1}{p_c + \frac{\left[p_c \beta R (\pi \Omega^{NI,B} + (1-\pi)\Omega^{NI,G})\right]^{\frac{1}{\sigma}}}{R}} \left(\left(1-\tau^L\right) w^y - \tau\right), \\
s &= \frac{\frac{\left[p_c \beta R \left(\pi \Omega^{NI,B} + (1-\pi)\Omega^{NI,G}\right)\right]^{\frac{1}{\sigma}}}{R}}{p_c + \frac{\left[p_c \beta R (\pi \Omega^{NI,B} + (1-\pi)\Omega^{NI,G})\right]^{\frac{1}{\sigma}}}{R}} \left(\left(1-\tau^L\right) w^y - \tau\right).
\end{aligned}$$

We now summarize our solutions and distinguish agents according to superscript $ins_i = \{I \text{ or } NI\}$, where I stands for agents buying insurance and NI indicates agents that do not buy insurance.

$$
\begin{aligned}
c_i^{y,ins} &= \frac{1}{p_c + \frac{\left[p_c \beta R\left(\pi \Omega^{ins,B} + (1-\pi)\Omega^{ins,G}\right)\right]^{\frac{1}{\sigma}}}{R}} \left(\left(1-\tau^L\right) w_i - \tau - p^{ins}\right), \\
s_i^{ins} &= \frac{\frac{\left[p_c \beta R\left(\pi \Omega^{ins,B} + (1-\pi)\Omega^{ins,G}\right)\right]^{\frac{1}{\sigma}}}{R}}{p_c + \frac{\left[p_c \beta R\left(\pi \Omega^{ins,B} + (1-\pi)\Omega^{ins,G}\right)\right]^{\frac{1}{\sigma}}}{R}} \left(\left(1-\tau^L\right) w_i - \tau - p^{ins}\right), \\
c_i^{o,ins} &= \frac{1}{p_c + \left[p_h^{ins} - \left(1-\tau^L\right) w_i^o\right] \left(\theta \frac{p_c}{p_h^{ins} - (1-\tau^L) w_i}\right)^{\frac{1}{\sigma}}} \left(R s_i - \tau\right), \\
h_i^{ins} &= \frac{\left(\theta \frac{p_c}{p_h^{ins} - (1-\tau^L) w_i}\right)^{\frac{1}{\sigma}}}{p_c + \left[p_h^{ins} - \left(1-\tau^L\right) w_i^o\right] \left(\theta \frac{p_c}{p_h^{ins} - (1-\tau^L) w_i}\right)^{\frac{1}{\sigma}}} \left(R s_i - \tau\right), \\
m_i^{ins} &= \frac{1}{z_i} \frac{\left(\theta \frac{p_c}{p_h^{ins} - (1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}}{p_c + \left[p_h^{ins} - \left(1-\tau^L\right) w_i^o\right] \left(\theta \frac{p_c}{p_h^{ins} - (1-\tau^L) w_i^o}\right)^{\frac{1}{\sigma}}} \left(R s_i - \tau\right),
\end{aligned}
$$

with

$$
\begin{aligned}
p_c &= \left(1+\tau^c\right), p^{ins} = \begin{cases} p & \text{if buying insurance,} \\ 0 & \text{if not buying insurance,} \end{cases} \quad \text{and} \\
p_h^{ins} &= \begin{cases} \frac{\rho p_m m}{z} & \text{if insured,} \\ \frac{p_m m}{z} & \text{if not insured.} \end{cases}
\end{aligned}
$$

We next calculate the value functions of agents with and without insurance.

$$
\begin{aligned}
V^I\left(w_i^y, w_i^o\right) &= \frac{\left(c^y\right)^{1-\sigma}}{1-\sigma} + \beta\left(\pi \Omega^{I,B} + (1-\pi)\Omega^{I,G}\right) \frac{\left(Rs-\tau\right)^{1-\sigma}}{1-\sigma}, \\
&= \left(1 + \beta\left(\pi \Omega^{I,B} + (1-\pi)\Omega^{I,G}\right)\left(\left[p_c \beta R\left[\pi \Omega^{I,B} + (1-\pi)\Omega^{I,G}\right]\right]^{\frac{1-\sigma}{\sigma}}\right)\right) * \\
&\quad \frac{\left(\frac{1}{p_c + \frac{\left[p_c \beta R\left(\pi \Omega^{I,B} + (1-\pi)\Omega^{I,G}\right)\right]^{\frac{1}{\sigma}}}{R}} \left(\left(1-\tau^L\right) w^y - \tau - p\right)\right)^{1-\sigma}}{1-\sigma},
\end{aligned}
$$

and the value function of an agent with insurance is

$$\begin{aligned} V^{NI}\left(w_i^y, w_i^o\right) &= \left(1+\beta\left(\pi\Omega^{NI,B}+(1-\pi)\,\Omega^{NI,G}\right)\left(\left[p_c\beta R\left[\pi\Omega^{NI,B}+(1-\pi)\,\Omega^{NI,G}\right]\right]^{\frac{1-\sigma}{\sigma}}\right)\right)\frac{\left(c^y\right)^{1-\sigma}}{1-\sigma}, \\ &= \left(1+\beta\left(\pi\Omega^{NI,B}+(1-\pi)\,\Omega^{NI,G}\right)\left(\left[p_c\beta R\left[\pi\Omega^{NI,B}+(1-\pi)\,\Omega^{NI,G}\right]\right]^{\frac{1-\sigma}{\sigma}}\right)\right) * \\ & \quad \frac{\left(\frac{1}{p_c+\frac{\left[p_c\beta R\left(\pi\Omega^{NI,B}+(1-\pi)\Omega^{NI,G}\right)\right]^{\frac{1}{\sigma}}}{R}}\left(\left(1-\tau^L\right)w^y\right)\right)^{1-\sigma}}{1-\sigma}. \end{aligned}$$

When $V^I\left(w_i^y, w_i^o\right) > V^{NI}\left(w_i^y, w_i^o\right)$ agents will buy insurance in the first period.

