Financing Medicare: A General Equilibrium Analysis*

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Abstract

This paper develops a general equilibrium, overlapping-generations model of the U.S. economy where households face random fluctuations in health status. Health status determines households' productivity, mortality rate and their medical expenditures. Households make consumption and labor supply decisions, and can imperfectly insure medical expenditure shocks through markets. In addition, the government provides partial insurance against expenditure shocks through Medicare and a "social assistance" programs, and it runs a pay-as-you-go social security system. We calibrate the model based on the projected demographic and medical expenditure trends for the next 75 years. The model is used to study the macroeconomic and welfare implications of alternative funding schemes for Medicare. In the baseline closed-economy model, we find that the labor income tax will have to increase from 23% in 2005 to 36% in 2080 to finance the rising costs of Medicare. However, under an open-economy scenario, the tax would have to rise by much less. Limiting the increase in the wage tax through either a rise in the Medicare premium or a delay in the age of retirement is welfare improving.

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1 Introduction

The fiscal position of the U.S., given the current social security and health care legislation and the predicted demographic trends, is projected to worsen considerably over the next 15 to 30 years. The main reason behind the large projected deficits of the system is the ageing of the U.S. population, as the generation of the baby boomers approaches retirement. This generation, which is considerably larger than preceding ones, will enjoy longer and possibly healthier retirement, partly as a consequence of medical progress. Under current legislation, they are entitled to receive pensions, as social security payments, as well as health care, through Medicare, the universal health care program for the elderly. These gains, however, come at a cost which will have to be financed.

It is now clear that, under the current legislation, the fiscal problems created by Medicare are substantially larger in magnitude relative to those associated to social security. They are, however, much less studied in the literature. The main focus of this paper will be on the fiscal pressure created by Medicare. Our main aim is to look at this issue within a general equilibrium, overlapping-generations model calibrated to mimic the behavior of the aggregate U.S. economy.

The advantage of looking at the problem within a fully specified, structural, equilibrium model is that one can quantify the effects of rising aggregate Medicare expenditures on macroeconomic quantities (e.g., output, labor supply, and saving rates), on equilibrium prices (e.g., wages and interest rates), on the tax rate necessary to balance the government budget, and ultimately on household welfare.

Our model builds on the class of environments first studied by Auerbach and Kotlikoff (1987). Individuals are born as adults and are endowed with ability of generating income that depends on their skills and that evolves with age. Over the life cycle, they decide how much to work and how much to consume (and save). They are subject to medical expenditure shocks. During working ages, an exogenously given fraction of the population has employer-based health insurance, which is charged on the wage bill at an equilibrium premium. After the fixed retirement age, only some agents continue to receive supplemental coverage from employer-sponsored plans, but all are entitled to Medicare coverage and to social security benefits. All individuals are also covered by a safety net government program (representing Medicaid and other welfare programs), which effectively guarantees a minimal consumption, even in the face of extremely large medical expenditures.

The agents in our economy are heterogeneous in several dimensions: besides age and wealth, they differ because of their skill level (which is exogenously fixed), and their health status. The latter can take two values (good and bad health) and evolves stochastically over time according to a Markov process. Health status has an effect on individual productivity, on medical expenditures and on mortality. Healthier individuals are more productive, have lower medical expenditures and are less likely to die. We calibrate all these effects combining two databases, the Medical Expenditure Panel Survey (MEPS) and the Health and Retirement Study (HRS).

Armed with this framework, whose details we describe below, we focus on studying the effects of the two forces that will determine the evolution of the Medicare bill: changes in the demographic structure, and changes in the cost of health care. As the evolution of these two factors, and especially the second, are far from certain, we simulate different scenarios and different policy responses to these scenarios. Our model provides a first step in assessing quantitative implications of these alternative policies.

In our baseline experiment, we search for the adjustment in the labor income tax needed to finance the additional social security and Medicare outlays. We find that the taxation of labor must increase from 23% to 36% to balance the budget in the long run. Over two thirds of the higher taxation in 2080 is associated to Medicare.

