# Health Risk and the Optimality of Social Security*

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**Abstract**

We examine the welfare implications of Social Security in a calibrated overlapping-generations model with realistic labor income, mortality, and health risks. While Social Security may have positive insurance effects as an imperfect technology to save for old-age health risk, it may also interfere with a household's ability to achieve better short-term consumption smoothing during work life. We find that the latter effect dominates: Social Security has a larger negative effect on welfare in the presence of health risk. In addition, holding the payroll tax constant while making the Social Security benefit-earnings rule *less* progressive has a larger negative effect on households with low education and higher health spending risks. Making the benefit-earnings rule *more* progressive has a large positive effect on these households. Overall, we find evidence of small welfare gains from a benefit-earnings rule that is *more* progressive than the current U.S. rule when health risk affects both household income and expenditures.

**JEL:** C35, I23, I10

**Keywords:** health risk, Social Security, consumption smoothing, general equilibrium, benefit-earnings rule

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# Part I

# Main Document

## 1 Introduction

While the primary justification for the creation of Social Security in 1935 was to make "more adequate provision for aged persons,"[1] today it accounts for 16–17 percent of total annual federal government expenditures, second only to health expenditures (excluding defense). Economists have traditionally viewed Social Security as a vehicle that partially insures individuals against risks that markets do not insure well, such as the risk of an uncertain lifetime and old-age poverty caused by unfavorable labor-market outcomes. Social Security annuities are paid until death, so they insure individuals against the risk of out-living their own savings. Meanwhile, Social Security benefits are a concave function of work-life earnings, which limits how unfavorable labor-market events, such as the inability to secure a high-paying job or unemployment, affect work-retirement consumption smoothing.

While it is well known that the insurance effects of Social Security are significant, there is also considerable evidence that Social Security negatively affects households' consumption, saving, and labor supply decisions. Social Security causes households to exit from the labor market earlier, to work fewer hours during employment, and to also reduce the personal savings needed for financing retirement consumption (Jeske, 2003; Wallenius, 2013; Alonso-Ortiz, 2014). Because of this reason, the literature on Social Security's overall welfare consequences has traditionally evolved as a comparison of its insurance effects, to its distortionary effects on household behavior. This literature has broadly concluded that under traditional preferences, the welfare gains from the insurance effects of Social Security are considerably smaller than its distortionary welfare losses (Hubbard and Judd, 1987*b*; İmrohoroğlu, İmrohoroğlu and Joines, 1995; Bagchi, 2015).

This literature, however, has routinely ignored how Social Security might interact with a third type of risk: risks related to one's health status. Social Security transfers resources from early life, when health risks are relatively low, to old age, when health risks are considerably higher. This transfer can potentially improve welfare, especially if households cannot save efficiently for uncertain old-age medical expenditures. While there are both public and private avenues that allow households to partially insure against health risks, such as Medicaid, Medicare, employment-based, and individual health insurance, the importance of Social Security's consumption-smoothing role in this context is not well known. On the other hand, households engage in precautionary savings due to the presence of health risk in their budget constraints. Because Social Security has a negative effect on disposable income in early life, especially for households that are borrowing constrained, it can potentially reduce welfare by interfering with this precautionary saving motive. Traditional welfare analyses of Social Security have typically abstracted from health risks, and have therefore overlooked these additional positive and negative insurance effects (Hubbard and Judd (1987*b*), İmrohoroğlu, İmrohoroğlu and Joines (1995), Bagchi (2015)).

[1] The legislative history of the Social Security Act of 1935 is available on http://www.ssa.gov/history.

In this paper, we quantitatively examine the welfare implications of Social Security in an environment with mortality, labor income, as well as health risks that affect both household income and expenditures. To do this, we construct a calibrated general-equilibrium macroeconomic model with households, firms, markets for goods and services, and a government. Then, we compute two sets of experiments with this model. First, to evaluate the relative importance of the life-cycle and precautionary saving motives in a household's ability to smooth consumption in this environment, we compute the sensitivity of Social Security's welfare effects to the presence or absence of health risk in the households' budget constraints. Second, to examine how the degree of redistribution implicit in Social Security affects the welfare gains or losses for households with varying exposure to health risks, we compute the welfare effects of modifying the progressivity of the Social Security benefit-earnings rule. We also examine the implications of these experiments for labor supply, consumption, and saving decisions, the markets for goods and services, the values of key macroeconomic aggregates, and the government's budget.

Our findings from the computational experiments are twofold. First, we find that the presence of health risk actually worsens the welfare implications of Social Security, rather than improving them. This is because health risk increases the importance of short-term, within-work-life consumption smoothing from the perspective of a household, but Social Security interferes with the precautionary saving motive and negatively affects the ability to effectively accomplish this. Removing Social Security from a model with health expenditure risk increases steady state capital by almost 40 percent and GDP by over 12 percent. Average weekly work hours decrease significantly by about 4 hours. Without any health expenditure risk and with health not affecting the income process similar increases in steady state capital and output and decreases in hours worked are observed. In addition to the standard distortionary effects on labor supply and capital accumulation, we find that this effect is strong enough to cause a larger welfare loss from Social Security when health risk affects both household income and expenditures, as well as when it affects only household income.

Second, we find that holding the payroll tax constant, making Social Security's benefit-earnings rule less progressive (i.e. *reducing* the implicit redistribution) has a large negative effect on households with low education and worse health risks. Conversely, making Social Security's benefit-earnings rule more progressive (i.e. *increasing* the implicit redistribution) has a large positive effect on households with low education and worse health risks. Overall, we find evidence of small welfare gains from a benefit-earnings rule that is *more* progressive than the current U.S. rule when health risk affects both household income and expenditures.

With health expenditure and health income risk a highly progressive Social Security benefit formula leads to the highest welfare outcome whereas in a model without health expenditure and health income risk the least progressive (linear) benefit formula leads to the highest welfare outcome. In both cases we assume a fixed (and identical) size of Social Security payroll taxes that finance the payouts.

The U.S. recently experienced a significant regulatory overhaul of its healthcare system: on March 23, 2010, President Barack Obama signed into law the Patient Protection and Affordable Care Act, also known as the ACA, as the largest piece of healthcare reform legislation in the U.S.

over the past 40 years. While there is a burgeoning literature that examines the implications of the ACA with respect to household-level healthcare spending and welfare, not much is known regarding the role of Social Security in providing insurance against health risks. Currently, economists and policymakers understand Social Security as providing insurance against income and mortality risks, and the literature has already shown that under traditional preferences, these effects are not strong enough to yield overall welfare gains. However, insurance against health risks provides two separate channels through which Social Security might affect welfare, which have been ignored in the literature. Our paper is the first one in the literature to quantitatively evaluate and compare the importance of these two channels.

## 2 Literature review

Government transfer system can be classified as early (transfers to the young) vs. late transfers (transfers to the old) as discussed in Glomm and Jung (2013) and the government can either optimize the spending side, the revenue side or both. In this project, our objective is to examine the welfare implications of a late redistribution system (i.e., US Social Security) focusing on the spending side while taking the revenue side of Social Security as given. We use an environment with realistic mortality, labor income, and health risks. The latter affects both, household income and expenditures. This exercise will contribute to two separate strands of the literature. On the one hand, starting with Abel (1985) and Hubbard and Judd (1987*b*), a number of studies have examined the importance of the traditional roles of unfunded public pensions in justifying the size of U.S. Social Security. Abel (1985) and Hubbard and Judd (1987*b*) find a welfare-improving role for Social Security in a model with mortality risk and closed annuity markets, but Hubbard and Judd (1987*b*) find that these welfare gains are significantly reduced or even eliminated when there are borrowing constraints. In a related study, İmrohoroğlu, İmrohoroğlu and Joines (1995) examine the optimality of Social Security in a life-cycle economy with mortality risk, missing annuity markets, idiosyncratic employment risk, and borrowing constraints. They find that the optimal social security arrangement features a replacement rate of 30% and a tax rate of 6.1%. While this literature does not arrive at a consensus regarding the optimal size of Social Security in the U.S., it generally concludes that the welfare-improving role of Social Security is much smaller once the consumption, saving, and labor supply distortions from Social Security are accounted for. However, none of these studies account for health risks, i.e. they ignore the possibility that while Social Security might provide partial insurance against health risks, it might also interfere with a household's ability to accomplish better short-term consumption smoothing.

In addition there is a literature investigating optimal tax progressivity (e.g., Conesa and Krueger (2006), Heathcote, Storesletten and Violante (2017) and Jung and Tran (2019)) and the effects of tax progressivity on tax revenue, wealth equality and human capital accumulation (e.g., Holter, Krueger and Stepanchuk (forthcoming)). In this project we do not focus on the government income side but the government spending side.

Finally a rapidly growing macro-health literature investigates, among other things, how U.S. tax and health-care reform policies might affect household behavior, macroeconomic performance, and also welfare. Jeske and Kitao (2009b) show that U.S. tax subsidies on employer-provided health insurance are regressive, but may improve welfare by expanding group health-insurance coverage. Pashchenko and Porapakkarm (2013b) look at the ACA specifically and find evidence of higher insurance take-up rates and overall welfare gains, but mostly through the law's redistributive measures and not through the regulation of the individual health insurance market. Finally, Jung and Tran (2016a) find that the increase in the insurance take-up rates may be primarily due to the insurance mandate and Medicaid expansion accompanying the ACA. However, because these studies mostly focus on health-care reform, they do not examine how Social Security's insurance effects interact with health risks that affect both household income and expenditures, and they also do not consider how Social Security's implicit redistribution through the concave benefit-earnings rule affects welfare for households with varying exposure to health risks.[2]

# 3 Model

We develop a overlapping generations model consisting of utility-maximizing households, profit-maximizing firms, and a government that provides consumption insurance for low income households, Social Security, Medicare, and Medicaid.

## 3.1 Demographics

The economy is populated with overlapping generations of individuals who live to a maximum of $J$ periods. Individuals work for $J_1$ periods and then retire for $J-J_1$ periods. In each period individuals of age $j$ face an exogenous survival probability $\pi_j$. In addition, the population grows exogenously at an annual rate $\mathfrak{n}$ We assume stable demographic patterns, so that age $j$ agents make up a constant fraction $\mu_j$ of the entire population at any point in time. The relative sizes of the cohorts alive $\mu_j$ and the mass of individuals dying $\tilde{\mu}_j$ in each period (conditional on survival up to the previous period) can be recursively defined as $\mu_j = \frac{\pi_j}{(1+n)^{years}}\mu_{j-1}$ and $\tilde{\mu}_j = \frac{1-\pi_j}{(1+n)^{years}}\mu_{j-1}$, where $years$ denotes the number of years per model period.

## 3.2 Preferences

The period utility function $u(c_j, l_j; \bar{n}_j \cdot 1_{[n_{min} \leq n_j]})$ depends on consumption ($c$), leisure ($l$), and labor-force participation status, captured by the indicator variable $1_{[n_{min} \leq n_j]}$, where $1_{[true]} = 1$ and 0 otherwise. The age-dependent labor-force participation cost (measured in hours) is given by $\bar{n}_j$, and $n_{min}$ denotes the labor hours corresponding to the retirement threshold. When the individual dies she values bequests of assets $a_j$ according to function $b(a_j)$ which is increasing in asset holdings

[2] A notable exception is Zhao (2014a), who shows that growth in Social Security can explain a large fraction of the increases in aggregate health expenditures observed in the U.S.

$a_j$. Bequests are redistributed to all surviving households in equal amounts as a lump-sum payment $\bar{b}$.

### 3.3 Health expenditure shocks and health insurance status

Based on their health status $h$, households experience a random health/medical expenditure shock $\varepsilon_j^m$ every period. These health expenditure shocks follow a Markov process with age-dependent transition probability matrix $\Pi_j^m$. Transition probabilities to next period's medical spending shock $\varepsilon_{j+1}^m$ depend on the current health shock $\varepsilon_j^m$ so that an element of transition matrix $\Pi_j^m$ is defined as the conditional probability $\Pr\left(\varepsilon_{j+1}^m | \varepsilon_j^m\right)$.

We denote a household's deterministic private health-insurance state by $\mathrm{in}_j$ where $\mathrm{in}_j = 0$ if the household does not have employer provided insurance and $\mathrm{in}_j = 1$ if the household is enrolled in private employer-provided health insurance (EHI). This state is determined when the household becomes economically active. In addition, households qualify for Medicaid if they pass the Medicaid income and asset test (i.e., earnings are less than the threshold $y_{\mathrm{MAid}}$ and asset holdings are below $a_{\mathrm{MAid}}$), and they also qualify for Medicare after the eligibility age $J_r$. "Dual eligibles" are households that qualify for both, EHI and Medicaid before retirement or Medicare and Medicaid after retirement. In this case Medicaid is the secondary insurance or the payer of last resort. For "Triple eligibles" Medicare is the primary insurance, EHI is the secondary and Medicaid is the tertiary insurance. The out-of-pocket medical expenditures are therefore insurance-state dependent and can be written as

$$
o\left(\varepsilon_j^m\right)=\begin{cases}
\left(1-\overbrace{1_{[\text{MAid-Yes}]}\kappa_{\text{MAid}}}^{\text{Primary HI}}\right)\times\varepsilon_j^m & \text{if } \text{in}_j=0\,\wedge\, j<J_r\\
\left(1-\overbrace{\kappa_{\text{EHI}}}^{\text{Primary}}-\overbrace{1_{[\text{MAid-Yes}]}\kappa_{\text{MAid}}\left(1-\kappa_{\text{EHI}}\right)}^{\text{Medicaid is secondary HI}}\right)\times\varepsilon_j^m & \text{if } \text{in}_j=1\wedge j<J_r\\
\left(1-\overbrace{\kappa_{\text{MCare}}}^{\text{Primary}}-\overbrace{1_{[\text{MAid-Yes}]}\kappa_{\text{MAid}}\left(1-\kappa_{\text{MCare}}\right)}^{\text{Medicaid is secondary HI}}\right)\times\varepsilon_j^m & \text{if } \text{in}_j=0\,\wedge\, j\geq J_r\wedge n_j>0,\\
\left(\begin{array}{c}1-\overbrace{\kappa_{\text{MCare}}}^{\text{Primary}}-\overbrace{\kappa_{\text{EHI}}\left(1-\kappa_{\text{MCare}}\right)}^{\text{EHI is secondary HI}}\\ -\overbrace{1_{[\text{MAid-Yes}]}\kappa_{\text{MAid}}\left(1-\kappa_{\text{EHI}}\left(1-\kappa_{\text{MCare}}\right)-\kappa_{\text{MCare}}\right)}^{\text{Medicaid is tertiary HI}}\end{array}\right)\times\varepsilon_j^m & \text{if } \text{in}_j=1\,\wedge\, j\geq J_r\wedge n_j>0,\\
\left(1-\overbrace{\kappa_{\text{MCare}}}^{\text{Primary}}-\overbrace{1_{[\text{MAid-Yes}]}\kappa_{\text{MAid}}\left(1-\kappa_{\text{MCare}}\right)}^{\text{Medicaid is secondary HI}}\right)\times\varepsilon_j^m & \text{if } \text{in}_j=0\, j\geq J_r\wedge n_j=0,
\end{cases},
$$

where $\kappa_{\text{EHI}}$ is the reimbursement rate of EHI, $\kappa_{\text{MAid}}$ is the reimbursement rate of Medicaid, and $\kappa_{\text{MCare}}$ is the reimbursement rate of Medicare. Households with EHI pay a premium of $p_{\text{EHI}}$ every period, and households on Medicare pay Medicare Plan B Premium of $p_{\text{MCare}}$. Finally, we assume that a fixed percentage of every newborn cohort enters the model uninsured, i.e. with $\text{in}_j=0$.

### 3.4 Income process

Conditional on labor force participation, a household earns before-tax wage income $y(j)=w\times e_j\left(\vartheta,h,\varepsilon_j^n\right)\times n_j$ at age $j$, where $w$ is the wage rate, and $e_j\left(\vartheta,h,\varepsilon_j^n\right)$ is a labor productivity endowment that depends on age $j$, a permanent income group $\vartheta$, health status $h$, and an idiosyncratic productivity shock $\varepsilon_j^n$. The transition probabilities for the idiosyncratic productivity shock $\varepsilon_j^n$ follows a Markov process with transition probability matrix $\Pi^n$. Let an element of this transition matrix be defined as the conditional probability $\Pr\left(\varepsilon_{j+1}^n|\varepsilon_j^n\right)$, where the probability of next period's labor productivity $\varepsilon_{j+1}^n$ depends on today's productivity $\varepsilon_j^n$. We denote health status $h$ as a binary variable $h\in\{\text{healthy},\text{sick}\}$, which determines the labor productivity endowment $e_j\left(\vartheta,h,\varepsilon_j^n\right)$.

### 3.5 Technology and factor prices

The economy consists of firms that use physical capital $K$ and effective labor services $L$ to produce output. Firms are perfectly competitive and solve the following maximization problem

$$\max_{\{K,\ L\}} \left\{F\left(K, L\right) - (q+\delta)K - wL\right\}, \tag{1}$$

taking the rental rate of capital $q$ and the wage rate $w$ as given. Capital depreciates at rate $\delta$ in each period.

### 3.6 Government

**Tax Revenue.** The government collects three separate taxes: a progressive labor income tax on taxable income $y_j$ denoted $T_y(y_j)$, and payroll taxes $T_{ss}(y_j^n; \bar{y})$ and $T_{\text{MCare}}(y_j^n)$ for Social Security and Medicare respectively collected on labor income $y_j^n$. The payroll tax for Social Security is proportional only up to the maximum taxable earnings of $\bar{y}$.

**Government Spending.** The government has the following spending programs: Social Security , Medicare, Medicaid, lump-sum transfers to low income earners  to guarantee a minimum consumption level, and unproductive government consumption.

Households receive Social Security benefits after the eligibility age ($J_r$), and the amount of benefits paid to a particular household depends on its earnings history. For each household, the government calculates an average of past earnings (up to the maximum taxable earnings), referred to as the Average Indexed Monthly Earnings ($AIME$). The Social Security benefit amount, also called the Primary Insurance Amount (PIA), $b_{ss,j}$ (AIME) is a function of AIME.[3]

Households become eligible for Medicare after age $J_r$.,at which point they also start paying a Medicare premium $p_{\text{MCare}}$every period. We assume that the government's budgets, both for Social Security and Medicare, are balanced. This implies

$$\int 1_{[j\geq J_r]} b_{ss}(\text{AIME}\left(\boldsymbol{x}\right)) d\Lambda(\boldsymbol{x}) = \int T_{ss}\left(w \times e(\boldsymbol{x}) n(\boldsymbol{x});\, \bar{y}\right) d\Lambda(\boldsymbol{x}), \tag{2}$$

and

$$\int_{j\geq J_r} \kappa_{\text{MCare}} \varepsilon_j^m(\boldsymbol{x}) d\Lambda(\boldsymbol{x}) = \int \left(T_{\text{MCare}}\left(w \times e(\boldsymbol{x}) n(\boldsymbol{x})\right) + 1_{[j\geq J_r]} p_{\text{MCare}}\right) d\Lambda(\boldsymbol{x}). \tag{3}$$

Households become eligible for Medicaid payments if they pass and income and asset test $y(\boldsymbol{x}) < y_{\text{MAid}}$ and $a_j < a_{\text{MAid}}$.