2 Solving the full dynamic model

We solve the model backwards discretizing along a, and h. Choosing the optimal health level from a grid allows us to substitute health expenditures m_j out of the optimization problem via the law of motion of health

$$h_j = \phi_j m_j^{\xi} + (1-\delta_j)\,h_{j-1} + \varepsilon_j.$$

Instead of choosing how much to spend on health in period j, the consumer picks the new health level h_j directly. Health expenditure m_j is then the obtained via the following expression

$$m_j = \left[\frac{h_j - (1-\delta_j)\,h_{j-1} - \varepsilon_j}{\phi}\right]^{\frac{1}{\xi}}.$$

This method turns out to be simpler than picking m_j directly, since that would require an additional discretization over m_j. An alternative specification would be to let depreciation be a function of current health expenditures, $\delta(m_j)$. However, if the function $\delta(m_j)$ is nonlinear we cannot easily solve for m_j anymore which would increase the computational burden. We therefore limit the depreciation of health to only be a function of the current age j. We solve the model backwards using a grid search over all states $\{a_j, h_{j-1}, in_j, \varepsilon_j, \epsilon_j, i_{GI,j}\}$. The algorithm follows the steps given below

1. Discretize $\Theta = \{(a_j, h_{j-1}, in_j, \varepsilon_j, \epsilon_j, i_{GI,j})\}$ according to

   - $a = [0, ..., 3]_{1\times 18}$
   - $h = [0.01, ..., 3]_{1\times 15}$
   - $age = [20, ..., 90]_{1\times 14}$
   - $ins = \{0, 1, 2\}$
   - $\varepsilon_j = \{\varepsilon_1, \varepsilon_2, \varepsilon_3\}$, where $j = \{1, ..., 9\}$ income shocks
   - $\epsilon_j = \{\epsilon_1, \epsilon_2\}$, where $j = \{1, ..., 9\}$ health shocks

- $i_{GI,j} = \{0,1\}$, where $j = \{1,...,9\}$ employer provided health insurance (yes/no)

2. Guess prices w, R, p, p^{Med}, tax rates τ^{Med}, τ^{Soc}, and an initial capital stock K^{old}

3. Solve model backwards for optimal policy functions $a^*(\Theta), c^*(\Theta), m^*(\Theta)$, and $in^*(\Theta)$ assuming that savings in the last period are equal to zero

4. Solve forward: track agent masses over all states assuming that newborn generations have very low asset holdings at the beginning of their economic life at age 20 and store the distribution in an array Muw and Mur, for workers and retirees respectively (this method does not allow us to track individual agent histories)

5. Calculate aggregate asset holdings K^{new} using Muw and Mur

6. Calculate errors $\left\|K^{new} - K^{old}\right\|$, if error is small stop, if error is large set $K^{old} = \lambda K^{new} + (1-\lambda) K^{old}$

7. Calculate new prices and repeat step 3 until convergence

Asset and health spending grids are coarse and are likely to influence the comparative static results. The forward solving part of the algorithm can be improved upon by simulating the health shock and survival history of a large number of households. This method would then allows us to condition policies on agent income histories, a feature that is not captured by the current solution method.

3 Welfare calculations

In this section we provide details about the two welfare measures. We start with the following observation. When calculating the compensating consumption levels that equate an agent's utility as measured by her value function from the original steady state V with the value function from the new regime W, we can express the consumption levels needed as percentage ϕ of the current consumption levels. If an agent is worse of in the new regime, she needs to be given extra quantities of consumption, so that $\phi > 0$. If, on the other hand, the agent is better off under the new regime, then $\phi < 0$.

In addition we compensate the agent with fraction ϕ of her consumption in all of her life periods, so that the two value functions V (before the regime change) and W (after the regime change) become identical. In other words, we equate

$$\begin{aligned} V\left(x_1^1, \Psi^1\right) &= W\left(x_1^2, \Psi^2, \phi, t\right), \\ &= \max\left\{u\left((1+\phi)\, c_1^2, h_1^2\right) + \beta E W\left(x_2^2, \Psi^2, \phi, t\right)\right\}, \end{aligned}$$

where superscripts denote regime 1 (before the change) and regime 2 respectively, the subscript denotes the agent's age, $x_j^l = \{a, h, j, z, x\}$ is the state vector summarizing asset holdings, health capital, age, the health shock, and the insurance state of a j period old agent in regime l, and t is the calendar time the agent is born. Using the above described functional form for preferences we have

$$u(c,s) = \frac{\left(c^{\eta} s^{1-\eta}\right)^{1-\sigma}}{1-\sigma},$$

so that

$$\begin{aligned}
u(c,s,\phi) &= \frac{\left[\left((1+\phi)\,c_j\right)^{\eta} s_j^{1-\eta}\right]^{(1-\sigma)}}{1-\sigma}, \\
u(c,s,\phi) &= (1+\phi)^{\eta(1-\sigma)} \frac{\left[c_j^{\eta} s_j^{1-\eta}\right]^{(1-\sigma)}}{1-\sigma}, \\
u(c,s,\phi) &= (1+\phi)^{\eta(1-\sigma)}\, U(c,s).
\end{aligned}$$

Plugging this into the post reform value function we get

$$\begin{aligned}
W\left(x_1^2, \Psi^2, \phi, t\right) &= (1+\phi)^{\eta(1-\sigma)} \max\left\{u\left(c_1^2, s_1^2\right) + \beta\left[(1+\phi)^{\eta(1-\sigma)} \max\left\{u\left(c_2^2, h_2^2\right) + \beta EW\left(x_3^2, \Psi^2, t\right)\right\}\right]\right\}, \\
&\to W\left(x_1^2, \Psi^2, \phi, t\right) = (1+\phi)^{\eta(1-\sigma)} \max\left\{u\left(c_1^2, s_1^2\right) + \beta EW\left(x_2^1, \Psi^1, t\right)\right\}, \\
&\to W\left(x_1^2, \Psi^2, \phi, t\right) = (1+\phi)^{\eta(1-\sigma)}\, W\left(x_1^2, \Psi^2, t\right).
\end{aligned}$$

We can now equate the value function from before and from after the reform $V\left(x_1^1, \Psi^1\right) = W\left(x_1^2, \Psi^2, \phi, t\right)$, which yields

$$V\left(x_1^1, \Psi^1\right) = (1+\phi)^{\eta(1-\sigma)}\, W\left(x_1^2, \Psi^2, t\right).$$

The proportional increase in consumption can be computed analytically for each agent type over the transitions by

$$\phi\left(x_1^2, t\right) = \left[\frac{V\left(x_1^1, \Psi^1\right)}{W\left(x_1^2, \Psi^2, t\right)}\right]^{\frac{1}{\eta(1-\sigma)}} - 1.$$

If $V\left(x_1^1, \Psi^1\right) > W\left(x_1^2, \Psi^2, t\right)$, then $\phi > 0$, if $V\left(x_1^1, \Psi^1\right) < W\left(x_1^2, \Psi^2, t\right)$, then $\phi < 0$.