In our baseline experiment, we assume health-care inflation, in excess of productivity growth and general inflation, of 0.63% per year. We consider an alternative scenario where excess health care inflation is 0.86% per year between 2005 and 2080, close to the long-run projection of a 1% annual growth by the Social Security Administration (SSA). Under this scenario, the wage tax rises to 39%. To appreciate the macroeconomic effects of the predicted rise in medical costs, note that in the model consumption of non-medical services drops by 21% as medical expenditures (and labor taxation) eat up a larger fraction of household earnings. Moreover, the percentage of families who are recipients of social assistance doubles relative to the final steady-state in the baseline simulation.

In order to let the government alleviate the fiscal pressure from Medicare, we consider three alternative reforms: 1) a rise in the Medicare premium, 2) a reduction in the Medicare coverage rate, and 3) a rise in the retirement age. Interestingly, all three experiments reduce the equilibrium wage tax in 2080 by a similar magnitude (2%-3% relative to the baseline), and they are all welfare improving. Raising retirement age increases the aggregate labor supply and output and is shown to be the best option from the welfare perspective. Raising the Medicare premium dominates the alternative of reducing the coverage rate, since it shifts the costs of the program towards the beneficiaries without increasing the expenditure uncertainty they face.

In previous work (Attanasio, Kitao and Violante, 2006; 2007), we have argued that the extent to which capital will flow in and out of the U.S. in the next 75 years is key in determining the budgetary, macroeconomic and welfare implications of demographic trends. Here, we confirm that our quantitative conclusions depend on the path of factor prices associated with the openness of the economy. When the U.S. is seen as "small" relative to the world economy, the equilibrium wage tax rate increases only to 31% in 2080. As households increase their savings because of life-cycle and precautionary motives, their wealth grows, but the world interest rate remains fixed. As a result, the tax-base for capital income taxation increases significantly. This, in turn, allows the government to limit the rise in labor taxation.

Several studies sharing our same approach investigate the social security system and its reforms (see, for instance, Huang, et al., 1997; De Nardi, et al., 1999; Kotlikoff, et al., 1999, 2002; Huggett and Ventura, 1999; Fehr, et al., 2004; Attanasio, Kitao and Violante, 2006, 2007; Domeji and Floden, 2006; Fuster, et al., 2007, among others).

Some recent papers have tried to estimate the overall effect of the introduction of Medicare in 1965, taking into account the general equilibrium reaction of the supply of health services (see Finkelstein, 2007). Other papers have looked at life cycle models where health shocks and medical costs play an important role (see Palumbo, 1999; French and Jones, 2007; De Nardi, et al., 2006). Yet another set of studies looks at specific information imperfections in the market for health insurance (see, for instance, Finkelstein, 2004; Brown and Finkelstein, 2007a, 2007b; Brown, et al., 2007). However, to the best of our knowledge, the financing of Medicare and its implications have not been studied within a general equilibrium model.

The closest paper to ours is Borger et al. (2008). They calibrate a model of the U.S. economy where a representative household derives utility from consumption and health status, and health depends on the purchase of medical services. Medical services, in turn, are produced by a medical sector whose productivity growth determines "health-care inflation." The authors use the model to explain why the demand for medical services is expanding even though its relative price is rising. Relative to Borger, et al., our model has less detail in modelling production of medical services, and has no link from consumption of medical services to health status (albeit it has a link from health to medical expenditures and and from health to preferences through survival rates). However, we put more structure on the household side by modelling heterogeneity in demographics, health status, and medical expenditures. Finally, the focus of our paper is on the fiscal consequences of Medicare, a question that Borger et al. do not address explicitly.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 outlines the calibration. The results of our simulations are reported in Section 4. Section 5 concludes.

2 The model

2.1 Economic environment

In this section, we describe the model in a stationary economic environment.

Demographics and health status: The economy is populated by J overlapping generations of households. The size of a new cohort grows at rate g. Households enter the labor market at age $j = 1$ and retire at $j = j_R$. Within a cohort, households differ by their educational attainment, indexed by e. Let η_e be the fraction of type e in each cohort.