**Balanced budget condition.** The government also finances a minimum consumption floor with social transfers $b_{si}$. The level of expenditures on unproductive government consumption $G$ is

[3] While in reality, Social Security has a trust fund and does not satisfy the definition of a Pay-As-You-Go program in the narrow sense, it is a common practice in the literature to ignore the trust fund and model Social Security's budget as balanced every period (See, for example, studies such as Huggett and Ventura (1999*b*), Conesa and Krueger (1999*a*), İmrohoroğlu, İmrohoroğlu and Joines (2003), Jeske (2003), Conesa and Garriga (2009), and Zhao (2014*a*), among others). This is due to disagreement on whether or not the trust fund assets are "real", i.e., whether or not they have increased national saving. In fact, Smetters (2003) finds that the trust funds assets have actually increased the level of debt held by the public, or reduced national saving.

the residual such that its total revenues from capital and labor income taxes are sufficient to finance its expenditures:

$$G+\overbrace{\int\left(1_{[\text{MAid-Yes}]}\kappa_{Maid}\varepsilon_j^m(\boldsymbol{x})\right)d\Lambda(\boldsymbol{x})}^{\text{Medicaid payments}}+\overbrace{\int b_{si}\left(\boldsymbol{x}\right)d\Lambda(\boldsymbol{x})}^{\text{social transfers}}=\int T_y\left(y(\boldsymbol{x})\right)d\Lambda(\boldsymbol{x}). \tag{4}$$

### 3.7 Insurance companies

Private insurance companies set premiums $p$ so that their zero-profit condition is satisfied

$$\kappa\int 1_{[\text{in}_j=1\,\wedge\,\text{MAid-No}]}m(\boldsymbol{x})d\Lambda(\boldsymbol{x})=p\int 1_{[\text{in}_j=1\,\wedge\,y_j(x)>y_{\text{MAid}}]}d\Lambda(\boldsymbol{x}). \tag{5}$$

### 3.8 The household maximization problem

The state vector of a household at a particular age is defined as $x_j=\left\{\vartheta,a_j,\text{AIME}_j,\text{in}_j,\varepsilon_j^n,\varepsilon_j^m\right\}\in\{1,2,3\}\times R^+\times R^+\times\{0,1\}\times R^+\times R^+$, where $\vartheta$ denotes the permanent income group of no-school, high-school and college types, $a_j$ denotes the beginning-of-period assets, $\text{AIME}_j$ denotes the average past earnings that determine Social Security benefits, $\text{in}_j$ denotes the deterministic health insurance state, $\varepsilon_j^n$ denotes the labor shock, and $\varepsilon_j^m$ denotes the health expenditure shock.

After the realization of the state variables, agents simultaneously chose from their choice set

$$\mathcal{C}_j\equiv\{(c_j,l_j,a_{j+1})\in R_+\times R_+\times R_+\}$$

where $c_j$ is consumption, $l_j$ is leisure, and $a_{j+1}$ are asset holdings for the next period, in order to maximize their lifetime utility. All choice variables in the optimization problem are functions of the state vector but we suppress this notation in order to not clutter the exposition.

**Working households.** The household problem of the working household can recursively be written as

$$V\left(x_j\right)=\max_{\{c_j,n_j,a_{j+1}\}}\left\{u\left(c_j,l_j;\bar{n}_j\cdot 1_{[n_{min}\leq n_j]}\right)+\beta\left(\pi_j\mathbb{E}\left[V\left(x_{j+1}\right)|\,x_j\right]+\left(1-\pi_j\right)b\left(a_{j+1}\right)\right)\right\} \tag{6}$$

$s.t.$

$$c_j+a_{j+1}\quad\overbrace{+o_j\left(\varepsilon_j^m\right)+}^{\text{Health spending risk}}\quad 1_{[\text{in}_j=1\,\wedge\,\text{MAid-No}]}p_{\text{EHI}}+1_{[j\geq J_r]}p_{\text{MCare}}+T_y\left(y_j\right)+T_{\text{ss}}\left(y_{n,j};\bar{y}\right)+T_{\text{MCare}}\left(y_{n,j}\right) \tag{7}$$
$$=\left(1+r\right)a_j+y_{n,j}+1_{[j\geq J_r]}b_{ss,j}\left(\text{AIME}_j\right)+b_{si,j}+\bar{b},$$

where $\beta$ is a time preference factor, $\pi_j$ is the age dependent survival probability, $w$ is the market wage rate, $r$ is the interest rate, $o_j$ is out-of-pocket medical spending, $p_{\text{EHI}}$ is the EHI premium,

$p_{\text{MCare}}$ is the Medicare Plan B premium, after tax income is

$$y_j^{\text{at}} = y_{\text{AGI},j} - T_y\left(y_j\right) - T_{\text{ss}}\left(y_{n,j}; \bar{y}\right) - T_{\text{MCare}}\left(y_{n,j}\right), \tag{8}$$

where $T_y$ is a progressive income tax function of taxable household income $y_j$, $T_{\text{ss}}$ is a social security payroll tax function of labor income $y_{n,j}$ and $T_{\text{MCare}}$ is a Medicare payroll function of labor income. Labor income $y_{n,j}$ and total taxable income $y_j$ are defined as

$$\begin{aligned} y_{n,j} &= w \overbrace{\times e_j\left(\vartheta, h, \varepsilon_j^n\right) \times}^{\text{Health affecting income}} (1 - l_j), \\ y_{\text{AGI},j} &= y_{n,j} + r \times a_j + 1_{[j \geq J_r]} b_{ss,j}\left(\text{AIME}_j\right), \\ y_j &= y_{\text{AGI},j} - 1_{[\text{in}_j = 1 \wedge \text{MAid-No}]} p_{\text{EHI}} - \max\left[0, \left(o_j\left(\varepsilon_j^m\right) + 1_{[j \geq J_r]} p_{\text{MCare}}\right) - 0.075 \times y_{\text{AGI},j}\right], \end{aligned} \tag{9}$$

where $y_{\text{AGI},j}$ is adjusted gross income. In addition, private health insurance premiums are tax deductible as are out-of-pocket health expenses and Medicare premiums that exceed 7.5 percent of $y_{\text{AGI}}$.[4] Social security payments are denoted $b_{ss,j}$ and social transfers are defined as

$$b_{si,j} = \max\left[0,\ \underline{c} + o_j\left(\varepsilon_j^m\right) + 1_{[\text{in}_j = 1 \wedge \text{MAid-No}]} p_{\text{EHI}} + 1_{[j \geq J_r]} p_{\text{MCare}} - y_j^{\text{at}} - a_j - b_{ss,j} - \bar{b}\right],$$

and ensure a minimum consumption floor $\underline{c}$ after medical expenses, insurance premiums and taxes are paid for. A household consuming at the lower bound cannot save into the next period. Accidental bequests are denoted $\bar{b}$.

Average past labor earnings follows

$$\text{AIME}_{j+1} = \begin{cases} \min\left(\frac{(j-1) \times \text{AIME}_j + y_{n,j}}{j}, \bar{y}\right) & \text{if } 1 \leq j < J_r, \\ \text{AIME}_j & \text{if } j \geq J_r, \end{cases}$$

and

$$0 \leq l_j \leq 1,$$

and $J_r$ is the eligibility age for Social Security and Medicare. The indicator functions are defined as $1_{[true]} = 1$ and $1_{[false]} = 0$.

**Fully retired households.** Households can stop working at any time, however they can only begin to draw social security benefits and qualify for Medicare starting at age $j > J_r$. If they withdraw from the labor force then, retirement becomes an absorptive state. Once individuals turn

[4] We assume 100 percent wage pass through from employers to employees so that the employer portion of health insurance premiums is directly paid for by households. The tax deductibility is then also modeled on the household side. Details about the tax deductibility of out-of-pocket expenses and Medicare premiums can be found in IRS (2010).

$j > J_r$ they are forced to retire. A retired households optimization problem reduces to

$$V\left(x_j\right) = \max_{\{c_j, a_{j+1}\}} \left\{ u\left(c_j\right) + \beta\left(\pi_j \mathbb{E}\left[V\left(x_{j+1}\right) \mid x_j\right] + \left(1-\pi_j\right) b\left(a_{j+1}\right)\right)\right\} \tag{10}$$

$s.t.$

$$c_j + a_{j+1} + o_j\left(\varepsilon_j^m\right) + p_{\text{MCare}} + T_y\left(y_j\right) = \left(1+r\right) a_j + b_{ss,j}\left(\text{AIME}_j\right) + b_{si,j} + \bar{b}, \tag{11}$$

where adjusted gross income $y_{\text{AGI}}$ and taxable income $y_j$ is defined as

$$\begin{aligned} y_{\text{AGI},j} &= r \times a_j + b_{ss,j}\left(\text{AIME}_j\right). \\ y_j &= y_{\text{AGI},j} - \max\left[0, \left(o_j\left(\varepsilon_j^m\right) + 1_{[j \geq J_r]} p_{\text{MCare}}\right) - 0.075 \times y_{\text{AGI},j}\right]. \end{aligned}$$

Social transfers are defined as

$$b_{si,j} = \max\left[0,\ \underline{c} + o_j\left(\varepsilon_j^m\right) + p_{\text{MCare}} + T_y\left(y_j\right) - \left(1+r\right) a_j - b_{ss,j} - \bar{b}\right].$$

**Aggregation.** We denote $\boldsymbol{x} \equiv \{j,\, x_j\}$ as the augmented state vector including age $j$ and $\Lambda\left(\boldsymbol{x}\right)$ is the measure of households with state $\boldsymbol{x}$ which incorporates the relative cohort sizes $\mu_j$.

### 3.9 Equilibrium

Given the transition probability matrices $\left\{\Pi_j^n, \Pi_j^m\right\}_{j=1}^{J}$, the survival probabilities $\{\pi_j\}_{j=1}^{J}$ and the exogenous government policies $\{T_y, T_{\text{ss}}, T_{\text{MCare}}, b_{si}, b_{ss}, \kappa_{\text{MCare}}, \kappa_{\text{MAid}}, G\}_{j=1}^{J}$, a competitive equilibrium is a collection of sequences of distributions $\Lambda\left(\boldsymbol{x}\right)$ of individual household decisions $\{c\left(\boldsymbol{x}\right), n\left(\boldsymbol{x}\right), a\left(\boldsymbol{x}\right)\}$, aggregate stocks of physical capital and effective labor services $\{K, L\}$, factor prices $\{w, q, R\}$, and insurance premiums $\text{prem}^{\text{GHI}}$ such that:

($a$) $\{c\left(\boldsymbol{x}\right), l\left(\boldsymbol{x}\right), a\left(\boldsymbol{x}\right)\}$ solves the consumer problem (6, 7) ,

($b$) the firm first order conditions hold in both sectors

$$\begin{aligned} w &= \frac{\partial F\left(K, L\right)}{\partial L}, \\ q &= \frac{\partial F\left(K, L\right)}{\partial K} - \delta, \end{aligned}$$

($c$) markets clear

$$K = \int a(\boldsymbol{x}) d\Lambda(\boldsymbol{x}) \tag{12}$$

$$L = \int e(\boldsymbol{x}) n(\boldsymbol{x}) d\Lambda(\boldsymbol{x}). \tag{13}$$

$$T^{\text{Beq}} = \sum_{j=1}^{J} \tilde{\mu}_j \int a_j (x_j) \, d\Lambda (x_j) ,$$

($d$) the aggregate resource constraint holds

$$G + K + \int \left( c(\boldsymbol{x}) + \varepsilon_j^m (\boldsymbol{x}) \right) d\Lambda (\boldsymbol{x}) = Y + (1 - \delta) K,$$

($e$) the government programs clear so that (2) , (3) , and (4) hold,

($f$) the budget conditions of the insurance companies (5) hold and

($g$) the distribution is stationary

$$(\mu_{j+1}, \Lambda (x_{j+1})) = T_{\mu,\Lambda} (\mu_j, \Lambda (x_j)) ,$$

where $T_{\mu,\Lambda}$ is a one period transition operator on the measure distribution

$$\Lambda \left( \boldsymbol{x'} \right) = T_{\Lambda} (\Lambda (\boldsymbol{x})) .$$

# 4 Calibration

We calibrate the model developed in the previous section to match the U.S. economy. We entertain macroeconomic data targets such as overall capital accumulation, pattern of labor supply and health/medical expenditures over the life cycle, the life-cycle pattern of income heterogeneity, and also the share of medical and government expenditures in GDP. While calibrating the model, we pay special attention to the institutional details of Social Security, Medicare, and Medicaid, especially those relevant for its insurance effects against health risk.

For the calibration we distinguish between two sets of parameters: ($i$) *externally* selected parameters and ($ii$) *internally calibrated* parameters. *Externally* selected parameters are estimated independently from our model and are either based on our own estimates using data from the Medical Expenditure Panel Survey (MEPS) or the Panel Survey of Income Dynamics (PSID) or estimates provided by other studies. We summarize these external parameters in Table 1. *Internal* parameters are calibrated so that model-generated data match a given set of targets from U.S. data. These parameters are presented in Table 2. Model generated data moments and target moments from U.S. data are juxtaposed in Table 4.

## 4.1 Demographics

One model period is defined as one year. We model households from age 20 to age 95 which results in $J = 75$ periods. The retirement choice periods are $j \in (J_r + 1, J_R] = [41, 60]$ which corresponds to ages 65 and 84 respectively. Once the individual enters period 61, i.e. age 85, she is forced to retire. We set the population growth rate to $\mathfrak{n} = 1$ percent, and we take the age-specific death rates from the U.S. Life Tables (Arias, 2004*a*) to generate conditional survival probabilities that determine the relative cohort sizes $\mu_j$. In the model the total population over the age of 65 is very close to the 17.4 percent in the census.

### 4.2 Preferences

We specify period utility as

$$u(c_j, l_j; \bar{n}_j) = \frac{\left(c_j^{\eta} \times \left[l_j - \bar{n}_j \cdot 1_{[n_{min} \le n_j]}\right]^{1-\eta}\right)^{1-\sigma}}{1-\sigma}.$$

The fixed cost of working $\bar{n}_j$ is set to match the labor force participation rates from PSID. We set the relative risk aversion parameter $\sigma$ to 2.5, and the intertemporal discount factor $\beta$ to 0.99 to match the capital-output ratio target in equilibrium. The consumption intensity parameter $\eta$ is 0.25 to match the aggregate labor hours per worker target.

The warm-glow bequest function is

$$b(a_j) = \theta_0 \frac{(a_j + \theta_1)^{(1-\sigma)\eta}}{1-\sigma},$$

where $\theta_1$ determines the curvature of the function. This functional form is similar to the one in French (2005).[5] Parameter $\theta_0$ is a scaling parameter that is set to match the asset holdings of retired individuals.

### 4.3 Health expenditure shocks and health insurance status

We use data from MEPS 1999–2012 to estimate the magnitude of the age dependent health expenditure shocks $\varepsilon_j^m$ as well as the Markov transition probability matrix $\Pr\left(\varepsilon_{j+1}^m | \varepsilon_j^m\right)$. We group individuals into five health groups $h_g \in \{1, 2, 3, 4, 5\}$ by self-reported health status. The five groups report having "1. excellent health", "2. very good health", "3. good health", "4. fair health" and "5. poor health". We then calculate average medical spending by health group and age to determine the magnitude of the health spending shocks $\varepsilon_j^m$ associated with the self-reported health status $h_{g,j}$. Figure 13 in Online Appendix F plots the distribution of health groups by age and Figure 14 shows the associated distribution of medical spending shocks by health group and age.

We next estimate an ordered logit model to determine the conditional probability of moving to a specific health group $h_{g,j+1,t+1}$ in year $t+1$ conditional on being a member of health group $h_{g,j,t}$ at time $t$ of a $j$ year old individual. Figures 15–19 in Online Appendix F depict the conditional transition probabilities between the health groups.

Based on the five health groups we define two health states that together with educational

[5]This warm-glow type bequest motive was first introduced by Andreoni (1989) and used in a general equilibrium model in De Nardi (2004). A more sophisticated form of altruism would require an additional state variable and exceed our current computational capacity.

attainment determine the wage efficiency profile. The two health states are

$$h = \begin{cases} \text{healthy} & \text{if } h_g \in \{1,2,3\} \\ \text{sick} & \text{if } h_g \in \{4,5\}. \end{cases}$$

These are standard definitions for healthy/sick in the health macro literature. Figure 1 depicts the fraction of healthy individuals per age group.

Following Zhao (2014*a*), we assume that the fraction of newborn households with employer provided health insurance is 70 percent. At the age of 65 households become eligible for Medicare and are assumed to enroll in it. A household is eligible for Medicaid if it passes an earnings test, which can become their secondary insurance if they already have private insurance or Medicare. In rare cases, Medicaid may be tertiary insurance if households that are older than 65 are still working and qualify for Medicare. In this case Medicare becomes primary insurance, private employer sponsored insurance is the secondary and Medicaid functions as tertiary insurance.

## 4.4 Income process

To calibrate the labor income process, we assume that labor productivity at age $j$ can be decomposed as

$$e_j\left(\vartheta, h, \varepsilon_j^n\right) = \bar{e}_j\left(\vartheta, h\right) \times \exp\left(\varepsilon_j^n\right), \tag{14}$$

where $\bar{e}_j(\vartheta, h)$ is a deterministic age $j$, education level $\vartheta$, and health state $h$ dependent deterministic component, and $\varepsilon_j^n$ is a stochastic component, given by

$$\varepsilon_j^n = z_j + \epsilon_{1,j}, \tag{15}$$

$$z_j = \rho z_{j-1} + \epsilon_{2,j}. \tag{16}$$

The education level is permanent and fixed at age 20. We define three permanent educational groups:

$$\vartheta = \begin{cases} 1 & \text{if less than high school,} \\ 2 & \text{if high school,} \\ 3 & \text{if college graduate or higher.} \end{cases}$$

According to MEPS data the relative share of these subgroups in our sample are 18.6, 46.76 and 34.64 percent respectively. Income is determined by a transitory shock $\epsilon_{1,j} \sim N\left(0, \sigma_{\epsilon_1}^2\right)$ and a persistent shock $z_j$. The persistent shock follows a first-order autoregressive process with $z_0 = 0$, persistence parameter $\rho$, and a white-noise disturbance $\epsilon_{2,j} \sim N\left(0, \sigma_{\epsilon_2}^2\right)$.