We have reported two welfare measures. The first measures the fraction of aggregate compensating consumption per aggregate consumption for each generation t over the transition period. This measure allows us to identify which generations on average stand to win or lose from the reform. We can write this measure as

$$\frac{\sum_{j=1}^{J} \mu_j \int \left(\phi\left(x_j^2, \tau\right) c\left(x_j^2, \tau\right)\right) d\Lambda\left(x_j^2\right)}{\sum_{j=1}^{J} \mu_j \int c\left(x_j^2, \tau\right) d\Lambda\left(x_j^2\right)} \text{ for each transition generation } \tau = \{-13, -12, ..1, ..., T-J\},$$

where transition generation $\tau = -13$ is the generation born 13 periods before the reform. This generation has one period $j = 14$, left to live under the new policy regime. Generation $\tau = 0$ is the first generation born under the new regime at calendar time t.

The second welfare measure calculates how much it would cost to compensate the individuals over the transition period in order to make them indifferent between the current U.S. economy and the equilibrium with health insurance vouchers. We express this cost in terms of fraction of GDP. Formerly this can be expressed as

$$\frac{\sum_{j=1}^{J} \mu_j \int \left(\phi \left(x_j^2, t-j+1 \right) c \left(x_j^2, t-J+1 \right) \right) d\Lambda \left(x_j^2 \right)}{Y_t} \text{ for each transition period } t = \{0, ..., T\}.$$

4 Data

4.1 General

Data from the Medical Expenditure Panel Survey (MEPS) are available for the years 2003 to 2006. MEPS provides a nationally representative information about health care use, health expenditures, health insurance coverage as well as demographics data and data on income, health status, and other socioeconomic characteristics. The household component of MEPS was initiated in 1996. Each year a about 15,000 households are selected and interviewed 5 times over 2 full calendar years.

We use data from year 2004 and year 2005 of the MEPS. The dataset contains 34,403 individuals in 2004 and 33,961 individuals in 2005. After dropping individuals younger than age 20 and individuals that do not report the appropriate data we are left with 45,005 individual observations over the two year period. For 10,589 individuals we have observations from two years which allows us to construct a panel if needed. For the other 23,827 individuals we either have observations from year 2004 or from year 2005.

In our analysis we concentrate on heads of households in $2004 - 2005$. MEPS groups individuals into so called Health Insurance Eligibility Units (HIEU), variable: HIEUIDX. We define the person with the highest income within each HIEU as the head of the household. If individuals have equal income, we pick the older one as the household head. We concentrate on heads of households since they are most likely to be the person making the health insurance choice, group vs. individual market. Dependents in the household are often times added to the head's insurance policy. In addition this strategy allows us to abstract from family size effects. The data is now reduced to 32,106 individual observations over two years, where for 6,825 individuals we have information in both years. For the other 18,456 individuals we either have observations from year 2004 or from year 2005. We present summary statistics of the available data, pooled over the years $2004 - 2005$ in table 1. All dollar values are denominated in 2004 dollars using the Personal Consumption Expenditures (PCE - chain price) index.

4.2 Health Expenditure, Healthy Individuals, and Insurance Profiles

Figure 1 presents the life-cycle profiles of annual health expenditure, annual total income, medical expenditure to income ratio, and average weekly work hours.

The expenditure definition in MEPS refers to what is paid for health care services. More specifically, expenditures are defined as the sum of direct payments for care provided during the year, including out-of-pocket payments and payments by private insurance, Medicaid, Medicare, and other sources. Payments for over-the-counter drugs are not included in MEPS total expenditures. Indirect payments not related to specific medical events, such as Medicaid Disproportionate Share and Medicare Direct Medical Education subsidies, are also not included (This definition is from MEPS documentation HC-097: 2005 pp. C-106ff).

Figure 2 presents the life-cycle profiles of health status, where we define a healthy individual as a person with a health status of excellent, very good, or good. Persons with health status of fair and poor are considered unhealthy.

Figure 3 reports the insurance status over all age groups. We distinguish between no insurance, public insurance only, and some private insurance. In figure 4 we describe individuals with private insurance bought in the individual market and individuals with group insurance (from their employers). Group insurance are variable HELD31X, HELD42X, and HELD53X). The variable for type of health insurance coverage is INSCOVyy (where yy=05 for 2005).

MEPS data also contains data on who was offered group insurance (variables OFFER31X, OFFER42X, and OFFER53X) which allows us to calculate take up ratios.

4.3 Methodology

4.3.1 Markov transition matrix for working ability/efficiency units

We measure the individuals' working ability/efficiency unit in terms of the hourly wage rate (labor income per hour) of individuals, or

$$\text{Hourly wage} = \frac{\text{Gross labor income}}{\text{Total hours worked}}.$$

We classify individuals into 3/5 quantiles of hourly wage rates and $J_w = 9$ separate five year age cohorts. The cohorts assumed to be active in the labor market are: $20-24$, $25-29$, $30-34$, $35-39$, $40-44$, $45-49$, $50-54$, $55-59$, and $60-64$. We assume that individuals in each age-quantile group have identical working abilities, so that each cohort consists of 3/5 discrete states of productivity. To measure the discrete levels of working ability we use the average hourly wage rate conditioning on the income quantile and on age. We can therefore write the productivity of an individual age j in income group i as

$$e_j^i = \frac{\sum_{i=1}^{N_j^i} \text{Hourly wage}_j^i}{N_j^i},$$

where i denotes the income class, j denotes the age-cohort, and e_j^i is the level of working ability (average working ability within income/age class), and N_j^i is the total number of individuals of cohort age j and income i. We report graphs of the average productivity profiles per income group in figure **??**