Households face exogenous uncertainty about their health status h. Conformably with the data, we let the stochastic evolution of health status depend on education. More precisely, the health status of a household of type e and age j evolves over the life-cycle according to the Markov chain $\Lambda^h_{e,j}(h', h)$ for $j > 1$, with the implied distribution $\bar{\Lambda}^h_{e,j}(h)$ at age j.

Agents of age j and education e with health status h survive into next period with probability $\pi_{e,j}(h)$. Let $\Pi_{e,j}(\mathbf{h})$ denote the probability of surviving until age j for a newborn of type e, conditional on experiencing health history $\mathbf{h} = \{h_1, ..., h_{j-1}\}$.. Households die with certainty at the end of period J, i.e. $\pi_{e,J}(h) = 0$ for all h and e. Unintended bequests of the deceased are seized by the government.

A household's labor productivity is determined by the product of two type-specific, orthogonal components, $\varepsilon_{e,j}$ and $\omega_e(h)$. The first is a deterministic age-dependent component whose level and shape depend on type e. To model retirement, we impose $\varepsilon_{e,j} = 0$ for $j \geq j_R$. The second is a stochastic component that depends on health status h and captures the fact that a deterioration of health status may reduce labor productivity vy different amounts, depending on education level.

Preferences: Households' preferences are separable over time and state, i.e.

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

where β denotes the discount factor, c consumption and n hours worked. The expectation operator is taken over all the possible idiosyncratic histories of health status $\mathbf{h}$ up to age $J-1$.

Health expenditures, and insurance: Households are subject to medical expenditure shocks. Gross (i.e., before insurance coverage) medical expenditures m are random draws from a distribution $\Lambda_{j,h}^m(m)$, with density function $\lambda_{j,h}^m$, that depends on age j and health status h. The dollar value of expenditures incurred by the household is expressed as qm, where q is the relative price of medical services to consumption. The variable q allows us to model the feature that cost-inflation for medical services is projected to be higher than general inflation and productivity growth. The persistence over the life cycle in medical expenses, an important feature of the data, follows from the persistence in health status.[1]

There are three types of medical insurance coverage in the economy: employer-based insurance, Medicare and social assistance. During the working age, some households are offered employer-sponsored health insurance that covers a fraction κ^w of gross expenditures. In addition, some of the workers are offered insurance from their previous employers throughout retirement, at coverage rate κ^{ret}. Access to employer-based health insurance is determined by a random draw at the beginning of life. Let $i \in \{0, 1, 2\}$ denote the insurance status with $i = 0$ indicating no coverage, $i = 1$ indicating employer-sponsored coverage only during the working stage, and $i = 2$ indicating employer-sponsored coverage throughout life. A draw at age $j = 1$ from the distribution $\Lambda_e^i(i)$ determines the individual state i.[2]

[1] We implicitly take the view that the amount of health expenditures drawn m is unavoidable to have any chance of survival into next period. As a result, households always optimally choose to incur such expenditures.

[2] In practice, the worker decides whether to purchase the employer-based insurance when it is offered. The majority of workers, however, take up the offer due to the subsidy provided by the employers and the tax benefit. See Jeske and Kitao (2007) for a model which endogenizes the health insurance decision.

Employer-sponsored health insurance is administered by competitive insurance companies which pool, separately, workers and retirees covered by employer-sponsored insurance. An agent of type $i = 1$ pays a premium p^w during work. An agent of type $i = 2$ pays the larger premium $p^w + \xi^w p^{ret}$ during work and the premium $\left(1 - \bar{\xi}^{ret}\right) p^{ret}$ during retirement. The parameter $\bar{\xi}^{ret}$ represents the fraction of the retirees' health insurance premium p^{ret} covered by the firm. The firm, in turn, shifts this cost to its current workers of type 2. In this sense, the system operates with a pay-as-you-go scheme: each current worker who will receive employer-sponsored insurance as a retiree (type 2) pays the extra premium $\xi^w p^{ret}$ necessary to finance the amount $\bar{\xi}^{ret} p^{ret}$ to each current covered retiree.[3] Insurance companies incur an administrative fees ϕ per unit of medical expenditure covered and, in equilibrium, they charge premia (p^w, p^{ret}) in order to break even. As in the U.S. economy, insurance premia are tax-deductable for workers with labor income.[4]

The second form of health insurance is provided by the government through Medicare: during retirement, all households are covered by Medicare with coverage rate κ^{med} and premium p^{med}. There are administrative costs ϕ^{med} per unit of medical expenditures covered by Medicare.