**Stochastic component.** To calibrate the stochastic component, we use estimates from Heathcote, Perri and Violante (2010*a*) and set the persistence parameter to $\rho = 0.973$, the variances of the transitory shock $\sigma_{\epsilon_1}^2 = 0.04$, and the variance of the white-noise disturbance to $\sigma_{\epsilon_2 \upsilon}^2 = 0.01$. We approximate the joint distribution of the persistent and transitory shocks using a five-state first-order discrete Markov process following Tauchen and Hussey (1991*a*).

**Deterministic component.** We construct the deterministic component of the labor income profiles for each subgroup $(\vartheta, h)$ following the procedure in French (2005) and Pashchenko and Porapakkarm (2013*a*). This procedure controls for selection issues and the fact that we only observe the labor income of the working individuals. With this procedure we are also able to determine the labor efficiency profile of non-working individuals. We proceed as follows.

For each subgroup $(\vartheta, h)$ we guess a cubic polynomial in age for the deterministic part of the income process

$$\bar{e}_j(\vartheta, h) = e_0(\vartheta, h) + e_1(\vartheta, h) \times j + e_2(\vartheta, h) \times j^2 + e_3(\vartheta, h) \times j^3.$$

This leaves us with four unknown parameters per subgroup.

From MEPS data between 1999–2012 we construct labor income profiles for each subgroup. Our definition of labor income follows the definition in PSID and comprises wage income (variable WAGEP) and 75 percent of business income (variable BUSNP). We deflate this variable with the CPI and remove cohort effects as described in Online Appendix C. We next remove individuals with incomes smaller than $400 and calculate population weighted profiles of labor income by education and health status. We finally smooth the labor income profiles with a third degree polynomial in age. Figure 4 shows the labor income lifecycle profiles per subgroup. We use a starting guesses for the unknown parameters of the deterministic income polynomial and solve the model. We then update our initial guesses by solving directly for the four parameters of the polynomial. Since we have to solve for four parameters in the deterministic (age efficiency) profiles we pick four data moments from the labor income profiles from MEPS for each subgroup. More specifically we use the population weighted average labor income of 25 , 40 , 50, and 60 year olds so that $\bar{I}_j(\vartheta, h)$ is the population weighted average labor income of age group $j$, education group $\vartheta$, and health group $h$ for $j = \{25, 40, 50, 60\}$ in US dollars from MEPS. We then set the expected labor income from the model equal to the data moment for each age group and solve directly for the parameters of the cubic polynomials. Online Appendix **??** provides a formal setup of this procedure. We then resolve the model with the new deterministic income profile. Figure 4 shows how the model income process matches the income process from MEPS for the health/education subgroups.

## 4.5 Technology and factor prices

We assume that output is produced using a Cobb-Douglas production function with inputs capital and labor

$$Y = K^{\alpha}(AL)^{(1-\alpha)}, \tag{17}$$

where $\alpha$ is the share of capital in total income. We set the capital share $\alpha = 0.35$ and the annual capital depreciation rate at $\delta = 0.06$, which are both similar to standard values in the calibration literature (e.g., Kydland and Prescott (1982)). Total factor productivity $A$ is normalized to unity.

## 4.6 Government

**Taxes.** The progressive income tax function has the following specification

$$T_y(y) = \max\left[0,\, y - \tau_0 \times y^{(1-\tau_1)}\right],$$

where $T_y(y)$ denotes net tax revenues as a function of pre-tax income $y$ , $\tau_1$ is the progressivity parameter, and $\tau_0$ is a scaling factor to match U.S. income tax revenue.[6] We impose a non-negative tax payment restriction in the benchmark model, $T_y(y) \geq 0$. This restriction excludes all government transfers embedded in the progressive tax function. Government transfers are explicitly modeled in government spending programs.[7]

The Social Security system is self-financed via a payroll tax with a contribution limit. The tax function is defined as $T_{\text{ss}}(y_{n,j};\bar{y}) = \tau^{SS} \times \max(y_{n,j}, \bar{y})$ with $\tau^{SS} = 10.6$ percent. The Social Security payroll tax is collected on labor income up to a maximum of \$106,800 or 2.47 times median income.[8]

The Medicare tax function is $T_{\text{MCare}}(y_{n,j}) = \tau^{\text{MCare}} \times y_{n,j}$ with $\tau^{\text{MCare}} = 2.9$ percent. It is not restricted by an upper limit (see SSA (2007)). Overall, the model results in total tax revenue of 19.4 percent of GDP. This finances a consumption floor of about \$70 per household per period and residual (unproductive) government consumption of 18.5 percent of GDP.

**Social Security.** The standard retirement age in the model is 65, after which households can start drawing Social Security benefits as well as Medicare benefits. For each household, the government calculates an average of past earnings (up to the maximum taxable earnings), referred to as the Average Indexed Monthly Earnings ($AIME$). The Social Security benefit amount in 2010, also called the Primary Insurance Amount ($PIA$), is calculated as 90 percent of the first \$761 of AIME, plus 32 percent of AIME over \$761 and through \$4,586, plus 15 percent of AIME over \$4,586 up to a maximum AIME of 2.47 of median income.[9] We approximate this step function with the following parsimonious polynomial

$$b_{ss}(\text{AIME}) = \phi_0 \times \text{AIME}^{\phi_1}$$

and use a cap on the AIME grid of 2.47 of median income which corresponds well with the maximum Social Security payments. Parameter $\phi_1 = 0.567$ determines the curvature of the Social Security

[6] This tax function is fairly general and captures the common cases:

$$\begin{cases} \text{(1) Full redistribution: } T_y(y) = y - \tau_0 \text{ and } T_y'(y) = 1 & \text{if } \tau_1 = 1, \\ \text{(2) Progressive: } T_y'(y) = 1 - \overbrace{(1-\tau_1)}^{<1}\tau_0 y^{(-\tau_1)} \text{ and } T_y'(y) > \frac{T_y(y)}{y} & \text{if } 0 < \tau_1 < 1, \\ \text{(3) No redistribution (proportional): } T_y(y) = y - \tau_0 y \text{ and } T_y'(y) = 1 - \tau_0 & \text{if } \tau_1 = 0, \\ \text{(4) Regressive: } T_y(y) = 1 - \overbrace{(1-\tau_1)}^{>1}\tau_0 y^{(-\tau_1)} \text{ and } T_y'(y) < \frac{T_y(y)}{y} & \text{if } \tau_1 < 0. \end{cases}$$

[7] This tax function was implemented into a dynamic setting by Benabou (2002) and more recently in Heathcote, Storesletten and Violante (2017). These authors do not model transfers explicitly and therefore allow income taxes to become negative for low income groups.

[8] Compare contribution bases for Social Security contributions at https://www.ssa.gov/oact/cola/cbb.html

[9] Compare SSA 2010 for bend points in the Social Security benefits formula at: https://www.ssa.gov/oact/cola/bendpoints.html

benefit-earnings formula, and the scale parameter $\phi_0$ adjusts so that Social Security's budget is balanced with the current payroll tax rate and the taxable maximum. Figure 2 depicts the $PIA$ formula and the polynomial approximation that we use in this paper. Total pension payments amount to 5.3 percent of GDP in the baseline equilibrium, similar to the number reported in the budget tables of the Office of Management and Budget (OMB) for 2008. The distribution of pension payments is shown in Figure 5.[10]

**Medicare and Medicaid.** According to data from the National Health Expenditure Accounts (NHEA 2010) Medicare spending in 2010 was 3.47 percent of GDP and Medicaid spending (Federal and State) was 2.65 percent of GDP.[11] Given reimbursement rates for Medicare $\kappa_{\text{MCare}}$ from MEPS shown in Figure 3, the size of Medicare in the model is 4.6 percent. The total premium for Medicare is 2.7 percent of GDP as in Jeske and Kitao (2009*a*). In order to qualify for Medicaid individuals have to pass an earnings test, and we set the eligibility threshold in the model to 100 percent of the federal poverty level (FPL), which is close to the average state eligibility level according to Kaiser (2013) .[12] In addition, the household has to pass an asset test so that her asset holdings are below the threshold of $\bar{a}_{Maid}$ which is calibrated to 17 percent of the FPL. The reimbursement rate Medicaid $\kappa_{\text{MAid}}$ depends on the medical spending level as can be seen in Figure 3 which is based on data from MEPS. Using these reimbursement levels, Medicaid spending in the model is about 1 percent of GDP, which is somewhat lower than the 2.65 percent of GDP in NHEA 2010.

**Consumption Insurance.** The government pays a lump-sum transfer to maintain a minimum level of consumption $c_{min}$ of ??

## 4.7 Insurance companies

We set the reimbursement rate of private insurance companies $\kappa_{\text{PHI}}$ according to MEPS data in Figure 3. PHI premiums $p_{\text{PHI}}$ clear the zero-profit condition (5) and result in annual premium payments of $\$7,654$ in the baseline equilibrium. Claxton et al. (2010) report average annual premiums for employer-sponsored health insurance in 2010 are $\$5,049$for single coverage and $\$13,770$ for family coverage.

## 4.8 Model performance

Table 4 and Figure 4 show the targeted moments for the calibration. In addition we perform checks of non-targeted data moments in Figures 5 and 6.

The model results in medical spending as fraction of GDP of 14.4 percent which is close to the 17.6 percent reported in the data. The percent of workers on Medicaid is 15 percent and slightly below the percentage of workers on Medicaid reported in MEPS. The capital output ratio is 2.98 and close to the standard values of 2.6–3 in the calibration literature. The interest rate in the model is 5.7 percent which is also a standard value in the calibration literature (e.g., Kydland and Prescott

[10] Data for the Social Security benefits distribution is from: https://www.ssa.gov/OACT/ProgData/benefits/ra_mbc201012.html

[11] https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.html

[12] Compare Remler and Glied (2001) and Aizer (2003) for additional discussions of Medicaid take-up rates.

(1982)).

The model provides a close fit for the lifecycle pattern of labor participation and labor supply (Figure 4, Panel 1 and 2). In addition, Panels 4–9 in Figure 4 show the match of labor income by education/health type.

The model reproduces the hump-shaped patterns of asset holdings (Figure 5, Panel 3). In addition, the model provides a close fit of the average HIEU labor income over the lifecycle (Figure 5, Panel 4) as well as gross HIEU income in Panel 5.

The model matches the lower and upper tails of the income distribution with around 12 percent individuals with income below 133 percent of the Medicaid eligibility level (MaidFPL). Finally, Table 4 compares first moments from the model to data moments from MEPS, CMS, and NIPA.

# 5 Experiments

As discussed earlier, we use this calibrated model to compute two sets of experiments. First, in order to evaluate the relative importance of the lifecycle and precautionary saving motives in a household's ability to smooth consumption, we compute the sensitivity of Social Security's welfare effects to the presence or absence of health risk in the households' budget constraint. Second, in order to examine how the degree of redistribution implicit in Social Security affects the welfare gains or losses for households with varying exposure to health risks, we compute the welfare effects of modifying the concavity of Social Security's benefit-earnings rule.

We investigate the effects using the following models. Model 1, the benchmark model described in Section 3 above, allows for health spending shocks in addition to a health dependent income process. Model 2A turns off health spending risk but retains the health dependent income process. Model 2B retains the medical spending shocks but removes the health dependency of the income process. Finally, Model 2C removes all health risk from the model, that is medical spending shocks are turned off and the income process is independent of the health state of the individual. We recalibrate the benchmarks of models 2A, 2B and 2C to match US data before using them to simulate the two policy experiments: Experiment 1 removes Social Security and Experiment 2 changes the progressivity level of Social Security payments.

In order to examine the welfare consequences, we calculate the consumption equivalence variation ($CEV$), which is defined as

$$CEV = \left( \frac{EU_{Experiment}}{EU_{Baseline}} \right)^{\frac{1}{\eta(1-\sigma)}} - 1.$$

Intuitively, this consumption equivalence captures the welfare gains (or losses) as percent of lifetime consumption of a newly entering individual (i.e., a 20 year old in the model) under each one of our computational experiments. We also examine the implications of these experiments for labor supply, consumption, and saving decisions, the markets for goods and services, the values of key macroeconomic aggregates, and the government's budget.

## 5.1 Removing Social Security – Experiment 1

### 5.1.1 Removing Social Security in model with health risk – Model 1

In our first experiment (Experiment 1), we completely eliminate Social Security from the baseline of Model 1 by setting the Social Security payout formula and the Social Security payroll taxes in the household budget constraint (7) equal to zero: $b_{ss,j}\left(\text{AIME}\right) = 0$ and $\tau_{SS} = 0$. We report the results from Experiment 1 in Table 6.

It is clear from the table that, not surprisingly, eliminating Social Security from the model leads to higher saving and labor supply, and a lower interest rate. With fixed medical/health expenditures, the increase in capital stock and labor causes an expansion in output, as a result of which there is a sharp decline in the ratio of medical expenditures to GDP. Finally, the increased labor supply, due to the elimination of Social Security, increases labor income and reduces the percentage of the model population on Medicaid. Overall, by eliminating Social Security a newly entering individual experiences a welfare gain of 135.46 percent of compensating consumption variation compared to entering the benchmark economy of Model 1. This result is consistent with the fact that in a general equilibrium model with endogenous labor supply, Social Security's distortionary welfare losses are larger than the welfare gains that Social Security triggers through partial insurance against labor income and mortality risk (Hubbard and Judd (1987*b*), İmrohoroğlu, İmrohoroğlu and Joines (1995), Bagchi (2015)).

### 5.1.2 Removing Social Security in model without health risk

The above results suggest that in the current model, Social Security has a large negative effect on overall welfare. What is not clear, however, is how much of this negative welfare effect is due to the presence of health risk in the households' budget constraints. This is particularly important, given that it is already well known that Social Security's distortions to labor supply and saving are larger than the partial insurance effects against mortality and labor income risks. To isolate the effect of health risk in the above welfare results, we now design the following two experiments.

First, we compute an alternative version of our baseline model in which we remove health risk from the income side of the household budget constraint. Functionally, this involves removing the correlation between health status $h$ and the age-dependent labor productivity endowment $e_j\left(\vartheta, h, \varepsilon_j^n\right)$ so that the endowment is just a function of the permanent income group and the idiosyncratic health shock $e_j\left(\vartheta, \varepsilon_j^n\right)$. In other words, this specification corresponds to a hypothetical world in which medical spending restores health so that the work ability of the individual is not affected by the health shock. We refer to this version of the framework as Model 2A. Before we proceed to conduct a welfare analysis of Social Security using this hypothetical model, we recalibrate Model 2A to the same US data moments that we used to calibrate Model 1.

Third, we finally remove all health related risk from the model. Specifically, in this case we set the medical expenditure shocks at every age $\varepsilon_j^m = 0$ for all households and also remove health status $h$ from the age-dependent labor productivity endowment which results in $e_j\left(\vartheta, \varepsilon_j^n\right)$. We refer to this framework as Model 2C and calibrate it to the same US data we used to calibrate Model 1. This specification of our model corresponds to the canonical rational-expectations overlapping-generations framework that is routinely used to evaluate dynamic public policy.

**Removing health risk from the income process – Model 2B.** We compare the equilibrium values of key macroeconomic variables under this alternative model in Table 7. The first column is the recalibrated benchmark economy with Social Security and the second column is the economy without Social Security. The table shows that eliminating health risk from the income side of the household budget constraint weakens the precautionary saving motive compared to Model 1 in Table 6. If we completely eliminate Social Security from this alternative model the increase in capital stock is less pronounced than eliminating Social Security from a model with health-income dependence where the precautionary savings motive is much stronger due to the additional risk. As a result, the welfare gains to households under this experiment are smaller at 124.34 percent in compensating consumption. Therefore, comparing our findings from Model 1 and Model 2B we conclude that the effect of uncertain income due to health status risk on the households' precautionary saving motives is quantitatively important. Social Security causes a welfare loss that is considerably smaller in magnitude when we reduce households' need for improved short-term, within work-life, consumption smoothing.

**Removing all health risk – Model 2C.** We again compare the equilibrium values of key macroeconomic variables under this alternative model in Table 8. Eliminating health risk from both, the income and expenditure side of the household budget constraint removes even more of the precautionary savings motive so that eliminating Social Security leads to smaller capital stock increases than in the previous experiments. However, removing Social Security still leads to sizable increases in GDP and welfare gains of 58 percent of compensating consumption of a newly entering individual.

Summarizing the findings from the experiments using Model 1, 2B and 2C we find that the presence of health risk results in sizable differences overall effects of health risk on the households' budget constraints are quantitatively important. Eliminating health risk from both labor income as well as expenditures, we find that Social Security's negative welfare effects are considerably smaller in magnitude.

## 5.2 Changing the level of progressivity of Social Security's benefit-earnings rule – Experiment 2

While the above experiments show that the overall welfare consequences of Social Security are, in fact, sensitive to the presence of health risk in the household budget constraint, they do not shed much light on the importance of Social Security as a partial insurance tool for households exposed to varying levels of health and labor income risk. For example, if the relative importance of long-term work-retirement consumption smoothing and short-term within-period consumption smoothing depends on a household's exposure to health risk, it will be interesting to see which households benefit the most from Social Security's implicit insurance effects.

One of the primary determinants of Social Security's implicit insurance effects is the formula that governs the relationship between a household's past work-life income and the level of Social Security benefits received during retirement. Currently, the U.S. benefit-earnings formula replaces 90 percent of the average work life earnings for a household in the bottom 20 percent of the wage distribution, but only about 40–50 percentage for households with higher income. This concavity in the benefit-earnings rule is intended to facilitate better work-retirement consumption smoothing for households that might experience unfavorable health and labor income shocks in early life.

Given this fact, we now evaluate how changing the curvature of the the Social Security benefit-earnings rule affects the welfare of households exposed to varying levels of health and labor income risk. To do this, we recompute our baseline models under Social Security's curvature parameter values $a_1 = 0.0, 0.25$,0.75, and 1.0. Figure 7 shows the payout formula for various values of curvature parameter $a_1$. It is useful to note here that $a_1 = 0.0$ and $a_1 = 1.0$ correspond to the two corner cases where Social Security benefits are equal for all households and completely unrelated to past work-life income, and when they are a fully proportional (linear) function of past work-life income. Also, note that in each experiment Social Security's scale parameter $a_0$ adjusts to balance the Social Security budget constraint under the current payroll tax rate $\tau^{ss}$, taxable maximum, and the curvature parameter under that experiment.

**Changes in Social Security payout formula with health risk – Model 1.** We report the results from changing the curvature parameter $a_1 = 0.0, 0.25$,0.75, and 1.0 for Model 1 with all the health risk channels active in Table 9. We also show distributions of labor income, assets, and Social Security payouts in Figure 8.