We use a Markov transition matrix to characterize the dynamics of working abilities over the life cycle. One often used method is a simple counting approach to calculate the transition probabilities (e.g. Nishiyama and Smetters (2005) or Jeske and Kitao (2009)). We record the number of individuals in income class 1 of cohort 1 and then count how many of those stayed in income class 1 in the next period and how many moved to income classes $2-3/5$ in the next period. We then get the transition probability $p_j^{i',i}$ of an individual of age j in income class i who moves to income class i' when age is $j+1$ as

$$p_j^{i',i}\left(e_{j+1}^{i'}|e_j^i\right) = \frac{n_{j+1}^{i'|i}}{N_j^i},$$

where N_j^i is the total number of individuals with working ability i at age j, $n_{j+1}^{i'|i}$ is the number if individuals of pool N_j^i who have working ability i' in the next period $j+1$. Note that all individuals with working ability i' in period $j+1$ can be calculated as $N_j^{i'} = \sum_{i=1}^{3/5} n_{j+1}^{i'|i}$. We report the number of individuals in each productivity class per age cohort in table 2 and summary statistics of labor productivities of all individuals that report income data in two consecutive years in table 3.

Since we assume that each period in the model corresponds to five years, we need to calculate the transition probability matrix of working abilities for $5-year$ periods. We assume that the transition probabilities are constant for a five year span and therefore express the labor productivity transition matrix of an individual of age j for one period (of five years) as the matrix product

$$P_j = P_{j1} \times P_{j1} \times P_{j1} \times P_{j1} \times P_{j1},$$

where P_{j1} is the annual transition matrix with elements $p_j^{k,i}$.

4.3.2 Markov transition matrix for health insurance offer status

We next construct income class dependent transition matrices of group insurance offers from employers. The idea is that an individual has a certain chance that her employer will offer tax deductible and non-screening group insurance, that the individual can either accept or decline. If the individual is not offered group insurance, she still has the opportunity to buy health insurance in the individual market. However, the premiums in the individual market are higher because insurance companies screen individuals (for starter only screening by age is implemented) and premiums are also not tax deductible. Since we need to track two possible state $offer/no-offer$, we need to construct a 2×2 transition matrix.

We use variables from MEPS, OFFER31X, OFFER42X, and OFFER53X. These are dummy variables that indicate whether an individual is offered health insurance from her employer. The numbers 31, 42, and 53 refer to the interview round within the year (individuals are interviewed 5 times in two years). We assume that an individual was offered group health insurance when either one of the three variables indicates so. Since the probability of a group insurance offer will be highly correlated with income, we condition on income class when constructing the transition matrices. That is for each income class we count what fraction of individuals with a group offer in year 2004 was still offered group insurance in 2005. This results in probability $\pi_i^{s',s}$, where $s = \{no-offer, offer\}$ in year j, $s' = \{no-offer, offer\}$ in year $j+1$ and i denotes the income class. We report the matrices in tables 4 to 6.

5 Aggregate Resource Constraint

After aggregating we get the following equations from the households, government, social security system, medicare system, insurance companies and voucher system:

$$\begin{aligned}
& \left(1+\tau^C\right) C + (1+g) A_t + O^W + O^R + P_1 + P_2 + P_{Med} \\
= \; & wH + RA_{t-1} + RT^{Beq} + Insprofit_1 + Insprofit_2 \\
& -Tax - Tax_{SS} - Tax_{Med} + T^{SI} + T^{Soc},
\end{aligned}$$

$$\begin{aligned}
G + T^{SI} + V &= Tax + \tau^C C, \\
T^{Soc} &= \tau^{Soc} \times TaxableIncome, \\
MedicarePayments &= \tau^{Med} \times TaxableIncome + P_{Med}, \\
InsPay_1 + Insprofit_1 &= RP_1, \\
InsPay_2 + Insprofit_2 &= RP_2, \\
InsPay_v &= RV_j.
\end{aligned}$$

Adding up the households' and government budget constraints we get:

$$\left(1+\tau^C\right) C + (1+g) A_t + O^W + O^R + P_1 + P_2 + P_{Med} + G + T^{SI} + V$$

$$\begin{aligned}
= \; & wH + RA_{t-1} + RT^{Beq} + Insprofit_1 + Insprofit_2 \\
& -Tax - Tax_{SS} - Tax_{Med} + T^{SI} + T^{Soc} + Tax + \tau^C C,
\end{aligned}$$

which after some preliminary cancellations results in

$$
\begin{aligned}
& C+(1+g)\,A_t+O^W+O^R+P_1+P_2+P_{Med}+Tax_{Med}+G+V \\
= \quad & wH+RA_{t-1}+RT^{Beq}+Insprofit_1+Insprofit_2
\end{aligned}
$$

$$
\begin{aligned}
& C+(1+g)\,A_t+O^W+P_1+P_2+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\
= \quad & wH+RA_{t-1}+RT^{Beq}+Insprofit_1+Insprofit_2
\end{aligned}
$$

$$
\begin{aligned}
& C+(1+g)\,A_t+O^W+P_1+P_2+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\
= \quad & wH+(1-\delta+q)\left(A_{t-1}+T^{Beq}\right)+Insprofit_1+Insprofit_2
\end{aligned}
$$

$$
\begin{aligned}
& C+(1+g)\,A_t+O^W+P_1+P_2+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\
= \quad & wH+qA_{t-1}+(1-\delta+q)\left(A_{t-1}+T^{Beq}\right)+Insprofit_1+Insprofit_2
\end{aligned}
$$

Now remember that capital is

$$K=A+T^{Beq}+P_1+P_2,$$

since premiums are invested for one period. We then have

$$
\begin{aligned}
& C+(1+g)\,A_t+O^W+P_1+P_2+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\
= \quad & wH+R\left(A_{t-1}+T^{Beq}\right)+RP_1-InsPay_1+RP_2-InsPay_2
\end{aligned}
$$

$$\begin{aligned} & C+(1+g)\,A_t+O^W+P_1+P_2+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\ = \;& wH+R\left(\overbrace{A_{t-1}+T^{Beq}+P_1+P_2}^{K}\right)-InsPay_1-InsPay_2 \end{aligned}$$

$$\begin{aligned} & C+(1+g)\,A_t+O^W+P_1+P_2+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\ = \;& wH+(1-\delta+q)\,K-InsPay_1-InsPay_2 \end{aligned}$$

$$\begin{aligned} & C+(1+g)\,A_t+O^W+P_1+P_2+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\ = \;& wH+qK+(1-\delta)\,K-InsPay_1-InsPay_2 \end{aligned}$$