Finally, the government also acts as a last-resort insurer. It runs a social assistance program which guarantees a minimum level of consumption $\bar{c}$ to every household by supplementing income with a transfer tr in the event households' disposable assets fall below $\bar{c}$. This policy provides insurance against health expenditure and survival risk –the two sources of individual uncertainty in the economy. As such, it summarizes succinctly various U.S. transfer programs such as Food Stamp, Temporary Assistance for Needy Families (TANF), Supplemental Security Income, and especially, Medicaid.

Commodities, goods and input markets: There are three commodities: 1) final goods that can be used for private consumption, public consumption and addition to the existing capital stock (investment), 2) medical services, and 3) labor services supplied by households. All markets are competitive.

[3]Note that $\bar{\xi}^{ret}$ need not be equal to ξ^w since the number of retirees that the firm subsidizes is not identical to the number of workers who share the cost because of the age-dependent survival rates.

[4]More precisely, employer contributions are treated as a business expense and excluded from income and payroll tax bases. Employees' share of the premium can also be tax-exempt if it is offered through flexible spending plans. See Lyke (2003) for more details on the current legislation on the tax treatment.

Technology: There are two sectors in the economy. One sector produces the final good that can be used for private and public consumption and for investment. The other sector produces medical services. We assume that the production function in the two sectors is the same, except for the dynamics of sector-specific TFP. Given competitive markets and free movement of factors across sectors, it is easy to show that the model admits aggregation into a one-sector economy. Thus, we postulate an aggregate production function

$$Y = ZF\left(K, N\right),$$

where K is aggregate capital, N aggregate labor input in efficiency units and Z total factor productivity. The economy-wide resource constraint reads as

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

where δ is the geometric depreciation rate of the capital stock. C denotes aggregate private consumption, M aggregate expenditures on medical services (including administrative costs associated with employer-based health insurance and Medicare), and G aggregate public consumption expenditures.

Fiscal policy: The government has five different types of outlays: general public consumption G, Medicare expenses, social assistance payments, social security benefits, and services to public debt. We have already described the first three expenditure items.

The social security program is pay-as-you-go as it is in the U.S. economy. Retired households of age $j \geq j_R$ and type e receive a pension benefit b_e through the social security system. Benefits replace a fraction ρ_e of the average earnings across all household of type e in the cohort, i.e. we have

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

where $\bar{y}_e(j)$ are average earnings of households of type e and age j, that is the product of four components: average hours worked by education type, $\bar{n}_e$, the wage rate per efficiency units w, and the number of efficiency units jointly determined by the age-efficiency profile $\varepsilon_{e,j}$ and the impact of health status on productivity $\omega_e(h)$.[5]

[5]Modelling benefits this way strikes a compromise between realism and computational efficiency. We capture that household benefits depend on their past earnings, as in the actual system. But we posit they depend on average earnings of group e, that households take as given, instead of past individual earnings which would require an additional continuous state variable as well as an additional effect on the labor supply decision. The dependence on economy-wide average earnings does not require any additional state since households in the model must forecast prices anyway to compute their decisions.

The government supplies an amount of one-period risk-free debt D which, by no arbitrage, must carry the same return r in equilibrium as claims to physical capital.

Finally, the government collects revenues from various sources: labor income taxation at rate τ^w, consumption taxation at rate τ^c, capital income taxation at rate τ^r, Medicare premium p^{med} and accidental bequests. In the baseline economy, we treat $\left(\tau^c, \tau^r, p^{med}, \rho_e, D, G\right)$ as parameters, and we let τ^w be determined in equilibrium to balance the government budget.

Assets and financial markets: As in İmrohoroğlu (1989), Huggett (1993), Aiyagari (1994) and Ríos-Rull (1996), financial markets are incomplete in the sense that agents trade risk-free bonds, subject to a borrowing constraint, but do not have access to state-contingent insurance against individual risk.