It is clear from the table that in general, making Social Security's benefit-earnings rule less progressive (increase $a_1$) will reduce the implicit redistribution through Social Security and therefore lower welfare of low income groups. For example, sick households experience a welfare loss equivalent to a 2-11 percent decline in compensating consumption with a benefit-earnings rules *less* progressive than the baseline, but healthy households experience much smaller losses. In fact, healthy households with a college degree are the only ones to experience a slight welfare gain under the fully proportional (linear) benefit-earnings rule.

Conversely, making Social Security's benefit-earnings rule more progressive compared to the benchmark economy has a large positive effects on sick household with low education. For example, sick households experience a welfare gain equivalent to a 7–28 percent increase in compensating consumption with benefit-earnings rules *more* progressive than the baseline, but healthy households experience only a 20 percent gain. Healthy households with a college degree are the only ones to experience welfare losses under the equal-benefit rule. Overall, we find evidence of welfare gains of 14 percent of compensating lifetime consumption from a benefit-earnings rule that is *more* progressive than the current U.S. rule when health risk affects household income and triggers medical spending shocks.

**Changes in Social Security payout formula without health risk in income process – Model 2B.** We next provide a similar analysis for the case where health does not affect the income process but with health expenditure shocks still present. Table

33 as well as Figure 9. We find a similar pattern but smaller magnitudes in terms of welfare

gains and losses.

**Changes in Social Security payout formula without any health risk – Model 2C.** We finally present the analysis for the case without any health risk in Table 34 and Figure 10. We find the already similar pattern that a more progressive Social Security payout formula will benefit the sicker and lower income population and hurt the healthier and higher income population. However, without any health risk present these welfare effects are significantly smaller.

In summary we find that in the presence of health expenditure and health income risk a highly progressive Social Security benefit formula leads to the highest welfare outcome (see Table 9) whereas in a model without health expenditure and health income risk, the least progressive (linear) benefit formula leads to the highest welfare outcome (see Table 34). In both cases we assume a fixed (and identical) size of Social Security payroll taxes that finance the payouts.

# 6 Conclusions

In this paper, we quantitatively examine the welfare implications of Social Security in an environment where it provides partial insurance against mortality, labor income, as well as health risks. To do this, we construct a calibrated general-equilibrium macroeconomic model with households, firms, markets for goods and services, and a government. Then, we compute the welfare effects of Social Security using this calibrated model. First, to evaluate the relative importance of the life-cycle and precautionary saving motives in a household's ability to smooth consumption in this environment, we compute the sensitivity of Social Security's welfare effects to the presence or absence of health risk in the households' budget constraints. Second, to examine how the degree of redistribution implicit in Social Security affects the welfare gains or losses for households with varying exposure to health risks, we compute the welfare effects of modifying the concavity of Social Security's benefit-earnings rule. We also examine the implications of these experiments for labor supply, consumption, and saving decisions, the markets for goods and services, the values of key macroeconomic aggregates, and also the government's budget.

Our findings from the computational experiments are twofold. First, we find that the presence of health risk actually worsens the welfare implications of Social Security, rather than improving them. This is because health risk increases the importance of short-term, within-work-life consumption smoothing from the perspective of a household, but Social Security interferes with the precautionary saving motive and negatively affects the ability to effectively accomplish that. In addition to the standard distortionary effects on labor supply and capital accumulation, we find that this effect is strong enough to cause a larger welfare loss from Social Security when health risk affects both household income and expenditures, as well as when it affects only household income. Second, we find that holding the payroll tax constant, making Social Security's benefit-earnings rule *less* concave (i.e. *reducing* the implicit redistribution) has a large negative effect on households with low education and worse health risks. Conversely, making Social Security's benefit-earnings rule *more* concave (i.e. *increasing* the implicit redistribution) has a large positive effect on households with low education and worse health risks. Overall, we find evidence of small welfare gains from a benefit-earnings rule that is *more* progressive than the current U.S. rule when health risk affects both household income and expenditures.

We leave human capital accumulation processes that can be affected by health investments for future analysis. In addition, we also assume stable demographic preferences and exogenous health spending risk. Modeling an endogenous health capital investment processes that can affect survival and productivity is left for future research.

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# A Tables

| Parameter Description | Parameter Values | Source |
|---|---|---|
| Periods | $J = 75$ | |
| Periods work choice | $J_r = 40$ | |
| Periods forced retirement | $J_R = 60$ | |
| Years modeled | $years = 75$ | Age 20–95 |
| Population growth rate | $n = 1.2\%$ | CMS 2010 |
| GDP growth rate | $g = 2\%$ | NIPA |
| Total factor productivity | $A = 1$ | Normalization |
| Capital share in production | $\alpha = 0.35$ | Kydland and Prescott (1982) |
| Capital depreciation | $\delta = 6\%$ | Kydland and Prescott (1982) |
| Survival probabilities | $\pi_j$ | CMS 2010 |
| Health Shocks | $\varepsilon_j^m$ see Technical Appendix | MEPS 1999–2009 |
| Health transition prob. | $\Pi_j^m$ see Technical Appendix | MEPS 1999–2009 |
| Persistent labor shock autocorrelation | $\rho = 0.973$ | Heathcote, Storesletten and Violante (2010) |
| Variance of transitory labor shock | $\sigma_{\epsilon_1}^2 = 0.04$ | Heathcote, Storesletten and Violante (2010) |
| Variance of white noise shock | $\sigma_{\epsilon_2}^2 = 0.005$ | Heathcote, Storesletten and Violante (2010) |
| Reimbursement Rates: PHI | $\kappa_j$ see Figure 3 | MEPS 1999–2009 |
| Medicaid reimbursement rate in % | $\kappa_{\text{MAid},j}$ see Figure 3 | CMS 2005 |
| Medicare reimbursement rate in % | $\kappa_{\text{MCare}} = 20\%$ | CMS 2005 |
| Payroll tax Social Security: | $\tau^{Soc} = 9.4\%$ | IRS |
| Payroll tax Medicare: | $\tau^{Med} = 2.9\%$ | SSA (2007) |
| Tax progressivity parameter | $\tau_1 = 0.053$ | Guner, Lopez-Daneri and Ventura (2016) |
| Pension progressivity parameter | $\phi_1 = 0.567$ | SSA 2010 |

Table 1: **External parameters**

These parameters are based on our own estimates from MEPS and CMS data as well as other studies.

| Parameters Description | Parameter Values | Calibration Target | Nr.M. |
|---|---|---|---|
| Relative risk aversion | $\sigma = 2.5$ | to match $\frac{K}{Y}$ and $r$ | 1 |
| Pref. of consumption vs. leisure | $\eta = 0.25$ | to match labor supply and $\frac{p\times M}{Y}$ | 1 |
| Discount factor | $\beta = 0.99$ | to match $\frac{K}{Y}$ and $r$ | 1 |
| Bequest scale parameter | $\theta_0 = 0.2$ | to match asset holding of old | 1 |
| Bequest curvature parameter | $\theta_1 \approx 0.0$ | to match asset holding of old | 1 |
| Tax scaling parameter | $\tau_0 = 1.52$ | to match tax revenue | 1 |
| Pension scale parameter | $\phi_0 = 2.45$ | to match size of Social Security | 1 |
| Fixed time cost of labor | $\bar{n_j}$ Figure 4 | to match avge. work hours | 40 |
| Deterministic income process | $e_0(\vartheta, h)$–$e_3(\vartheta, h)$ | to match labor inc. by $(\vartheta, h)$ group | 32 |
| Medicare premium | $p_{\text{MCare}} = 10.6$ | to match Medicare premiums$/Y$ | 1 |
| Asset test level | $\bar{a}_{Maid} = 17\%$ of FPL | to match Medicaid take-up | 1 |
| Consumption floor | $c_{min} =??$ | | |
| Total number of internal parameters | | | 81 |

Table 2: **Internal parameters**

We choose these parameters in order to match a set of target moments in the data.

| Moments | Model=Data | Source |
|---|---|---|
| Sick-No School | 1.8% | MEPS 1999–2012 |
| Sick-High School | 4.6% | |
| Sick-College | 3.4% | |
| Healthy-No School | 16.76% | |
| Healthy-High School | 42.14% | |
| Healthy-College | 31.22% | |

Table 3: **Exogenous Health Shocks and Relative Cohort Sizes**
The health shock and the definition of sick/healthy state results in the above cohort sizes.

| Moments | Model | Data | Source | Nr.M. |
|---|---|---|---|---|
| Medical expenses HH income | 14.4% | 17.07% | CMS communication | 1 |
| Workers on Medicaid | 9.6% | 9.2% | MEPS 1999–2009 | 1 |
| Capital output ratio: $K/Y$ | 2.7 | 2.6 – 3 | NIPA | 1 |
| Interest rate: $r$ | 4.2% | 4% | NIPA | 1 |
| Size of Social Security/$Y$ | 5.9% | 5% | OMB 2008 | 1 |
| Size of Medicare/$Y$ | 4.6% | 3.47% | NHEA (2010) | 1 |
| Size of Medicaid/$Y$ | 0.65% | 2.65% | NHEA (2010) | 1 |
| Size of Medicare Premium Payments/$Y$ | 2.75% | 2.11% | Jeske and Kitao (2009*a*) | 1 |
| Tax revenue | 19.4% | 20% | | 1 |
| Labor force participation | Figure 5 | Figure 5 | MEPS 1999–2009 | 39 |
| Average labor hours | Figure 5 | Figure 5 | PSID 1984–2007 | 1 |
| Labor income profile | Figure 4 | Figure 4 | MEPS 1999–2009 | 32 |
| Total number of moments | | | | 81 |

Table 4: **Calibration targets**
We choose internal parameters so that model generated data matches data from MEPS, CMS, and NIPA.

| Moments | Model | Data | Source |
|---|---|---|---|
| Gini labor income | 0.632 | 0.553 | MEPS 1999–2012 |
| Gini assets | 0.419 | 0.763 | PSID 1999–2009 |
| Gini social security payments | 0.191 | 0.232 | SSA 2010 |
| Gini medical spending | 0.408 | 0.761 | MEPS 1999–2012 |
| | | | |

Table 5: **Model performance I**
These are not calibration targets.
Data source is MEPS 1999–2012, heads of HIEU, population weighted, PSID 1999–2009 heads of households, population weighted and SSA 2010.

| | Benchmark | No-SocSec |
|---|---|---|
| Output $Y$ | 100.000 | 118.427 |
| Capital $K$ | 100.000 | 152.055 |
| Consumption $C$ | 100.000 | 101.789 |
| Medical Spending $M$ | 100.000 | 100.000 |
| Bequest $Beq$ | 100.000 | 117.962 |
| K/Y | 2.979 | 3.826 |
| C/Y % | 40.276 | 34.618 |
| M/Y % | 14.449 | 12.201 |
| Avge hours/week workers | 41.016 | 37.170 |
| Social Security | 100.000 | 0.000 |
| Medicare | 100.000 | 100.000 |
| Medicaid | 100.000 | 114.514 |
| Social Ins | 100.000 | 196.141 |
| GRev | 100.000 | 120.381 |
| Income Tax Revenue | 100.000 | 120.381 |
| SS Tax Revenue | 100.000 | 0.000 |
| Interest rate $r$ | 0.057 | 0.032 |
| Wages $w$ | 100.000 | 114.188 |
| Median income | 100.000 | 87.342 |
| Premium 0 | | |
| Premkum 1 | 100.000 | 93.930 |
| Premium Medicare | 100.000 | 87.119 |
| a0 | 2.447 | 0.000 |
| a1 | 0.566 | 0.000 |
| ARC in % of $Y$ | -0.852 | -0.587 |
| Gini labor income | 0.655 | 0.634 |
| Gini assets | 0.584 | 0.602 |
| Gini soc.sec. payments | 0.258 | |
| Gini medical spending | 0.408 | 0.408 |
| Welfare All GDP | 0.000 | 0.802 |
| Welfare All $\%C$ | 0.000 | 125.760 |
| Welf. Sick-NoSchool | 0.000 | 329.275 |
| Welf. Sick-HiSchool | 0.000 | 936.547 |
| Welf. Sick-College | 0.000 | 92.643 |
| Welf. Healthy-NoSchool | 0.000 | 129.194 |
| Welf. Healthy-HiSchool | 0.000 | 160.079 |
| Welf. Healthy-College | 0.000 | 40.238 |

Table 6: **Model 1 – Medical spending shocks and health state affecting income**
The first column is the normalized benchmark economy. Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are normalized with values of the benchmark case (first column). Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual with respect to consumption levels in the benchmark. [back to 19]

| | Benchmark | No-SocSec |
|---|---|---|
| Output $Y$ | 100.000 | 119.188 |
| Capital $K$ | 100.000 | 149.423 |
| Consumption $C$ | 100.000 | 104.838 |
| Medical Spending $M$ | 100.000 | 100.000 |
| Bequest $Beq$ | 100.000 | 118.625 |
| K/Y | 2.947 | 3.695 |
| C/Y % | 40.384 | 35.522 |
| M/Y % | 14.863 | 12.471 |
| Avge hours/week workers | 40.765 | 37.339 |
| Social Security | 100.000 | 0.000 |
| Medicare | 100.000 | 100.000 |
| Medicaid | 100.000 | 111.123 |
| Social Ins | 100.000 | 198.744 |
| GRev | 100.000 | 122.296 |
| Income Tax Revenue | 100.000 | 122.296 |
| SS Tax Revenue | 100.000 | 0.000 |
| Interest rate $r$ | 0.059 | 0.035 |
| Wages $w$ | 100.000 | 112.712 |
| Median income | 100.000 | 88.612 |
| Premium 0 | | |
| Premkum 1 | 100.000 | 93.642 |
| Premium Medicare | 100.000 | 87.091 |
| a0 | 2.476 | 0.000 |
| a1 | 0.566 | 0.000 |
| ARC in % of $Y$ | -0.925 | -0.648 |
| Gini labor income | 0.651 | 0.632 |
| Gini assets | 0.588 | 0.606 |
| Gini soc.sec. payments | 0.271 | |
| Gini medical spending | 0.000 | 0.408 |
| Welfare All GDP | 0.000 | 0.744 |
| Welfare All $\%C$ | 0.000 | 112.084 |
| Welf. Sick-NoSchool | 0.000 | 750.733 |
| Welf. Sick-HiSchool | 0.000 | 101.227 |
| Welf. Sick-College | 0.000 | 83.051 |
| Welf. Healthy-NoSchool | 0.000 | 119.820 |
| Welf. Healthy-HiSchool | 0.000 | 154.424 |
| Welf. Healthy-College | 0.000 | 38.045 |

Table 7: **Model 2B – Medical spending shocks but health does not affect income**
The first column is the normalized benchmark economy without the medical spending shock and without medical spending affecting income. Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are normalized with values of the benchmark case (first column). Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual with respect to consumption levels in the benchmark.[back to 20]

| | Benchmark | No-SocSec |
|---|---|---|
| Output $Y$ | 100.000 | 113.057 |
| Capital $K$ | 100.000 | 131.765 |
| Consumption $C$ | 100.000 | 102.833 |
| Medical Spending $M$ | | |
| Bequest $Beq$ | 100.000 | 113.257 |
| K/Y | 2.972 | 3.464 |
| C/Y % | 54.652 | 49.710 |
| M/Y % | 0.000 | 0.000 |
| Avge hours/week workers | 41.094 | 39.403 |
| Social Security | 100.000 | 0.000 |
| Medicare | | |
| Medicaid | | |
| Social Ins | | |
| GRev | 100.000 | 111.299 |
| Income Tax Revenue | 100.000 | 111.299 |
| SS Tax Revenue | 100.000 | 0.000 |
| Interest rate $r$ | 0.058 | 0.041 |
| Wages $w$ | 100.000 | 108.712 |
| Median income | 100.000 | 93.374 |
| Premium 0 | | |
| Premkum 1 | 100.000 | 0.695 |
| Premium Medicare | 100.000 | 0.695 |
| a0 | 2.517 | 0.000 |
| a1 | 0.566 | 0.000 |
| ARC in % of $Y$ | -0.429 | -0.346 |
| Gini labor income | 0.679 | 0.662 |
| Gini assets | 0.640 | 0.628 |
| Gini soc.sec. payments | 0.283 | |
| Gini medical spending | 0.000 | |
| Welfare All GDP | 0.000 | 0.474 |
| Welfare All $\%C$ | 0.000 | 58.820 |
| Welf. Sick-NoSchool | 0.000 | 82.682 |
| Welf. Sick-HiSchool | 0.000 | 66.925 |
| Welf. Sick-College | 0.000 | 24.951 |
| Welf. Healthy-NoSchool | 0.000 | 82.682 |
| Welf. Healthy-HiSchool | 0.000 | 66.925 |
| Welf. Healthy-College | 0.000 | 24.951 |

Table 8: **Model 2C – No medical shocks and health does not affect income**

The first column is the normalized benchmark economy without the medical spending shock. Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are normalized with values of the benchmark case (first column). Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual with respect to consumption levels in the benchmark. [back to 20]

| | Benchmark ($a_1 = 0.5664$) | $a_1 = 0(equal)$ | $a_1 = 0.25$ | $a_1 = 0.75$ | $a_1 = 1(linear)$ |
|---|---|---|---|---|---|
| Output $Y$ | 100.000 | 96.315 | 98.576 | 100.858 | 101.762 |
| Capital $K$ | 100.000 | 93.635 | 97.145 | 102.200 | 104.272 |
| Consumption $C$ | 100.000 | 94.942 | 98.839 | 100.754 | 102.182 |
| Medical Spending $M$ | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Bequest $Beq$ | 100.000 | 95.665 | 98.086 | 100.759 | 101.689 |
| K/Y | 2.979 | 2.897 | 2.936 | 3.019 | 3.053 |
| C/Y % | 40.276 | 39.701 | 40.383 | 40.234 | 40.442 |
| M/Y % | 14.449 | 15.002 | 14.658 | 14.326 | 14.199 |
| Avge hours/week workers | 41.016 | 40.070 | 41.073 | 40.929 | 40.714 |
| Social Security | 100.000 | 93.450 | 98.606 | 100.828 | 102.806 |
| Medicare | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Medicaid | 100.000 | 97.697 | 102.353 | 98.498 | 97.908 |
| Social Ins | 100.000 | 43.213 | 75.881 | 111.852 | 131.242 |
| GRev | 100.000 | 97.210 | 97.936 | 100.713 | 100.901 |
| Income Tax Revenue | 100.000 | 97.210 | 97.936 | 100.713 | 100.901 |
| SS Tax Revenue | 100.000 | 94.045 | 98.723 | 101.063 | 102.888 |
| Interest rate $r$ | 0.057 | 0.061 | 0.059 | 0.056 | 0.054 |
| Wages $w$ | 100.000 | 98.144 | 98.930 | 100.687 | 101.267 |
| Median income | 100.000 | 94.537 | 99.898 | 100.908 | 103.733 |
| Premium 0 | | | | | |
| Premkum 1 | 100.000 | 100.468 | 99.472 | 99.523 | 99.619 |
| Premium Medicare | 100.000 | 102.150 | 100.351 | 99.326 | 98.895 |
| a0 | 2.447 | 21.708 | 8.588 | 1.159 | 0.415 |
| a1 | 0.566 | 0.000 | 0.250 | 0.750 | 1.000 |
| ARC in % of $Y$ | -0.852 | -0.925 | -0.831 | -0.830 | -0.796 |
| Gini labor income | 0.655 | 0.665 | 0.658 | 0.655 | 0.655 |
| Gini assets | 0.584 | 0.603 | 0.593 | 0.577 | 0.573 |
| Gini soc.sec. payments | 0.258 | 0.072 | 0.183 | 0.299 | 0.354 |
| Gini medical spending | 0.408 | 0.408 | 0.408 | 0.408 | 0.408 |
| Welfare All GDP | 0.000 | 0.084 | -0.018 | 0.003 | -0.009 |
| Welfare All %$C$ | 0.000 | 13.095 | -2.765 | 0.488 | -1.421 |
| Welf. Sick-NoSchool | 0.000 | 24.778 | -3.639 | 0.122 | -4.752 |
| Welf. Sick-HiSchool | 0.000 | 2.563 | -1.940 | 0.483 | 0.231 |
| Welf. Sick-College | 0.000 | -0.508 | -6.145 | 1.359 | -1.843 |
| Welf. Healthy-NoSchool | 0.000 | 17.664 | -3.337 | 0.574 | -2.757 |
| Welf. Healthy-HiSchool | 0.000 | 19.958 | -3.085 | 0.210 | -2.105 |
| Welf. Healthy-College | 0.000 | -2.620 | -1.329 | 0.969 | 1.701 |