Using the production function and Euler's theorem for a function of homogeneity of degree one we have

$$\begin{aligned} & C+(1+g)\,A_t+P_1+P_2+\overbrace{O^W+InsPay_1+InsPay_2}^{p_m\times M(young)}+\overbrace{O^R+P_{Med}+Tax_{Med}}^{p_m\times M(old)}+G+V \\ = \;& Y+(1-\delta)\,K \end{aligned}$$

$$\begin{aligned} & C+(1+g)\,A_t+P_1+P_2+p_m\times M+G+V \\ = \;& Y+(1-\delta)\,K \end{aligned}$$

5.1 Three Period Model

Three period model with insurance and medical spending from period 2 onwards and no work in the third period. The survival probability is 90% from period to period, so that the mass of agents in the respective three periods is 1, 0.9, and 0.81.

$$\begin{aligned} c_1 + s_1 + p_1 &= wL_1, \\ c_2 + s_2 + p_2 + p_m m_2 &= wL_2 + Rs_1 + RT_{beq2} + insPay_2, \\ c_3 + p_m m_3 &= Rs_2 + RT_{beq2} + insPay_3. \end{aligned}$$

We first assume a PAYGO insurance so that the per capita premiums are determined by

$$\begin{aligned} p_1 &= 0.9 \times insPay_2, \\ 0.9p_2 &= 0.81 \times insPay_3. \end{aligned}$$

There are now two ways to determine the capital stock. Either we use savings or we use assets. If we use savings the capital stock is

$$K = s_1 + 0.9s_2.$$

If we use assets the capital stock is

$$K = a_1 + 0.9a_2 + 0.81a_3 + 0.9T_{beq2} + 0.81T_{beq3},$$

where

$$a_1 = 0,\ a_2 = s_2,\ a_3 = s_3,$$

and per capita bequests are

$$\begin{aligned} T_{beq2} &= \frac{0.1s_1}{0.9}, \\ T_{beq2} &= \frac{0.1 \times 0.9 \times s_2}{0.81}. \end{aligned}$$

Now capital stock is again

$$K = 0 + 0.9s_1 + 0.81s_2 + 0.9\frac{0.1s_1}{0.9} + 0.81\frac{0.1 \times 0.9 \times s_2}{0.81} = s_1 + 0.9s_2.$$

When we derive the ARC we aggregate over all households and get:

$$C + S' + P + p_m M = wL + RA + RT_{beq} + InsPay,$$

where $A = 0.9S_1 + 0.81S_2$ stands for assets. We then get

$$C + S' + P + p_m M = wL + (1 - \delta + q)\left(\overbrace{A + T_{beq}}^{K}\right) + InsPay,$$

which becomes

$$C + S' + P + p_m M = wL + qK + (1 - \delta) K + InsPay,$$

and using the production function of homogeneity of degree 1 (Euler's theorem) and the zero profit constraint of PAYGO insurance companies so that aggregate premiums cover the insurance payments $P = InsPay$, we have

$$C + S' + p_m M = Y + (1 - \delta) K.$$

5.2 Premiums are saved for one period before they are paid out

Now if in addition, premiums are saved for one period before they are paid out, we have to add them to the capital stock:

$$\begin{aligned} K &= s_1 + 0.9 s_2 + p_1 + 0.9 p_2, \text{ or} \\ K &= a_1 + 0.9 a_2 + 0.81 a_3 + 0.9 T_{beq2} + 0.81 T_{beq3} + p_1 + 0.9 p_2. \end{aligned}$$

Now the insurance is NOT pay as you go anymore. It therefore has to hold that after premiums earned interest they fully pay for the insurance outlays

$$\begin{aligned} R p_1 &= 0.9 \times insPay_2, \\ 0.9 R p_2 &= 0.81 \times insPay_3. \end{aligned} \tag{1}$$

We can now again aggregate and get

$$C + S' + P + p_m M = wL + RA + RT_{beq} + InsPay,$$

replacing $InsPay$ with the aggregate of (1) which is $RP = InsPay$ we have

$$C + S' + P + p_m M = wL + RA + RT_{beq} + RP.$$

Collecting terms we have

$$C + S' + P + p_m M = wL + R\left(\overbrace{A + T_{beq} + P}^{K}\right),$$

so that using the production function again together with $R = 1 - \delta + q$ the ARC becomes

$$C + S' + P + p_m M = Y + (1 - \delta) K.$$

References

Jeske, Karsten and Sagiri Kitao. 2009. "U.S. Tax Policy and Health Insurance Demand: Can a Regressive Policy Improve Welfare?" *Journal of Monetary Economics* 56(2):210–222.

Jung, Juergen and Chung Tran. 2009. "The Macroeconomics of Universal Health Insurance Vouchers." Working Paper.

Nishiyama, Shinichi and Kent Smetters. 2005. "Does Social Security Privatization Produce Efficiency Gains?" Michigan Retirement Research Center, WP 2005-106.

6 Tables and Figures

Table 1: Summary statistics of head of households of the pooled data 04 to 05

Variable	Mean	(Std. Dev.)	Min.	Max.	N
age as of 12/31/05 (edited/imputed)	46.174	(17.641)	20	85	32106
female	0.483	(0.5)	0	1	32106
married	0.412	(0.492)	0	1	32106
black	0.173	(0.379)	0	1	32106
wageIncome	24605.565	(28767.473)	0	437812	32106
totalIncome	29849.794	(29402.622)	0	437861	32106
healthExpenditure	3707.617	(10018.975)	0	440524	32106
yearEducation	12.326	(3.149)	1	17	31388
student	0.022	(0.146)	0	1	32106
healthy	0.849	(0.358)	0	1	31954
bmi	27.803	(6.263)	9.200	239.2	31011