2.2 Household problem

Work stage: The timing of events is as follows. At the beginning of each period, households observe their health status h and their disposable resources ("cash in hand") x. When household resources x are not large enough to finance the minimum consumption $\bar{c}$, the government intervenes through its social assistance program with a transfer tr. Next, households make consumption and labor supply decisions. Note that these decisions are made under uncertainty about medical expenditure shocks hitting the individual later in the period. Then, labor income and capital income are earned and the insurance premium is paid if the household is covered by health insurance ($i = 1, 2$). Then, the medical expenditure shock m is realized, a fraction κ^w of which is covered in case of coverage. The residual $(1 - \kappa^w)\, qm$ represents out-of-pocket expenses. Finally, the mortality shock is realized and, conditional on surviving, households enter next period with a new health status h'. We can describe the problem working household recursively as:

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

subject to

$$x' = \left[1 + \left(1-\tau^r\right) r\right] \left[x - \left(1+\tau^c\right) c + tr\right] + \left(1-\tau^w\right) \left[w \varepsilon_{e,j} \omega_e(h) n - d\left(i\right)\right] - (1 - \kappa^w \cdot I_{\{i>0\}}) qm$$

$$d = \begin{cases} 0 & \text{if } i = 0 \\ p^w & \text{if } i = 1 \\ p^w + \xi^w p^{ret} & \text{if } i = 2 \end{cases}$$

$$tr = \max\{0, \left(1+\tau^c\right) \bar{c} - x\}$$

$$c \leq \frac{x + tr}{1 + \tau^c}$$

$$h' \sim \Lambda^h_{e,j}\left(h', h\right) \text{ and } m \sim \Lambda^m_{j,h}\left(m\right)$$

The first constraint is the budget constraint of the household, and $I_{\{\cdot\}}$ is the indicator function. The second line describes the deduction $d\left(i\right)$ on the health insurance premium. The third equation models the social assistance policy. The fourth line is the no-borrowing constraint. The laws of motion for medical expenditure shocks and health status appear in the last line. For future reference, it is also useful to define households' asset holdings as $a \equiv x - \left(1+\tau^c\right) c + tr$.

Retirement stage: At the beginning of each period, households observe health status h and their disposable resources x. If disposable assets fall below $\bar{c}$, the government transfers the residual amount tr. Next, the household makes its consumption decision under uncertainty about medical expenditure shocks. Then, social security benefits are earned, the Medicare premium is paid, and the additional insurance premium is paid in case of employer-sponsored coverage ($i = 2$). Next, medical expenditure shocks m are realized, a fraction κ^{med} of which are covered by Medicare for everyone. An additional fraction κ^{ret} is covered if the household is insured through its past employer ($i = 2$). The residual represents out-of-pocket expenditures for the household. Finally, the mortality shock is realized and, conditional on surviving, households enter next period. We can write the problem of a retired household recursively as:

$$V_r(e,i,j,h,x) = \max_{c} \{u(c,1) + \beta\pi_{e,j}(h)\,\mathbb{E}V_r(e,i,j+1,h',x')\} \tag{RHP}$$

subject to

$$x' = [1+(1-\tau^r)\,r]\,[x-(1+\tau^c)\,c+tr] + b_e - \left[1-\kappa^{med}-\kappa^{ret}\cdot I_{\{i=2\}}\right] qm - p^{med} - \left(1-\bar{\xi}^{ret}\right) p^{ret}\cdot I_{\{i=2\}}$$