Table 9: **Changing PIA progressivity $a_1$ in Model 1**

With medical spending shock and with health affecting income

The first column is the normalized benchmark economy. Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are normalized with values of the benchmark case (first column). Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual with respect to consumption levels in the benchmark. [back to 21]

| | Benchmark ($a_1 = 0.5664$) | $a_1 = 0(equal)$ | $a_1 = 0.25$ | $a_1 = 0.75$ | $a_1 = 1(linear)$ |
|---|---|---|---|---|---|
| Output $Y$ | 100.000 | 96.045 | 98.285 | 101.150 | 101.582 |
| Capital $K$ | 100.000 | 93.108 | 96.386 | 102.364 | 103.847 |
| Consumption $C$ | 100.000 | 95.050 | 98.467 | 101.742 | 101.588 |
| Medical Spending $M$ | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Bequest $Beq$ | 100.000 | 95.552 | 97.850 | 101.157 | 101.530 |
| K/Y | 2.947 | 2.857 | 2.890 | 2.983 | 3.013 |
| C/Y % | 40.384 | 39.966 | 40.459 | 40.620 | 40.387 |
| M/Y % | 14.863 | 15.475 | 15.123 | 14.694 | 14.632 |
| Avge hours/week workers | 40.765 | 39.680 | 40.981 | 40.587 | 40.495 |
| Social Security | 100.000 | 94.075 | 98.122 | 102.206 | 101.912 |
| Medicare | 100.000 | 100.000 | 100.000 | 100.000 | 100.000 |
| Medicaid | 100.000 | 97.553 | 100.354 | 101.352 | 98.116 |
| Social Ins | 100.000 | 38.237 | 74.461 | 111.153 | 134.581 |
| GRev | 100.000 | 96.665 | 98.386 | 100.255 | 101.728 |
| Income Tax Revenue | 100.000 | 96.665 | 98.386 | 100.255 | 101.728 |
| SS Tax Revenue | 100.000 | 94.292 | 97.844 | 102.116 | 101.816 |
| Interest rate $r$ | 0.059 | 0.063 | 0.061 | 0.057 | 0.056 |
| Wages $w$ | 100.000 | 98.077 | 98.728 | 100.634 | 101.159 |
| Median income | 100.000 | 95.509 | 98.394 | 103.750 | 101.380 |
| Premium 0 | | | | | |
| Premkum 1 | 100.000 | 100.204 | 99.028 | 100.367 | 99.625 |
| Premium Medicare | 100.000 | 101.634 | 100.276 | 99.177 | 98.921 |
| a0 | 2.476 | 21.877 | 8.742 | 1.170 | 0.422 |
| a1 | 0.566 | 0.000 | 0.250 | 0.750 | 1.000 |
| ARC in % of $Y$ | -0.925 | -0.932 | -0.860 | -0.877 | -0.861 |
| Gini labor income | 0.651 | 0.662 | 0.653 | 0.653 | 0.649 |
| Gini assets | 0.588 | 0.612 | 0.598 | 0.583 | 0.578 |
| Gini soc.sec. payments | 0.271 | 0.087 | 0.194 | 0.315 | 0.364 |
| Gini medical spending | 0.408 | 0.408 | 0.408 | 0.408 | 0.408 |
| Welfare All GDP | 0.000 | 0.058 | -0.008 | -0.019 | 0.010 |
| Welfare All $\%C$ | 0.000 | 8.742 | -1.152 | -2.826 | 1.536 |
| Welf. Sick-NoSchool | 0.000 | 14.634 | -1.147 | -1.850 | 2.016 |
| Welf. Sick-HiSchool | 0.000 | -10.821 | -8.706 | 5.869 | 5.845 |
| Welf. Sick-College | 0.000 | -2.558 | -1.786 | 0.639 | 1.826 |
| Welf. Healthy-NoSchool | 0.000 | 18.347 | -0.863 | -4.387 | 1.709 |
| Welf. Healthy-HiSchool | 0.000 | 10.307 | -0.895 | -3.480 | 1.261 |
| Welf. Healthy-College | 0.000 | -2.511 | -1.473 | -0.318 | 1.593 |

Table 10: **Changing PIA progressivity $a_1$ in Model 2B**

Medical spending shocks but health does not affect income

The first column is the normalized benchmark economy. Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are normalized with values of the benchmark case (first column). Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual with respect to consumption levels in the benchmark.[back to 21]

| | Benchmark ($a_1 = 0.5664$) | $a_1 = 0(equal)$ | $a_1 = 0.25$ | $a_1 = 0.75$ | $a_1 = 1(linear)$ |
|---|---|---|---|---|---|
| Output $Y$ | 100.000 | 97.743 | 99.610 | 100.741 | 101.151 |
| Capital $K$ | 100.000 | 95.339 | 99.186 | 101.741 | 102.499 |
| Consumption $C$ | 100.000 | 97.822 | 99.623 | 100.648 | 101.090 |
| Medical Spending $M$ | | | | | |
| Bequest $Beq$ | 100.000 | 98.090 | 99.921 | 100.997 | 101.350 |
| K/Y | 2.972 | 2.899 | 2.959 | 3.001 | 3.012 |
| C/Y % | 54.652 | 54.696 | 54.660 | 54.602 | 54.619 |
| M/Y % | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Avge hours/week workers | 41.094 | 41.179 | 41.127 | 40.947 | 40.883 |
| Social Security | 100.000 | 96.149 | 99.099 | 101.378 | 102.614 |
| Medicare | | | | | |
| Medicaid | | | | | |
| Social Ins | | | | | |
| GRev | 100.000 | 100.238 | 99.946 | 99.984 | 99.935 |
| Income Tax Revenue | 100.000 | 100.238 | 99.946 | 99.984 | 99.935 |
| SS Tax Revenue | 100.000 | 95.640 | 99.397 | 101.432 | 102.440 |
| Interest rate $r$ | 0.058 | 0.061 | 0.058 | 0.057 | 0.056 |
| Wages $w$ | 100.000 | 98.881 | 99.999 | 100.632 | 100.811 |
| Median income | 100.000 | 94.466 | 99.233 | 102.296 | 103.345 |
| Premium 0 | | | | | |
| Premkum 1 | 100.000 | 0.257 | 0.000 | 0.001 | 0.074 |
| Premium Medicare | 100.000 | 0.257 | 0.000 | 0.001 | 0.074 |
| a0 | 2.517 | 22.907 | 8.949 | 1.187 | 0.424 |
| a1 | 0.566 | 0.000 | 0.250 | 0.750 | 1.000 |
| ARC in % of $Y$ | -0.429 | -0.415 | -0.440 | -0.419 | -0.403 |
| Gini labor income | 0.679 | 0.682 | 0.680 | 0.680 | 0.679 |
| Gini assets | 0.640 | 0.651 | 0.646 | 0.638 | 0.636 |
| Gini soc.sec. payments | 0.283 | 0.098 | 0.213 | 0.322 | 0.369 |
| Gini medical spending | | | | | |
| Welfare All GDP | 0.000 | 0.085 | 0.024 | -0.043 | -0.077 |
| Welfare All $\%C$ | 0.000 | 10.566 | 2.953 | -5.361 | -9.598 |
| Welf. Sick-NoSchool | 0.000 | 19.798 | 5.010 | -3.420 | -6.164 |
| Welf. Sick-HiSchool | 0.000 | 11.779 | 3.237 | -9.596 | -16.601 |
| Welf. Sick-College | 0.000 | -1.008 | 0.101 | 0.673 | 0.826 |
| Welf. Healthy-NoSchool | 0.000 | 19.798 | 5.010 | -3.420 | -6.164 |
| Welf. Healthy-HiSchool | 0.000 | 11.779 | 3.237 | -9.596 | -16.601 |
| Welf. Healthy-College | 0.000 | -1.008 | 0.101 | 0.673 | 0.826 |

Table 11: **Changing PIA progressivity $a_1$ in Model 2C**

No medical spending shocks and health does not affect income

The first column is the normalized benchmark economy. Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are normalized with values of the benchmark case (first column). Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual with respect to consumption levels in the benchmark. [back to **??**]

# B Figures

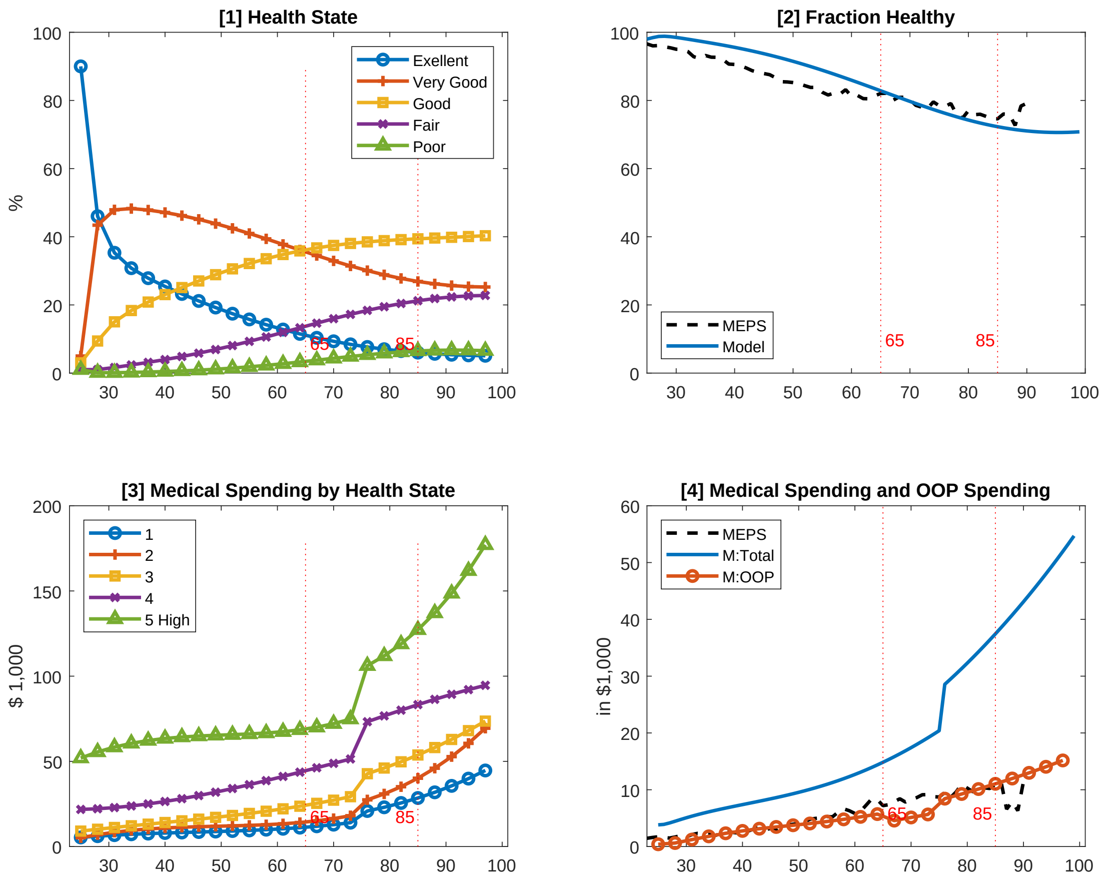


Figure 1: **Exogenous health state process and health spending shocks**
Healthy is defined as the head of the HIEU reporting either Excellent, Very Good, or Good health. Sick is defined as Fair or Poor health states.
Data source is MEPS 1999–2012, heads of HIEU, population weighted.

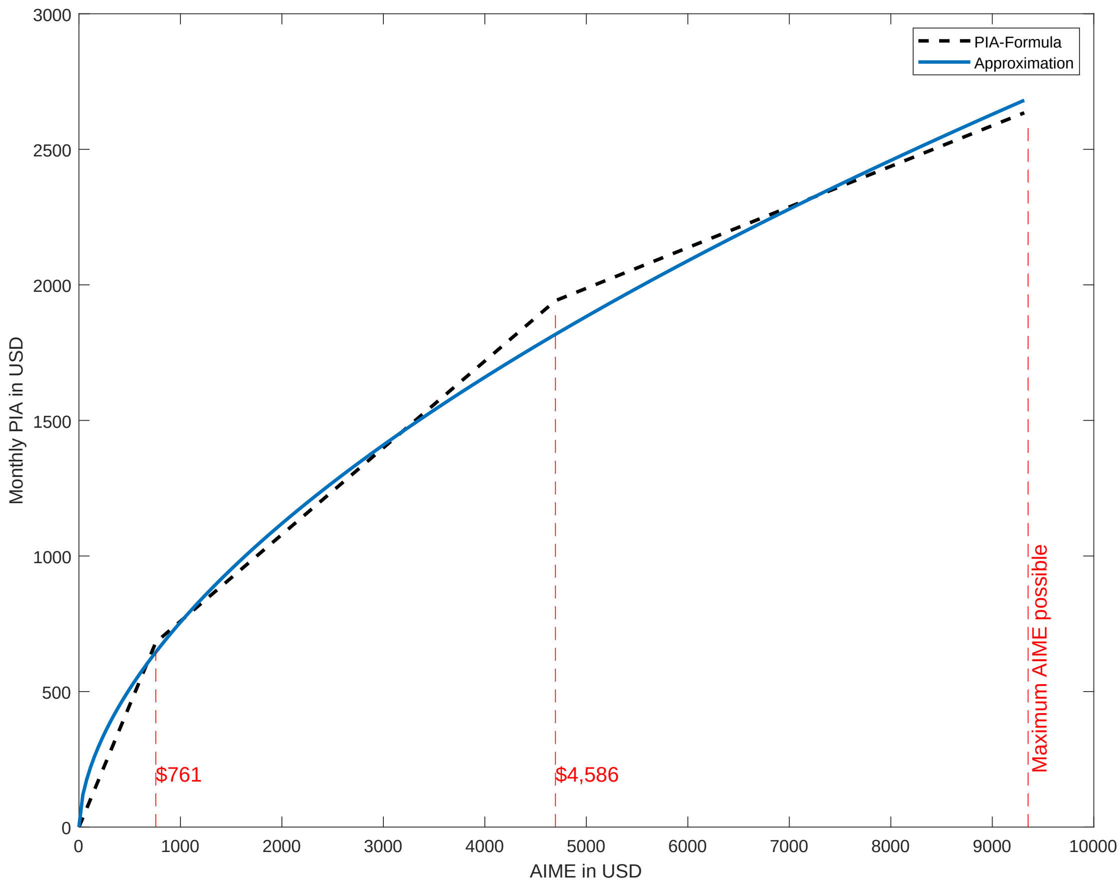


Figure 2: **PIA payout formula based on AIME.**
Source: Social Security Administration at https://www.ssa.gov/oact/cola/bendpoints.html

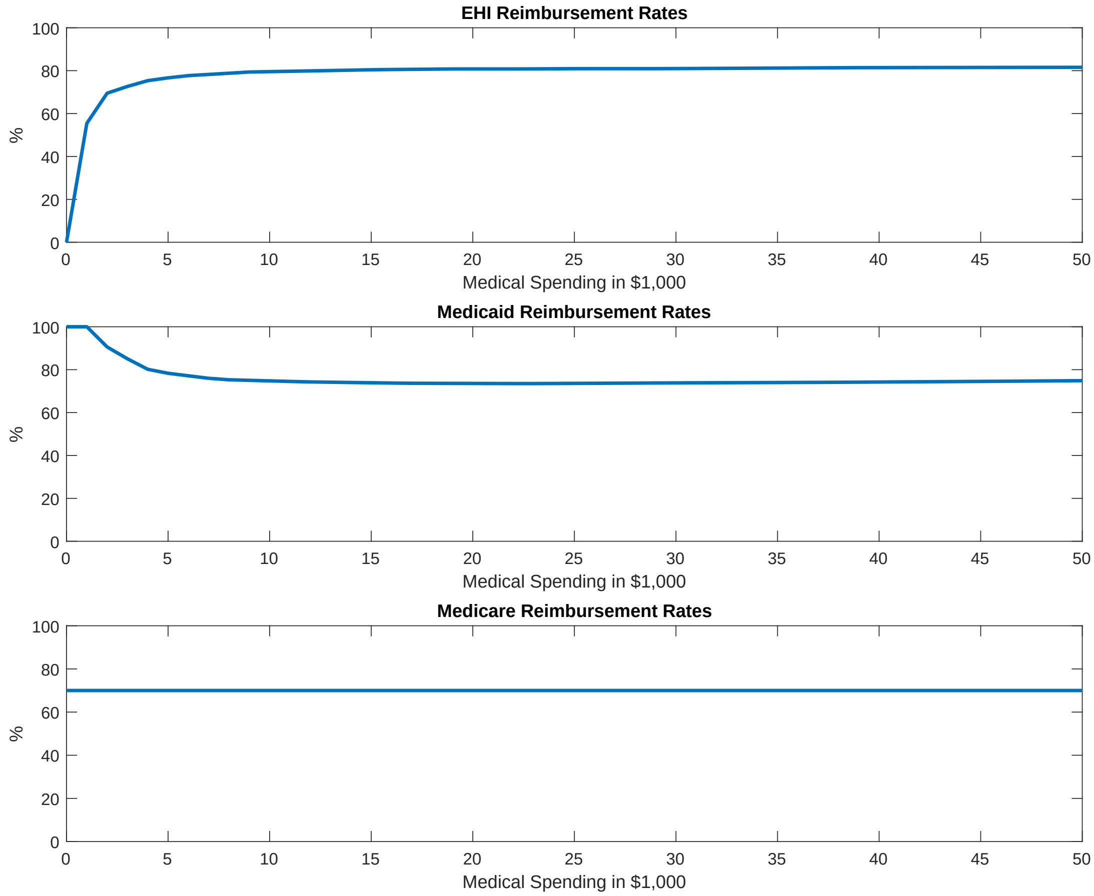


Figure 3: **Exogenous health insurance reimbursement rates.**
Source: MEPS 1999-2009