Table 2: **Age - Today by Wage rate class - Today**

	Wage rate class - Today			
Age - Today	1	2	3	Total
1	309	337	370	1,016
2	425	381	400	1,206
3	352	360	327	1,039
4	338	334	333	1,005
5	309	335	319	963
6	289	305	345	939
7	313	238	277	828
8	235	205	232	672
9	122	138	128	388
Total	2,692	2,633	2,731	8,056

Source: .04to05.dta

Table 3: Summary statistics of the pooled data

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**N**
Age - Today	4.429	(2.394)	1	9	8056
Wage rate - Today	15.993	(11.487)	0.07	70.059	8056
Wage rate class - Today	2.005	(0.821)	1	3	8056
Age - Next	4.523	(2.394)	1	9	4028
Wage rate - Next	15.884	(11.512)	0.078	70.059	4028
Wage rate class - Next	1.98	(0.820)	1	3	4028

Table 4: Markov transition matrix for earnings for age group: 1

	class1	class2	class3
class1	.4306582	.37860285	.19073894
class2	.34343946	.41853968	.23802086
class3	.25077599	.41660854	.33261547

Table 5: Markov transition matrix for earnings for age group: 2

	class1	class2	class3
class1	.77840123	.16108924	.06050954
class2	.5086613	.31344902	.17788968
class3	.2716173	.27734699	.45103571

Table 6: Markov transition matrix for earnings for age group: 3

	class1	class2	class3
class1	.90465852	.07022623	.02511525
class2	.56122633	.38187399	.05689969
class3	.23430181	.3483657	.41733248

Table 7: Markov transition matrix for earnings for age group: 4

	class1	class2	class3
class1	.85042687	.12250623	.0270669
class2	.28757565	.66526566	.04715869
class3	.06653564	.26517614	.66828822

Table 8: Markov transition matrix for earnings for age group: 5

	class1	class2	class3
class1	.78899864	.12840049	.08260087
class2	.35906711	.58377992	.05715297
class3	.06937002	.19921533	.73141465

Table 9: Markov transition matrix for earnings for age group: 6

	class1	class2	class3
class1	.85173011	.13513229	.0131376
class2	.22910051	.61444126	.15645822
class3	.06218231	.28571561	.65210208

Table 10: Markov transition matrix for earnings for age group: 7

	class1	class2	class3
class1	.86630537	.12432953	.0093651
class2	.29036284	.58295101	.12668616
class3	.07513653	.08284694	.84201653

Table 11: Markov transition matrix for earnings for age group: 8

	class1	class2	class3
class1	.78718784	.15892936	.05388279
class2	.35800711	.47934655	.16264635
class3	.06308082	.24048022	.69643896

Table 12: Markov transition matrix for insurance status for income group: 1

	Individual Insurance	Group Insurance
Individual Insurance	.61096411	.38903589
Group Insurance	.55351814	.44648186

Table 13: Markov transition matrix for insurance status for income group: 2

	Individual Insurance	Group Insurance
Individual Insurance	.47067959	.52932041
Group Insurance	.32858014	.67141986

Table 14: Markov transition matrix for insurance status for income group: 3

	Individual Insurance	Group Insurance
Individual Insurance	.40509134	.59490866
Group Insurance	.21282063	.78717937