$$tr = \max\{0,(1+\tau^c)\,\bar{c}-x\}$$

$$c \leq \frac{x+tr}{1+\tau^c}$$

$$h' \sim \Lambda^h_{e,j}(h',h) \text{ and } m \sim \Lambda^m_{j,h}(m)$$

2.3 Stationary equilibrium

Let $s \equiv \{e,i,j,h,x\}$ be the individual state vector, with $e \in \mathcal{E}$, $i \in \mathcal{I} = \{0,1,2\}$, $j \in \mathcal{J} = \{1,2,...,J\}$, $h \in \mathcal{H}$, and $x \in \mathcal{X} = [\underline{x},\bar{x}]$. Let $\mathcal{B}_{\mathcal{H}}$ and $\mathcal{B}_{\mathcal{X}}$ be the Borel sigma-algebras of $\mathcal{H}$ and $\mathcal{X}$, and $P(\mathcal{E})$, $P(\mathcal{I})$ and $P(\mathcal{J})$ be the power sets of $\mathcal{E}$, $\mathcal{I}$ and $\mathcal{J}$. The state space is denoted by $\mathcal{S} \equiv \mathcal{E}\times\mathcal{I}\times\mathcal{J}\times\mathcal{H}\times\mathcal{X}$. Let $\Sigma_{\mathcal{S}}$ be the sigma algebra on $\mathcal{S}$ defined as $\Sigma_{\mathcal{S}} \equiv P(\mathcal{E})\otimes P(\mathcal{I})\otimes P(\mathcal{J})\otimes\mathcal{B}_{\mathcal{H}}\otimes\mathcal{B}_{\mathcal{X}}$ and $(\mathcal{S},\Sigma_{\mathcal{S}})$ be the corresponding measurable space. Denote the stationary measure of households on $(\mathcal{S},\Sigma_{\mathcal{S}})$ as μ.

Given survival rates $\{\pi_{e,j}(h)\}$, fiscal variables $\{G, D, \rho_e, \tau^c, \tau^r, tr(s)\}$, and relative price of medical services q, a *stationary recursive competitive equilibrium* is a set of: i) value functions $V(s)$, ii) decision rules for the households $\{c(s), n(s)\}$, iii) firm choices $\{K, N\}$, iv) insurance premia $\{p^w, p^{ret}\}$, v) labor income tax rate τ^w, and vi) a measure of households μ such that:

1. Working households choose optimally consumption and labor supply by solving problem (WHP), and retired households choose optimally consumption by solving problem (RHP).

2. Firms maximize profits by setting their marginal productivity equal to factor prices

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

3. The labor market clears

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

4. The asset market clears
$$K + D = \int_{\mathcal{S}} a(s)\, d\mu$$

5. The private insurance market for working households, and retired households clears
$$\begin{aligned} p^{w} \int_{\mathcal{S}|j<j_R, i\in\{1,2\}} d\mu &= (1+\phi)\,\kappa^{w} q \int_{\mathcal{S}|j<j_R, i\in\{1,2\}} m\lambda_{j,h}^{m}(m)\, d\mu \\ p^{ret} \int_{\mathcal{S}|j\geq j_R, i=2} d\mu &= (1+\phi)\,\kappa^{ret} q \int_{\mathcal{S}|j\geq j_R, i=2} m\lambda_{j,h}^{m}(m)\, d\mu \end{aligned}$$
with all insurance companies making zero profits for the two separate pools.[6]

6. The final good market clears
$$ZF(K, N) = C + \delta K + qM + G,$$
where
$$C = \int_{\mathcal{S}} c(s) d\mu \quad \text{and} \quad M = \int_{\mathcal{S}} m(s)\, d\mu + \Phi,$$
and Φ represents the total administrative costs associated with the employer-based insurance and Medicare.[7]

7. The government budget constraint satisfies
$$\begin{aligned} & \tau^{c} C + \tau^{w} w N + \tau^{r} r \int_{\mathcal{S}} a(s)\, d\mu + p^{med} \int_{\mathcal{S}|j\geq j_R} d\mu + \int_{\mathcal{S}} \left[1 - \pi_{e,j}(h)\right] x d\mu \\ = \;& G + rD + \int_{\mathcal{S}} tr(x)\, d\mu + (1+\phi^{med})\kappa^{med} q \int_{\mathcal{S}|j\geq j_R} m\lambda_{j,h}^{m}(m)\, d\mu + \int_{\mathcal{S}|j\geq j_R} b_e d\mu \end{aligned}$$
where $a \equiv x - (1+\tau^{c})\, c + tr(x)$, the social assistance rule $tr(x)$ is described in $[WHP]$ and $[RHP]$, and social security benefits b_e are determined as in (1).