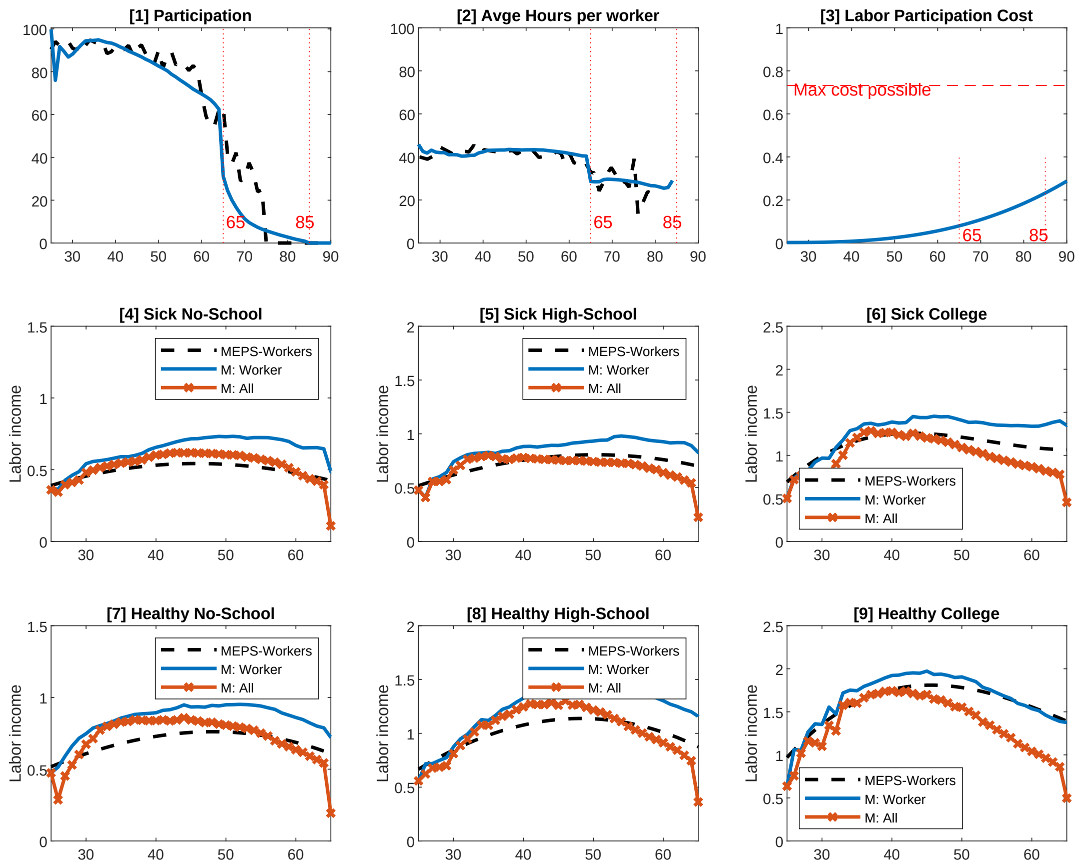


Figure 4: **Calibration Targets - Labor income profiles.**

Panel [2] and [3] are calibration targets that determine the fixed cost of labor participation as well as the consumption vs. leisure weight in the utility function. Panels [4]–[9] are calibration targets that determine the deterministic part of the labor income process.

Data source is MEPS 1999–2012, heads of HIEU, population weighted.

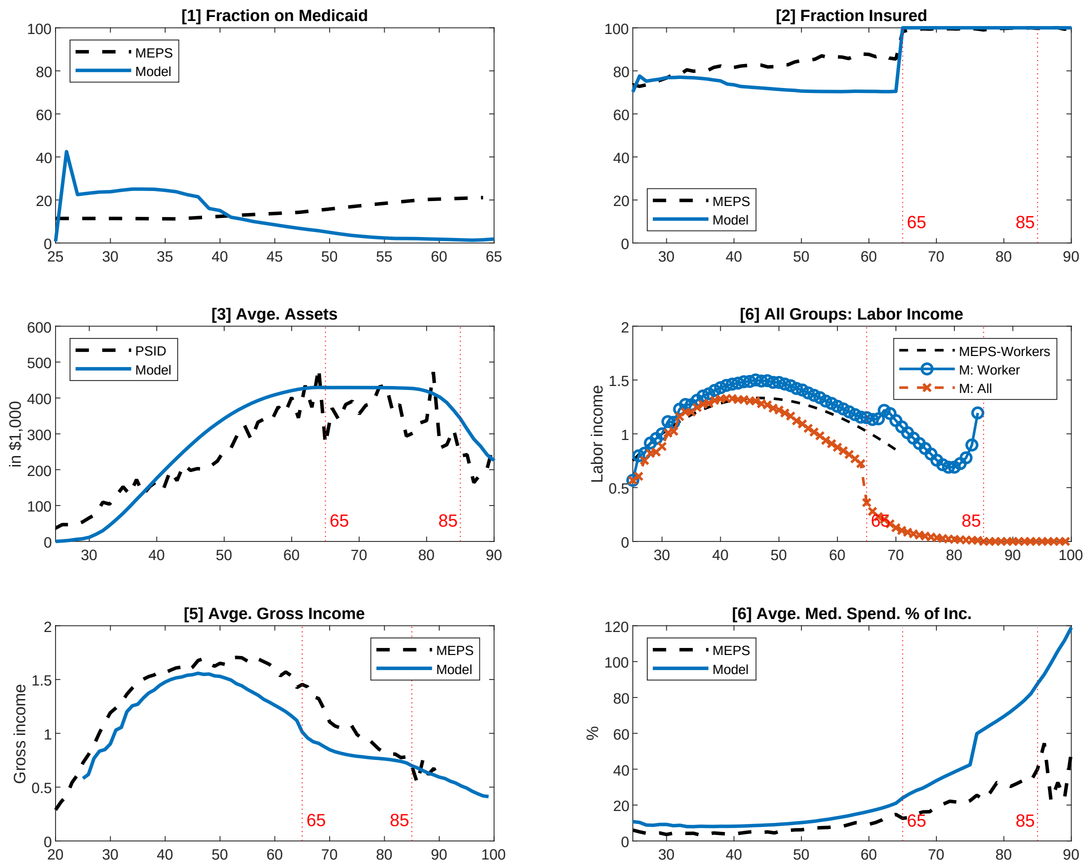


Figure 5: **Model performance II – Lifecycle profiles compared to data**

These are not calibration targets.

Data source is MEPS 1999–2012, heads of HIEU, population weighted.

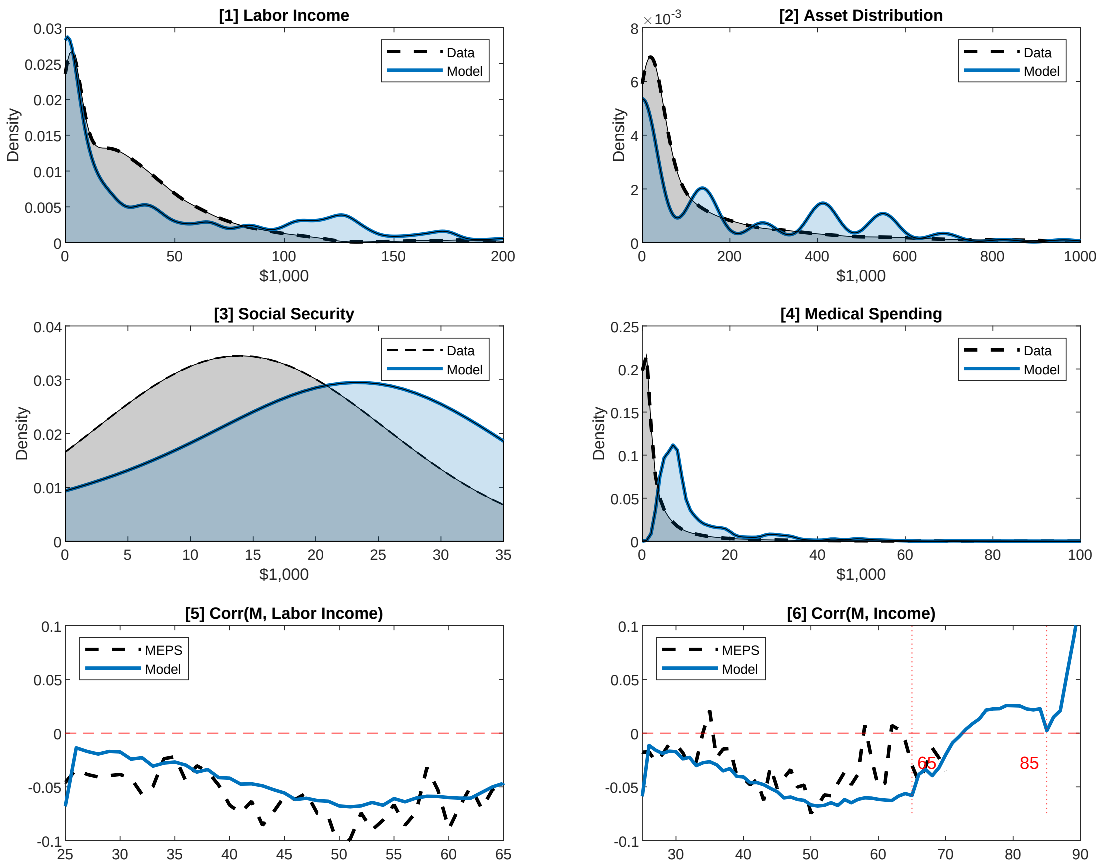


Figure 6: **Model performance III – Distributions and lifecycle correlations compared to data**

These are not calibration targets.

Data source is MEPS 1999–2012, heads of HIEU, population weighted.

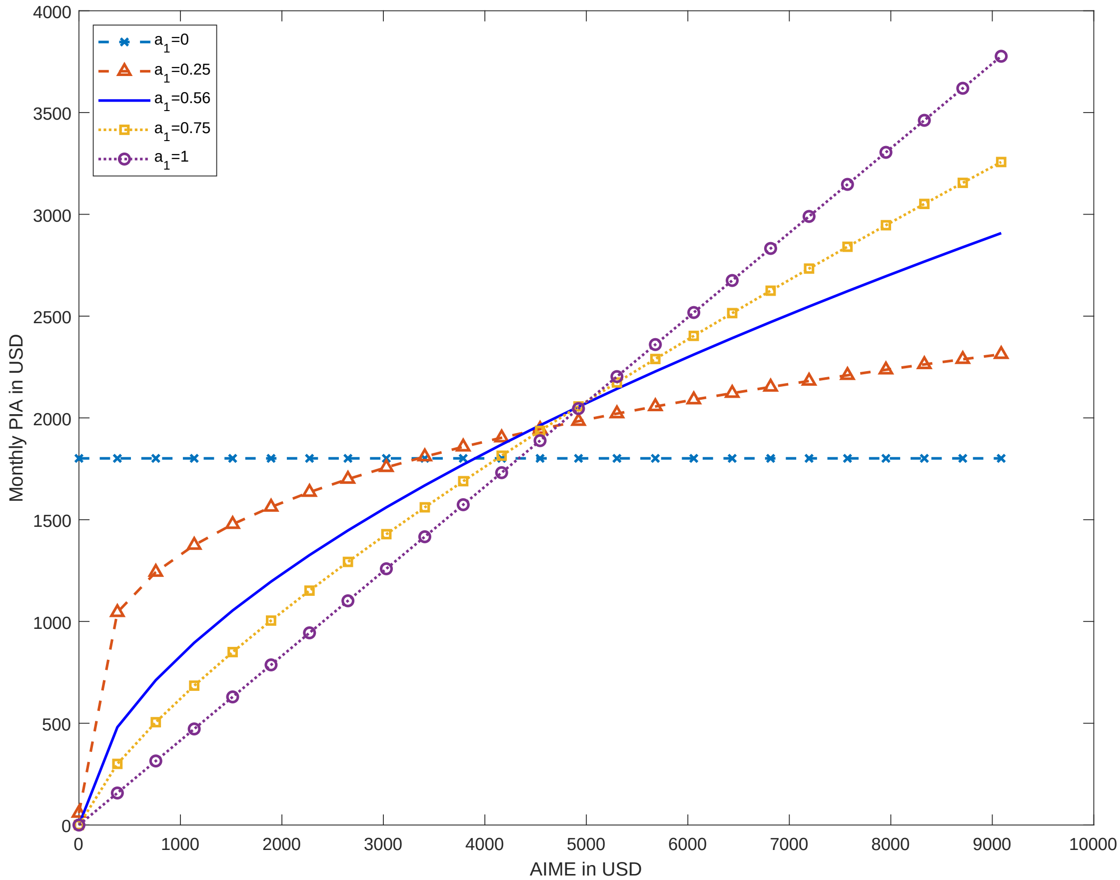


Figure 7: **Social Security payout formula for different values of curvature parameter $a_1$**

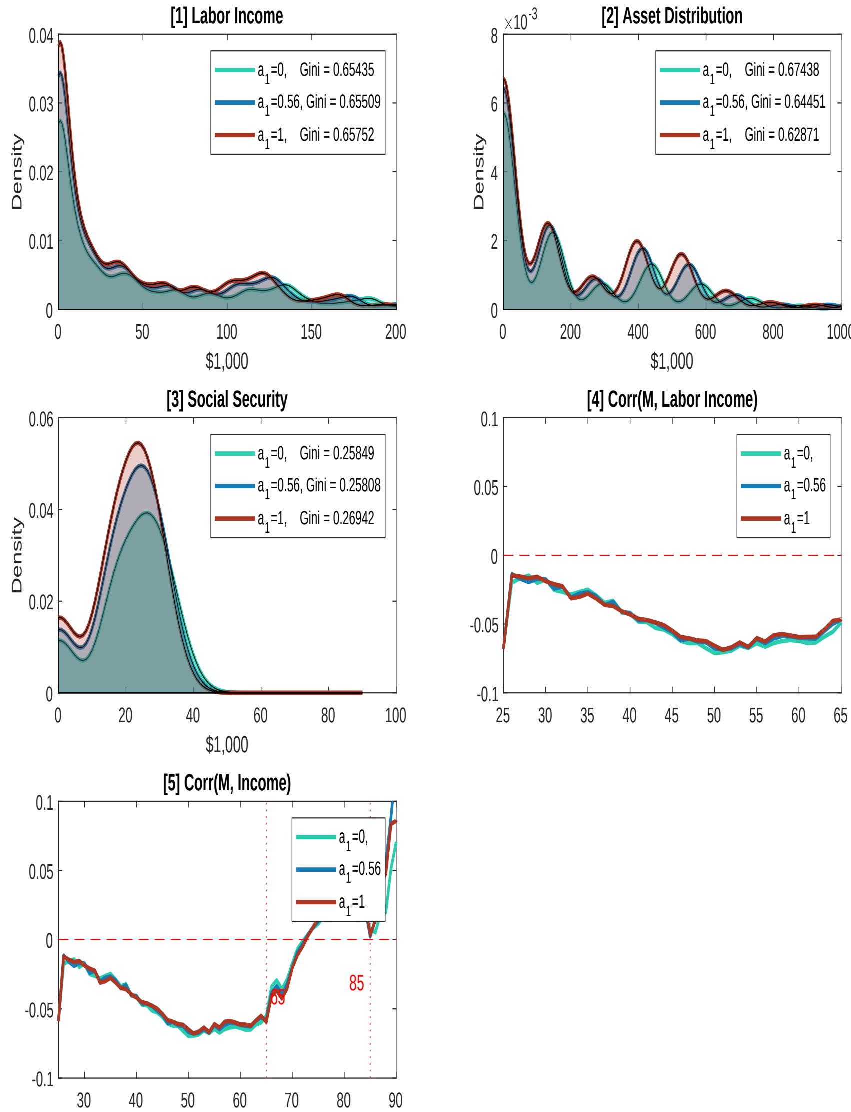


Figure 8: **Changing PIA progressivity $a_1$ in Model 1**
With medical spending shock and with health-income shock

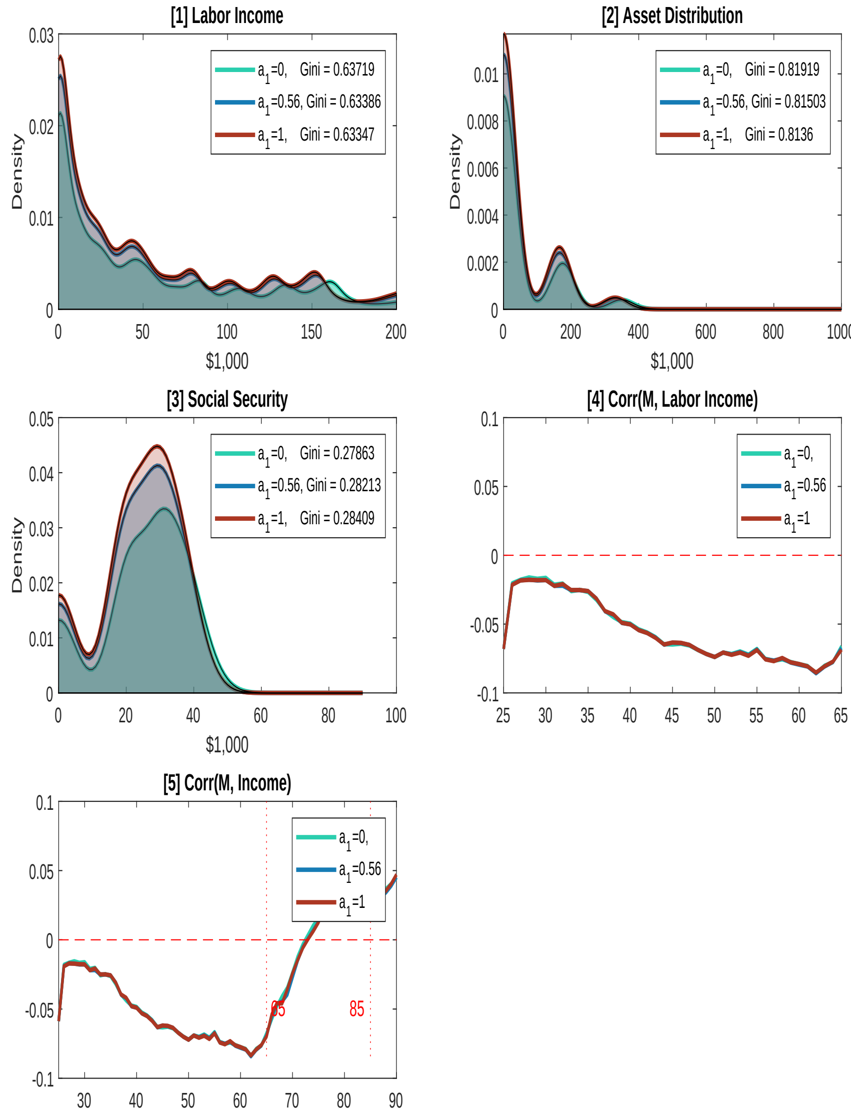


Figure 9: **Changing PIA progressivity $a_1$ in Model 2A**
Without health-income shock. NOTE: THIS IS ACTUALLY THE GRAPH FOR 2B.