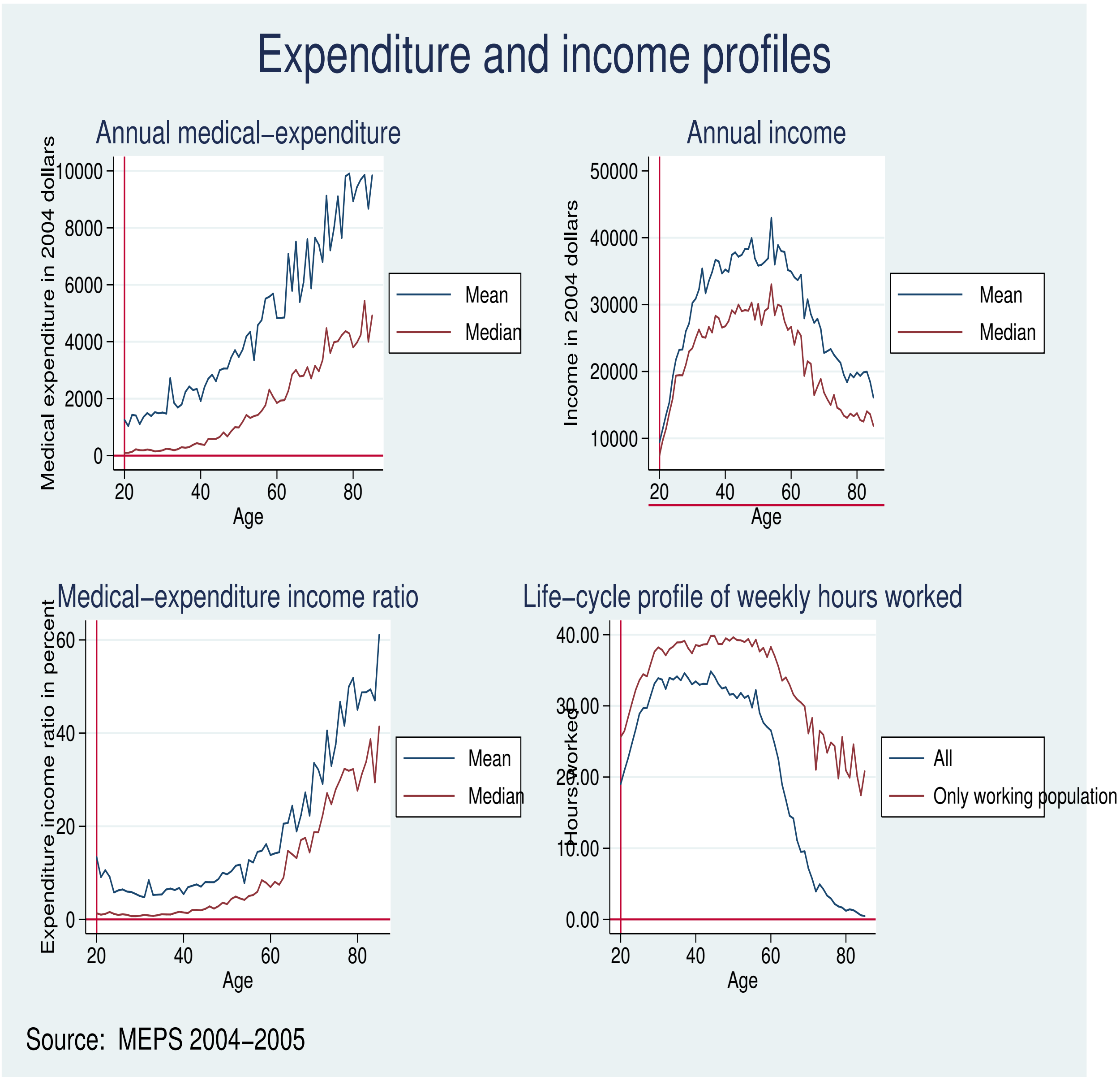

Figure 1: Life-cycle health expenditure profile: MEPS 2004-2005

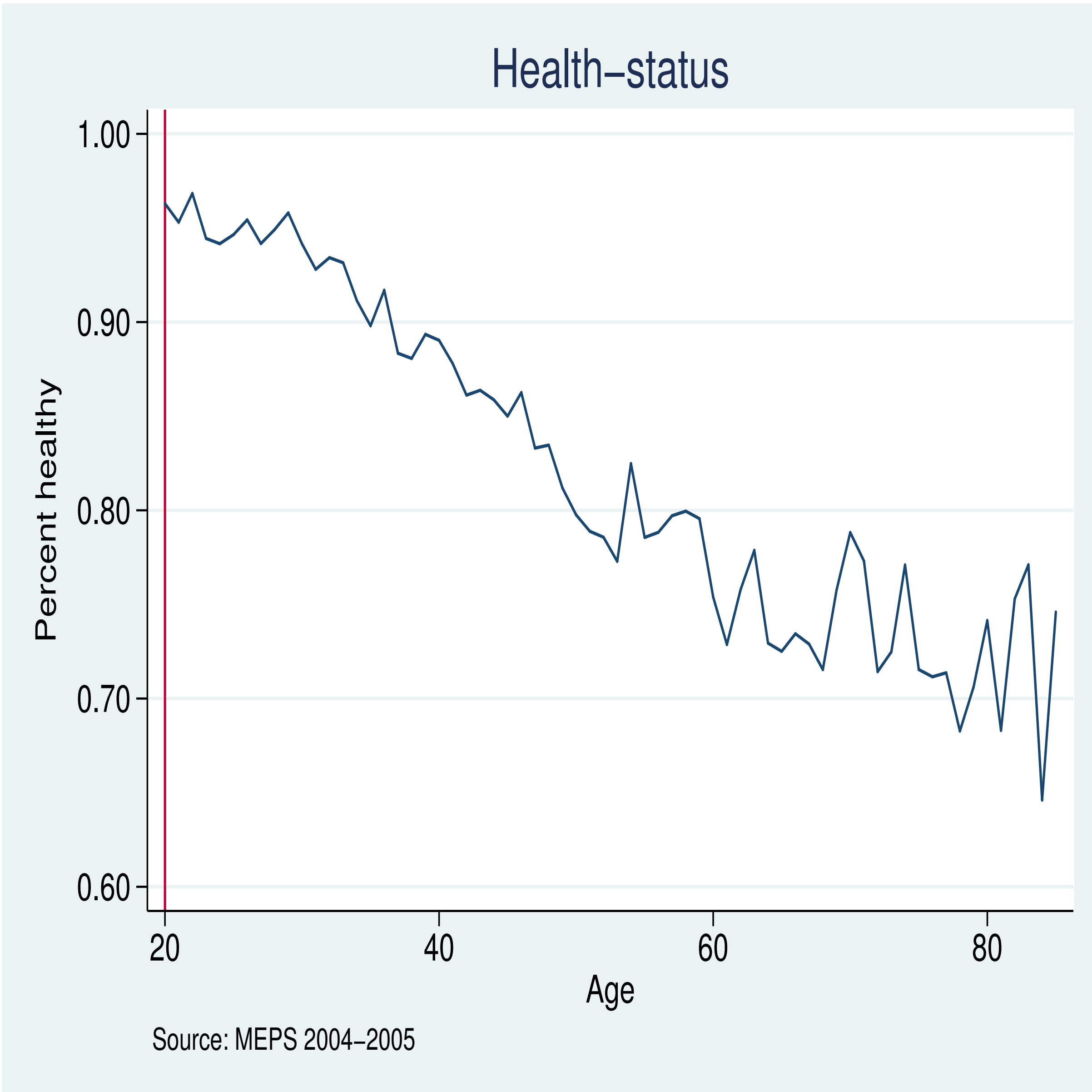

Figure 2: Life-cycle profile of health status: MEPS 2004-2005