[6]As discussed above, each retiree pays a fraction $(1-\bar{\xi}^{ret})$ of the premium p^{ret} and each worker with a life-time coverage pays a fraction ξ^{w} of p^{ret}, where
$$\xi^{w} = \bar{\xi}^{ret} \frac{\int_{\mathcal{S}|j\geq j_R, i=2} d\mu}{\int_{\mathcal{S}|j<j_R, i=2} d\mu}.$$

[7]More precisely,
$$\Phi = \phi \left[\kappa^{w} \int_{\mathcal{S}|j<j_R, i\in\{1,2\}} m\lambda_{j,h}^{m}(m)\, d\mu + \kappa^{ret} \int_{\mathcal{S}|j\geq j_R, i=2} m\lambda_{j,h}^{m}(m)\, d\mu\right] + \phi^{med}\kappa^{med} \int_{\mathcal{S}|j\geq j_R} m\lambda_{j,h}^{m}(m)\, d\mu.$$

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

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

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

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

with $\Pr\{x' \in \mathsf{X}|s\}$ jointly determined by the constraint sets of problems (WHP) and (RHP), the household decision rules, and the distribution function of medical expenditures $\Lambda^{m}_{e,j}(m)$.

3 Calibration

We calibrate our model to the U.S. economy and demographics in 2005. Then, we compare the stationary equilibrium of this economy to another economy that has the same set of parameter values, except for i) the demographic structure (population growth and survival rates), and ii) the price level q of medical expenditures. This second economy is meant to represent the U.S. in 2080.

Demographics: Households enter the economy at the age of 20 ($j = 1$) and survive up to the maximum age of 100 ($J = 81$). They can be of either type $e = 1$ (high education) or $e = 0$ (low education). We fix the proportion of high-educated newborn η_e at 0.30. Households retire from work at the mandatory retirement age of 65 ($j_R = 46$). A high education household in the data corresponds to single households where the adult holds a college degree, and to married households where at least one of the spouses has attained a college degree.

In our model, survival rates $\pi_{e,j}(h)$ depend on education level e, age j, and health status h. Let $\bar{\pi}_{e,j}$ be the average (across health status) survival rate at age j for education type e. Bhattacharya and Lakdawalla (2006) have computed these survival curves by age/education demographic groups, which we use for the values of $\bar{\pi}_{e,j}$. We then combine the differentials in longevity by group with the long-run projections of the aggregate surviving rates (i.e., those average across the entire population) formulated by the SSA (Bell and Miller, 2002) in order to construct the age and education specific surviving rates in 2080. The key assumption we make is that the ratio between the mortality rate of the college-educated type and that of the low-education type at each age, remains constant. The left panel of Figure 1 plots, for the high education groups, the average survival rates $\bar{\pi}_{1,j}$ as a function age in 2005 and 2080. The right panel plots the survival differential between the two education groups, by age.[8]

In the initial steady-state, we set the growth rate of the size of newborn cohorts to 1.35% per year in order to match an old-age dependency ratio (the ratio of the population aged 65 and over to that between 20 and 64) of 20%, the observed values for the U.S. economy. According to the U.S. Census Bureau's projection, the population growth will settle at 0.69-0.71% in 2050-2100. We set the growth rate at 0.70% in the final steady-state, which together with the survival probabilities in 2080 projected by the SSA implies the dependency ratio of 32.2%.

Preferences: Households have period utility over consumption and leisure:

$$u(c, 1-n) = \frac{c^{1-\gamma}}{1-\gamma} + \chi \frac{(1-n)^{1-\theta}}{1-\theta}. \tag{2}$$

We choose $\gamma = 2$, which implies the intertemporal elasticity of substitution of 0.5, in the middle of the range of micro estimates in the literature (see Attanasio, 1999, for a survey). We set the parameter χ so that the average fraction of the time endowment allocated to market work is 0.33, which implies $\chi = 2.028$. Under this preference specification, the intertemporal labor supply elasticity is $((1-n)/n)/\theta$. We set the average labor supply elasticity in the population to 0.50 which is a compromise between the small estimates for males and estimates for females which are above one (Browning, Hansen, and Heckman, 1999). Given our target for the market work hours, this requires setting $\theta = 4$. We set the subjective discount factor β to 0.9955 so that the economy in 2005 has wealth (claims to physical capital and to public debt) to GDP ratio equal to 3.4, similarly to the U.S. economy.