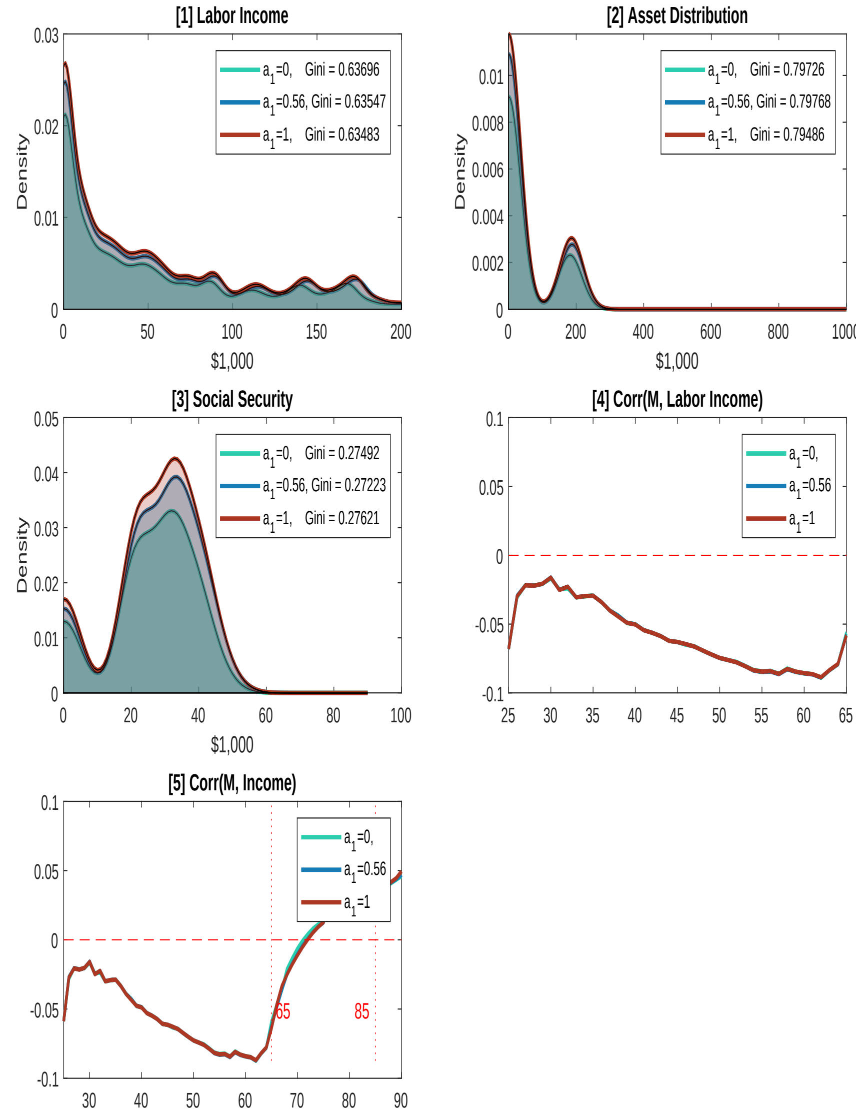


Figure 10: **Changing PIA progressivity $a_1$ in Model 2C**
Without any health risk present. medical spending shock and without health-income shock

# Part II

# Online Appendix

## C Medical Expenditure Panel Survey (MEPS)

We primarily use data from the Medical Expenditure Panel Survey (MEPS) from the years 1999 to 2012 for our estimation and calibration. MEPS provides a nationally representative survey about health care use, health expenditures, health insurance coverage as well as demographic data on income, health status, and other socioeconomic characteristics. The original household component of MEPS was initiated in 1996. Each year about $15,000$ households are selected and interviewed five times over two full calendar years. MEPS groups individuals into Health Insurance Eligibility Units (HIEU) which are subsets of households. We do abstract from family size effects and concentrate on adults aged 20 to 85 who are the head of the HIEU.

**Health Care Expenditure Data.** MEPS provides high quality health expenditure and health care utilization data. The MEPS Household Component (HC) collects data in each round on use and expenditures for office- and hospital-based care, home health care, dental services, vision aids, and prescribed medicines. In addition, the MEPS Medical Provider Component (MPC) is a follow-back survey that collects data from a sample of medical providers and pharmacies that were used by sample persons in a given year. Expenditure data collected in the MPC are generally regarded as more accurate than information collected in the HC and are used to improve the overall quality of MEPS expenditure data. Expenditures in MEPS refer to what is paid for health care services. 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 and neither are payments for long-term care. Similarly payments not related to specific medical events, such as Medicaid Disproportionate Share and Medicare Direct Medical Education subsidies, are also not included. MEPS records actual payments made and not original charges which tend to be much higher. However, it has become customary to apply discounts. In addition charges associated with uncollected liabilities, bad debt and charitable care do not constitute actual health care expenses and are therefore not counted.

**Cohort Effects.** Panel data variables over the lifecycle of an individual are determined by age, time and cohort effects. Since our model only explicitly accounts for age effects, we should ideally remove time and cohort effects from the data in order to make lifecycle observations from the data consistent with lifecycle statistics generated by the model. Since age, time and cohort effects are perfectly collinear it is difficult to estimate all three simultaneously (e.g., **?**). The literature (e.g., Kaplan (2012)) often suggests to conduct separate analyses once controlling for the cohort effect and in a repeat exercise controlling for the time effect. In this work we explicitly control for cohort effects of wages, income and health expenditures by regressing the log of the output variable on a set of age and cohort dummies. We focus on controlling for cohort effects because according to **?** they seem to be large in health expenditure data and time effects can be somewhat mitigated by deflating with the CPI index. We then use predictions of these regressions to generate a cohort-adjusted variable by predicting for a base cohort, that is we leave out the cohort dummies in the prediction. Summary statistics of the unweighted sample are presented in Table 13 and a histogram of the age

distribution is presented in Figure 11. All dollar values are denominated in 2010 dollars using the OECD CPI for the US for all monetary measures.[13]

# D Panel Study of Income Dynamics (PSID)

The PSID started in 1968 with more than 5,000 US households. Participants were then re-interviewed annually until 1997. This includes people who "split off" from their original families to form new families as well as people born into these families. Other members of new families are interviewed while they are in these families but not followed if the family dissolved. In 1997 the core sample was reduced, a refresher sample of immigrant families was added and the survey frequency changed to biennial interviews. Wealth survey data is available for the years 1984, 1989, 1994, 1999, 2001, 2003, 2005, 2007, and 2009. A Summary statistics of the unweighted sample are presented in Table 13 and a histogram of the age distribution is presented in Figure 12. All dollar values are denominated in 2010 dollars using the OECD CPI for the US for all monetary measures.[14]

[13]OECD (2018), Inflation (CPI) (indicator). doi: 10.1787/eee82e6e-en (Accessed on 29 June 2018) at https://data.oecd.org/price/inflation-cpi.htm

[14]OECD (2018), Inflation (CPI) (indicator). doi: 10.1787/eee82e6e-en (Accessed on 29 June 2018) at https://data.oecd.org/price/inflation-cpi.htm

# Online Appendix References

## References

Kaplan, Greg. 2012. "Inequality and the Life Cycle." *Quantitative Economics* 3(3):471–525. 45

# E Tables

| | (1)<br>All<br>mean/sd | (2)<br>LaborIncome>$400<br>mean/sd |
|---|---|---|
| Year | 2005.886 | 2005.815 |
| | (3.976) | (3.983) |
| Age of head of HIEU | 46.874 | 42.041 |
| | (17.717) | (14.295) |
| Five-year age groups | 5.991 | 5.017 |
| | (3.561) | (2.866) |
| Female | 0.444 | 0.400 |
| | (0.497) | (0.490) |
| Married/Partnered | 0.404 | 0.430 |
| | (0.491) | (0.495) |
| Black | 0.164 | 0.152 |
| | (0.371) | (0.359) |
| Years of education | 11.458 | 11.930 |
| | (4.788) | (4.611) |
| Avge hourly wage over 3 waves | 17.990 | 18.054 |
| | (12.619) | (12.644) |
| Labor income (in $1,000) | 25.264 | 35.314 |
| | (31.429) | (32.029) |
| Labor income of HH (in $1,000) | 46.695 | 58.682 |
| | (48.801) | (49.149) |
| Pre-government HH income (in $1,000) | 56.593 | 65.189 |
| | (50.425) | (52.264) |
| Pre-government HIEU income (in $1,000) | 43.385 | 51.844 |
| | (45.991) | (48.486) |
| Health status | 2.452 | 2.256 |
| | (1.006) | (0.896) |
| Indicator for healthy | 0.853 | 0.918 |
| | (0.354) | (0.274) |
| Total health expenditures (in $1,000) | 4.203 | 2.736 |
| | (11.705) | (8.524) |
| healthExpenditureHIEU | 6.555 | 5.084 |
| | (15.272) | (12.513) |
| Total health expenditures HIEU (in $1,000) | 8.624 | 6.983 |
| | (18.456) | (16.429) |
| Out-of-pocket health exp | 0.654 | 0.517 |
| | (1.768) | (1.357) |
| OOPExpenditureHIEU | 1.061 | 0.948 |
| | (2.268) | (1.980) |
| Total OOP expenditure HIEU ($1,000) | 1.360 | 1.235 |
| | (2.610) | (2.350) |
| No high school degree | 0.266 | 0.214 |
| | (0.442) | (0.410) |
| High school degree | 0.427 | 0.441 |
| | (0.495) | (0.497) |
| College or higher degree | 0.251 | 0.291 |
| | (0.434) | (0.454) |
| Insured | 0.789 | 0.770 |
| | (0.408) | (0.421) |
| Public health insurance | 0.215 | 0.103 |
| | (0.411) | (0.304) |
| Private health insurance | 0.574 | 0.667 |
| | (0.495) | (0.471) |
| d_head | 0.637 | 0.634 |
| | (0.481) | (0.482) |
| Observations | 223837 | 160225 |

Note: MEPS 1999-2012. Unweighted sample statistics.

Table 13: **Summary statistics.**
Unweighted summary statistics of heads of Health Insurance Eligibility Units (HIEU). MEPS 1999–2012

| | (1) 1999-2009 mean/sd | (2) 1999-2009: HH-Heads mean/sd |
|---|---|---|
| Calendar year | 2004.137 | 2004.137 |
| | (3.398) | (3.398) |
| Age of head of household | 46.596 | 46.596 |
| | (15.915) | (15.915) |
| Female | 0.280 | 0.280 |
| | (0.449) | (0.449) |
| Married | 0.533 | 0.533 |
| | (0.499) | (0.499) |
| Number of Years of Education | 12.839 | 12.839 |
| | (2.567) | (2.567) |
| Individual labor earnings in $1,000 | 43.034 | 43.034 |
| | (76.402) | (76.402) |
| Labor income HH in $1,000 | 59.436 | 59.436 |
| | (87.260) | (87.260) |
| Pre-government HH income in $1,000 | 66.401 | 66.401 |
| | (91.718) | (91.718) |
| Self-Rated Health Status | 2.426 | 2.426 |
| | (1.077) | (1.077) |
| No high school degree | 0.179 | 0.179 |
| | (0.384) | (0.384) |
| High school degree | 0.360 | 0.360 |
| | (0.480) | (0.480) |
| College | 0.214 | 0.214 |
| | (0.410) | (0.410) |
| Insured | 0.919 | 0.919 |
| | (0.272) | (0.272) |
| Head of HH | 1.000 | 1.000 |
| | (0.000) | (0.000) |
| Observations | 38536 | 38536 |

Note: Unweighted sample statistics.

Table 15: **Summary statistics - PSID.**
Unweighted summary statistics of heads of households. PSID 1999–2009.

# F Figures


Figure 11: **Age distribution.**
Data source is MEPS 1999–2012, heads of HIEU, population weighted.

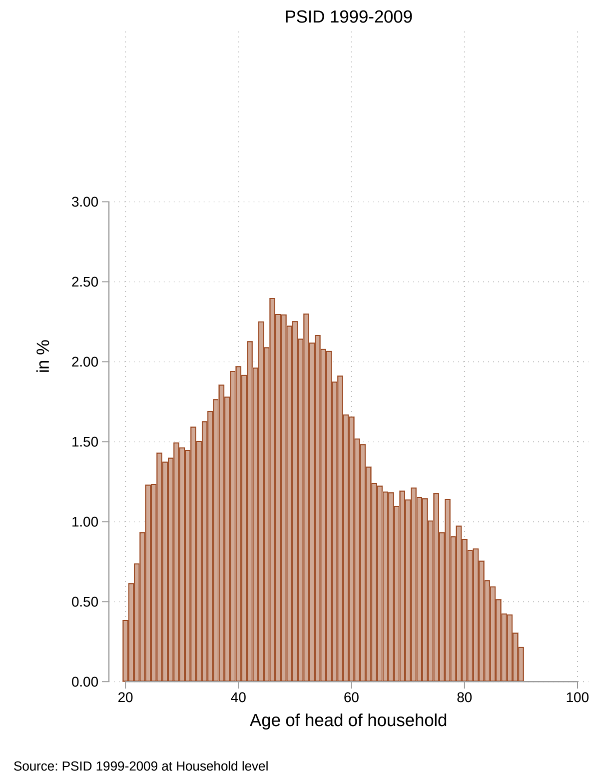


Figure 12: **Age distribution.**
Data source is PSID 1999–2009, heads of household, population weighted.

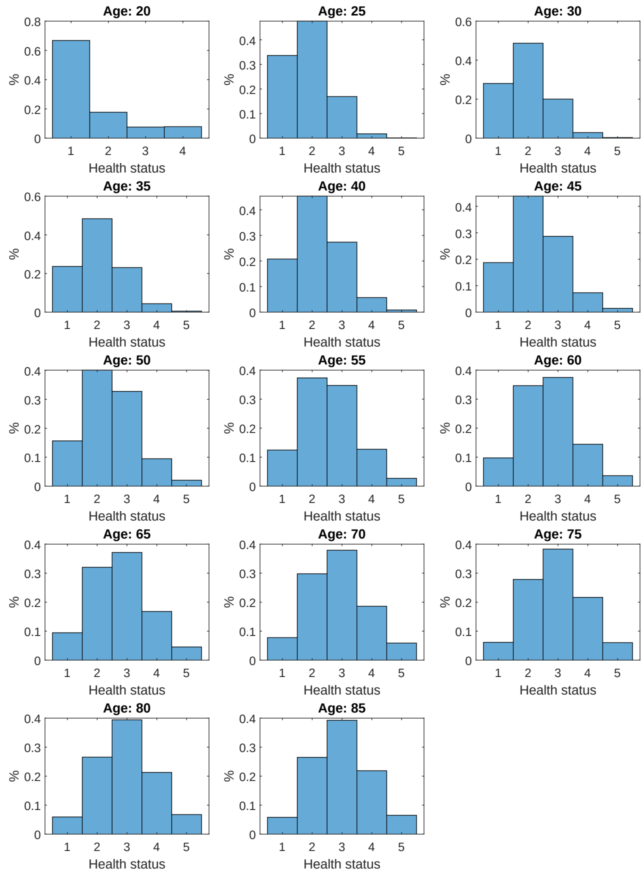


Figure 13: **Health state distribution.**

The 5 health states are "1. excellent health", "2. very good health", "3. good health", "4. fair health" and "5. poor health".

Data source is MEPS 1999–2012, heads of HIEU, population weighted.

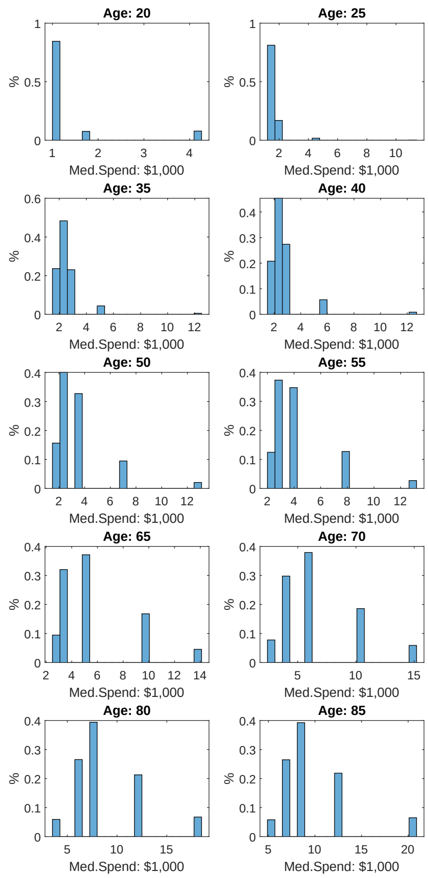


Figure 14: **Medical spending distribution.**

The distribution is based on a simulation of 75 periods of a Markov process of 5 health states and their associated state dependent health care spending.

Data source is MEPS 1999–2012, heads of HIEU, population weighted.