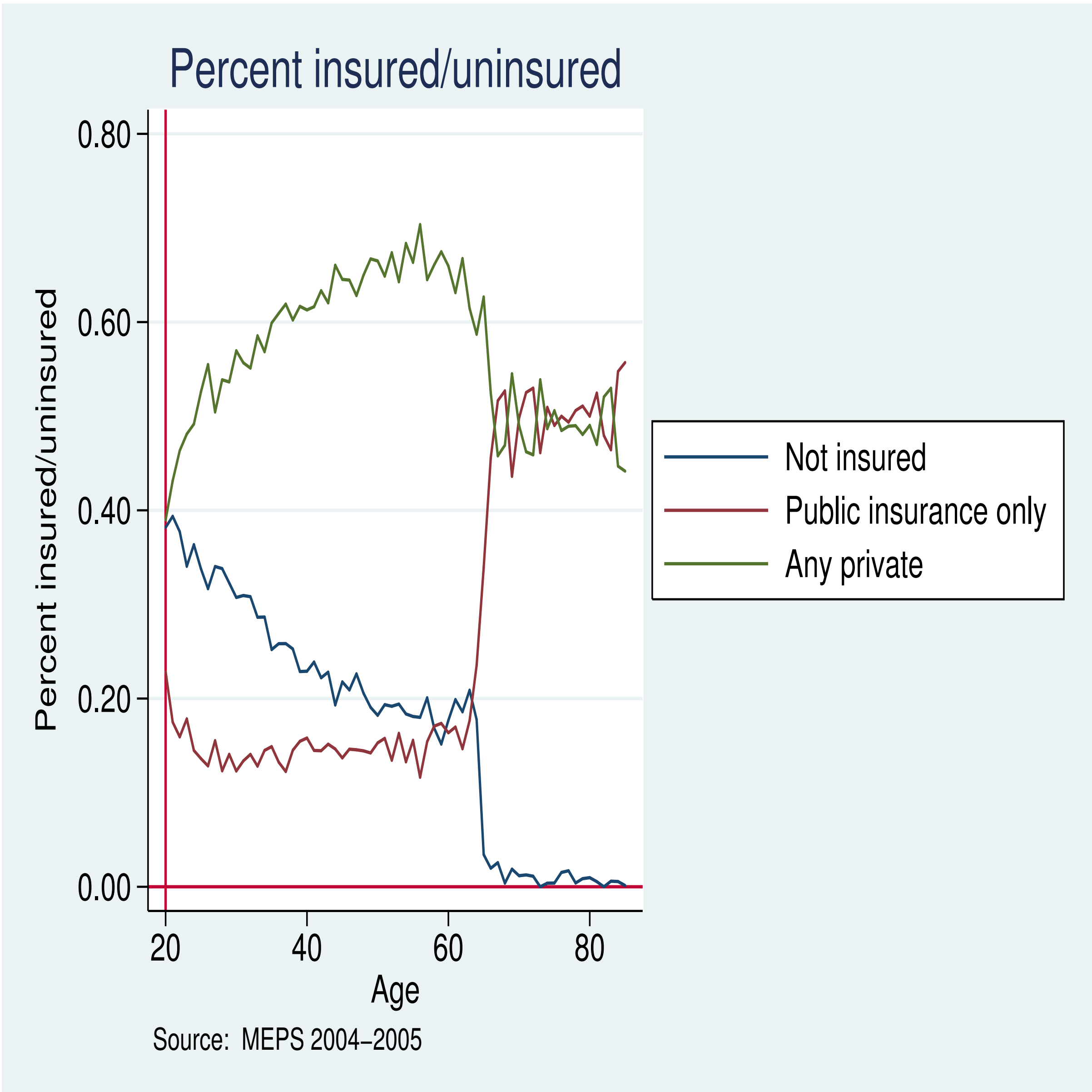

Figure 3: Health insurance profile: MEPS 2004-2005

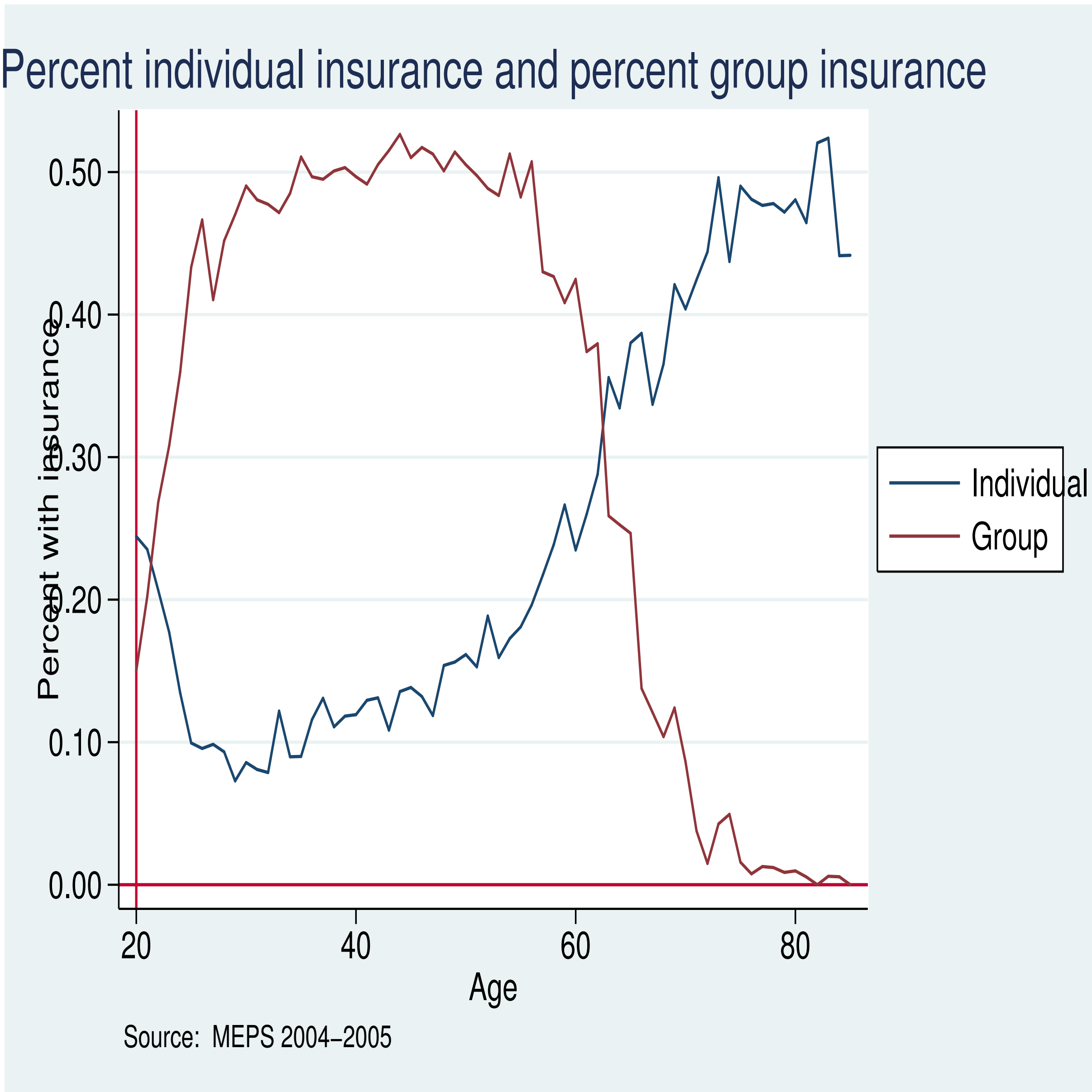

Figure 4: Individual vs. group insurance.profile: MEPS 2004-2005