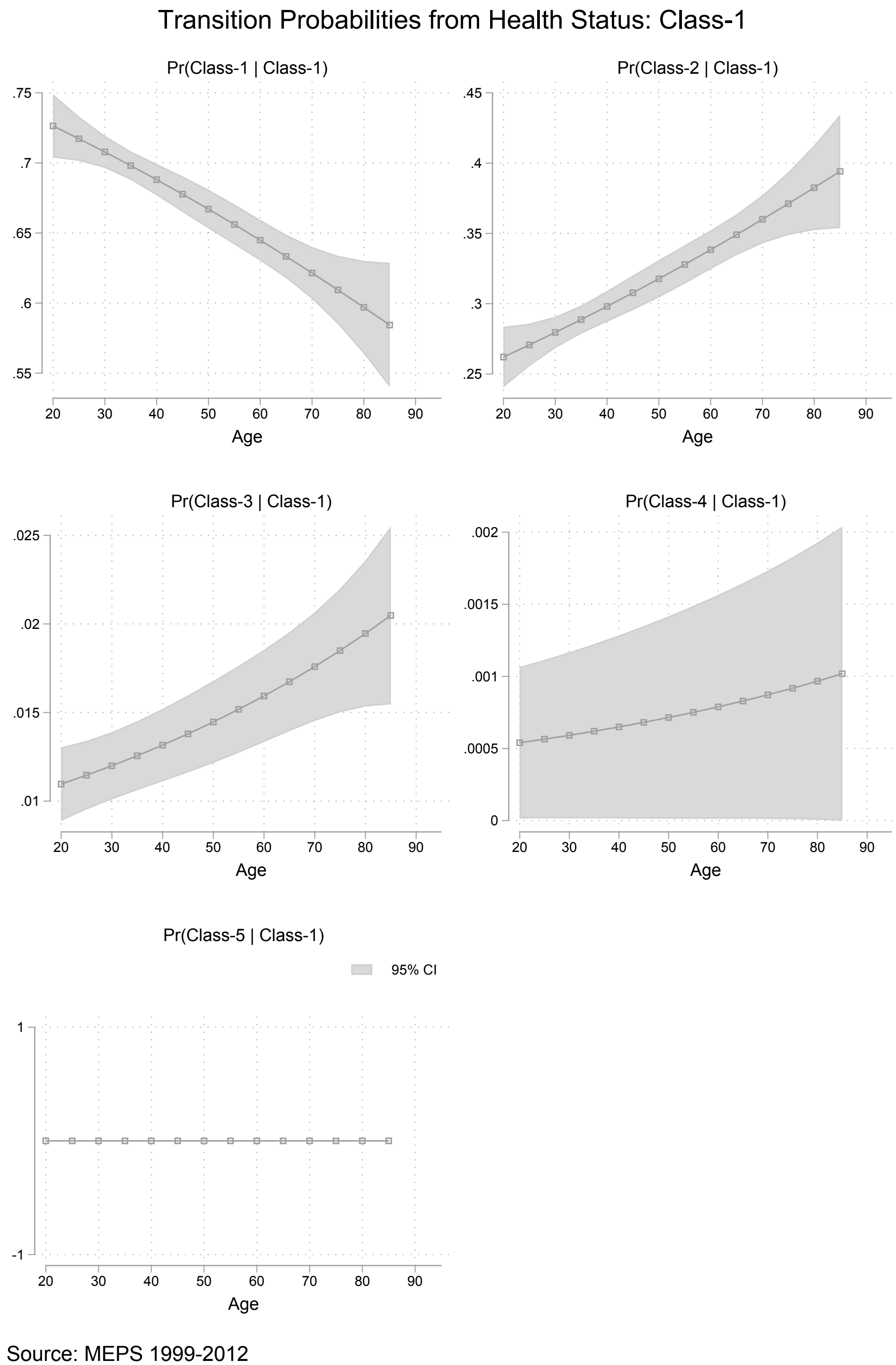


Figure 15: **Conditional health status Markov transition probabilities.**
Data source is MEPS 1999–2012, heads of HIEU, population weighted.

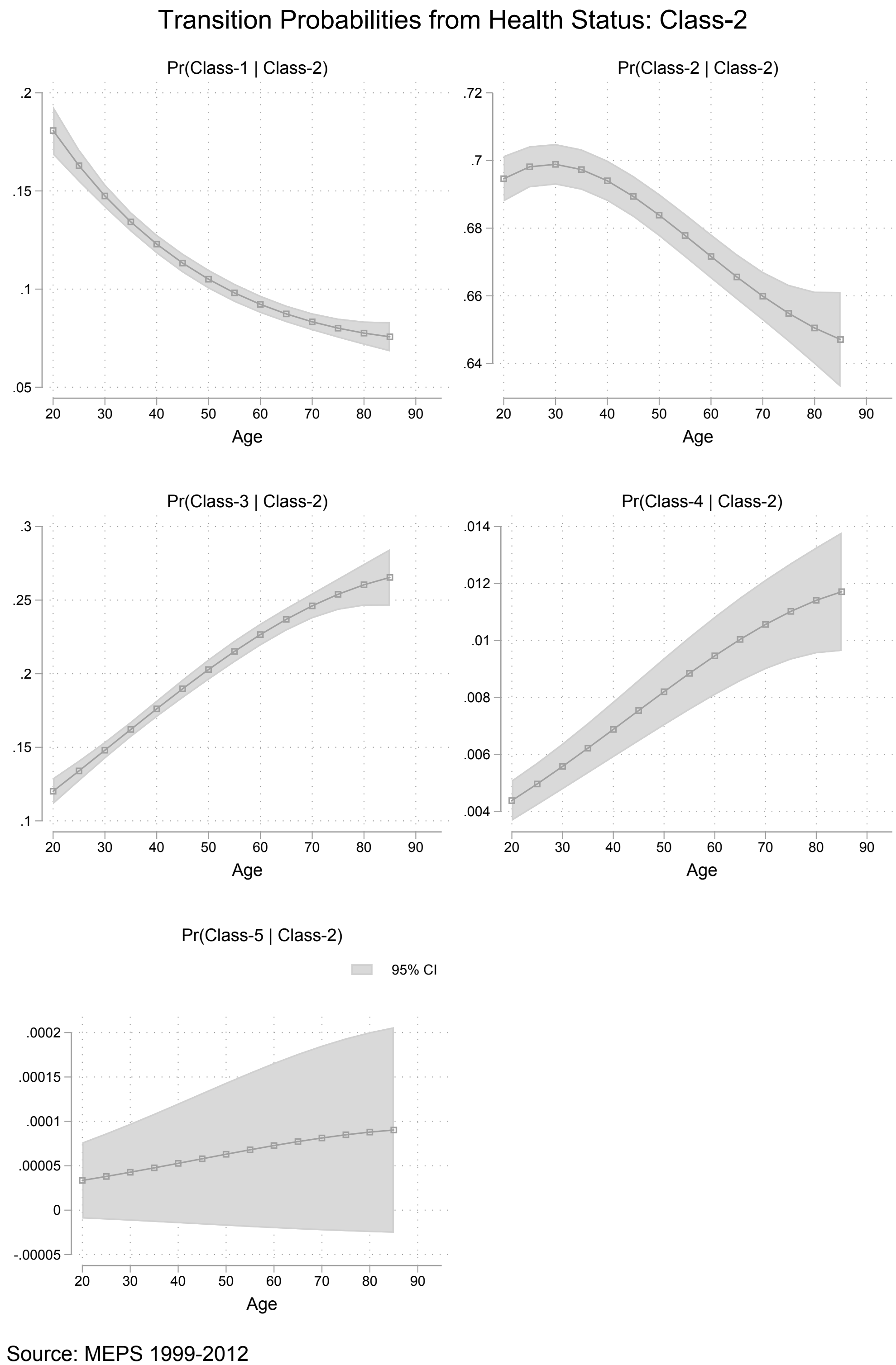


Figure 16: **Conditional health status Markov transition probabilities.**
Data source is MEPS 1999–2012, heads of HIEU, population weighted.

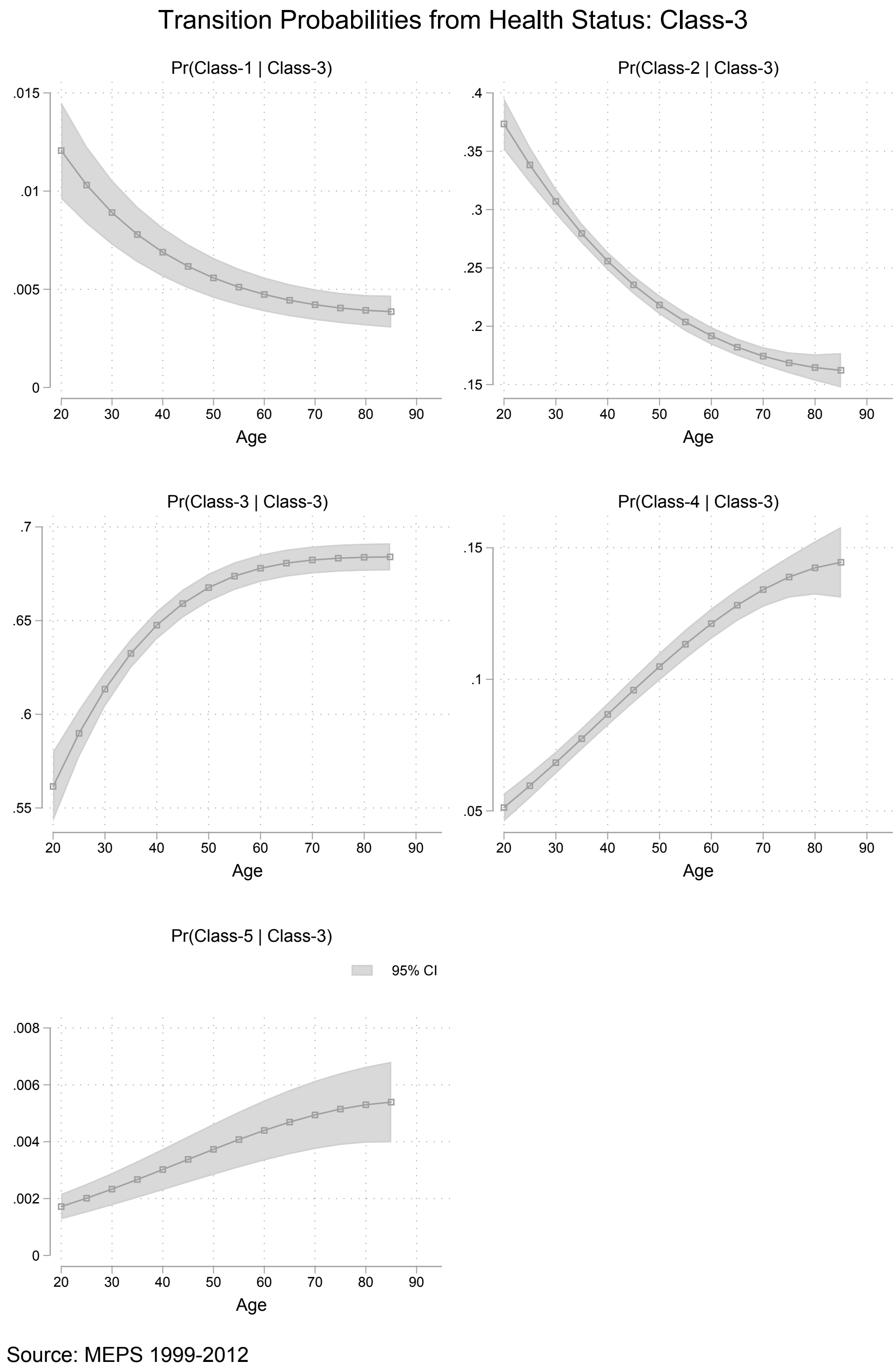


Figure 17: **Conditional health status Markov transition probabilities.**
Data source is MEPS 1999–2012, heads of HIEU, population weighted.

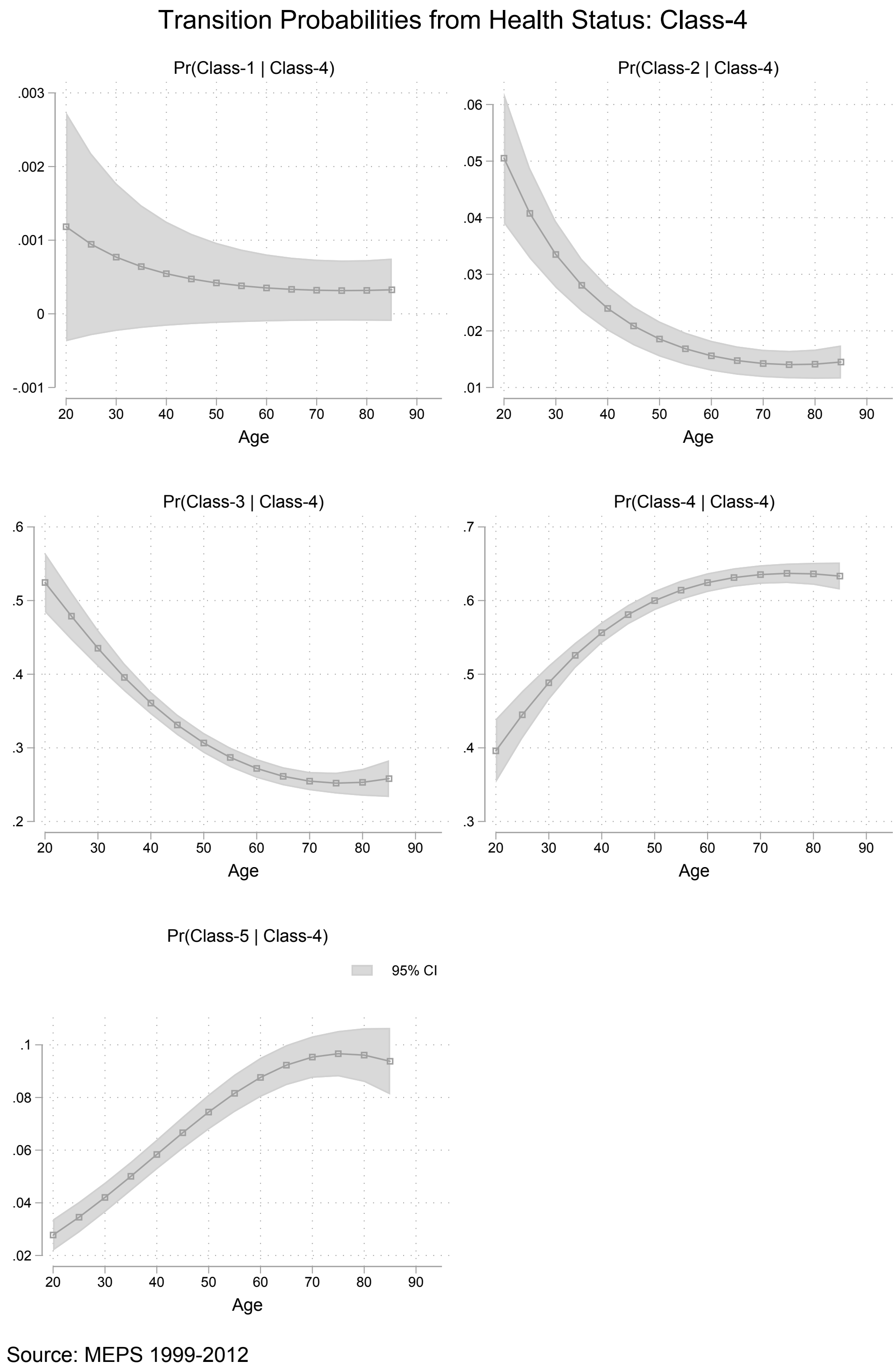


Figure 18: **Conditional health status Markov transition probabilities.**
Data source is MEPS 1999–2012, heads of HIEU, population weighted.

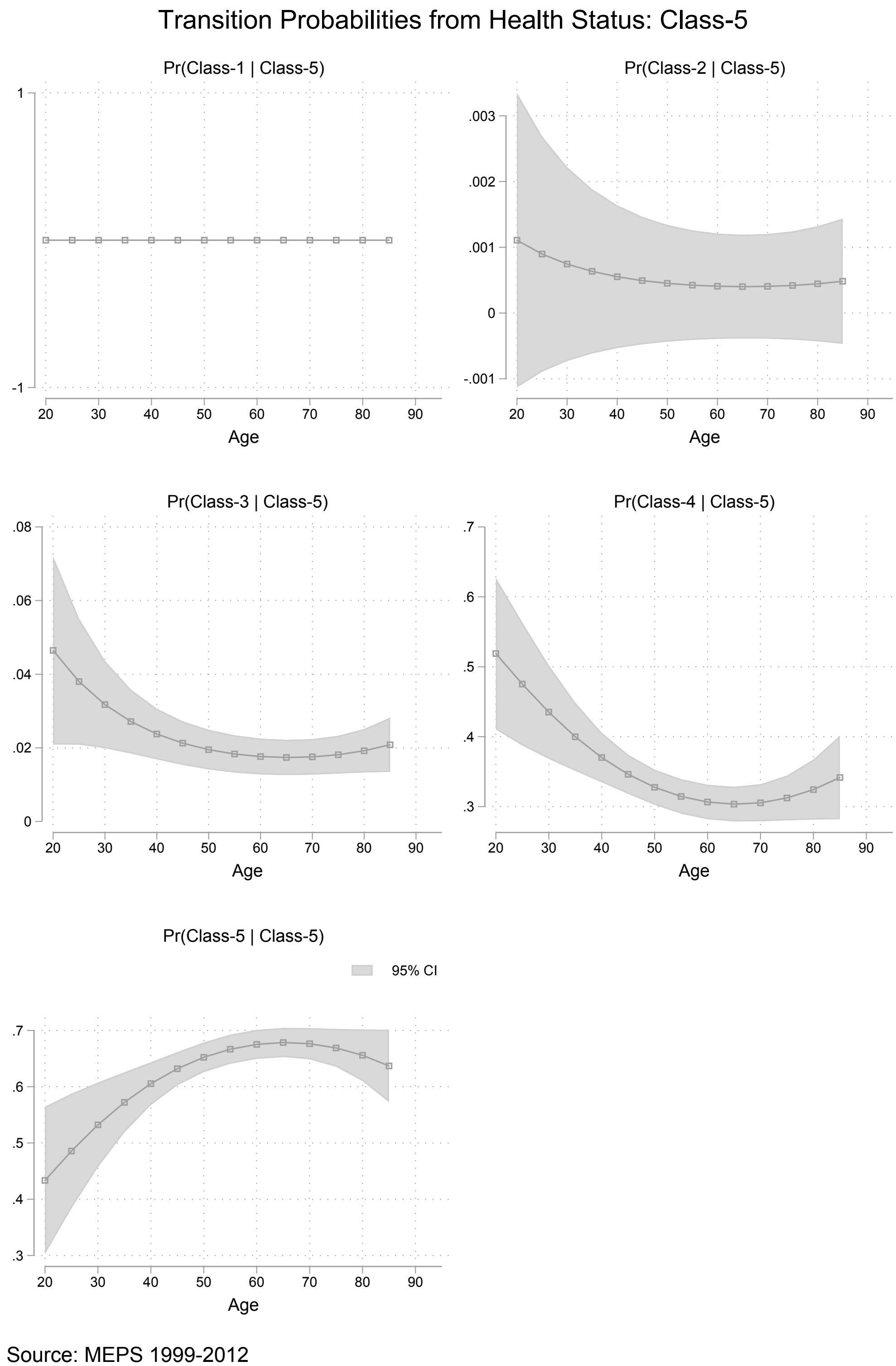


Figure 19: **Conditional health status Markov transition probabilities.**
Data source is MEPS 1999–2012, heads of HIEU, population weighted.