Technology: The aggregate production function is Cobb-Douglas in capital and effective labor:

$$Y_t = Z K_t^{\alpha} L_t^{1-\alpha}.$$

[8] Since it is the ratio of mortality rates of high to low educated that we assume to be constant, the ratio of survival rates changes from 2005 to 2080.

We set α at 0.33 to match the capital share of output, and the physical depreciation rate at 0.06. Total factor productivity Z is chosen so that income per capita ($42,000 in 2005) is normalized to 1.0 in the first steady state.

Health status and survival rates: Our main source of micro data on U.S. households is the Medical Expenditure Panel Survey (MEPS). MEPS is an ongoing annual survey of a representative sample of the civilian population with detailed information on demographics, income, labor supply, health status, health expenditures and health insurance.

The measure of health status in MEPS is self-reported.[9] Every annual MEPS survey has three waves, and this measure is present in each one. Since health status is reported at the individual level, we face the issue of aggregating this information into the health status of a household (often composed of more than one adult) on an annual basis while at the same time maintaining computational feasibility. We choose to define two levels of a household health status: good (h^g) and bad $\left(h^b\right)$. First, for each spouse in the household we compute the numerical average of the answer to the subjective health question across the three waves. We then define an individual to be in bad health that year if its average was strictly above 3. Finally, for married households we define the household to be in bad health if at least one of the spouses was in bad health.

Table 1 (upper panel) reports the estimated transition function $\Lambda^h_{e,j}$ for the two education groups for ten-year age classes 20-29, 30-39, and so on. We group ages 65 and higher in order to maintain a sufficiently large sample size. This transition matrix shows that the good health status is very persistent, more so for the college educated. The probability of a switch from good to bad health increases monotonically with age, from roughly 4.5% (1.4%) at age 25 to 13.7% (10.4%) beyond age 65 for the low-educated (for the high-educated). Also the persistence of the bad health status increases sharply with age.[10]

Figure 2 reports the implied fraction of households in bad health by age class and education group (solid lines) implied by the transition matrix against the empirical fractions measured directly from MEPS in each wave (stars). The fraction of households reporting

[9]The exact wording of the survey question on health status is: *"In general, compared to other people of (PERSON)'s age, would you say that (PERSON)'s health is excellent (1), very good (2), good (3), fair (4), or poor (5)?"*.

[10]The initial draw of health status for households in the model is calibrated from MEPS data on the health status at age 20. At this age, 98% of college graduates and 90% of high-school graduates are in good health.

to be in bad health increases sharply over the life-cycle. For example, for low-educated households it starts at around 10% at age 25 and reaches 45% beyond at age 65. Note that, due to the small sample size, the estimates become extremely noisy after age 65. The decline after age 65 is a natural consequence of selection: survivors are more likely to be in good health.

By design, MEPS data do not allow to quantify the effect of health status on mortality rates. First, their panel dimension is very short. Second, individuals drop out of the MEPS sample when they become institutionalized (e.g. enter a nursing home) and are not followed thereafter. As a result, the number of individuals who are recorded as deceased in the survey is extremely small and the sample is heavily selected. Therefore, to measure the marginal effect of bad health on mortality rates, we turn to the Health and Retirement Survey (HRS).

The main advantage of the HRS is that it focuses on a sample of older individuals (and their spouses) and follows them over a long period of time (seven waves are currently available, each contact being two years apart from the previous one). The HRS therefore provides the ideal sample to estimate mortality rates and how they relate to other variables. In addition, the HRS also contains a question on subjective health status. The exact wording is virtually identical to that used in MEPS and therefore we can confidently compare the two questions.

Before describing how we estimate the relationship between health status and mortality, we compare the distribution of health status and their persistence in the two datasets. In particular, both in MEPS and in the HRS (between 5th and 6th waves) we use exactly the same definition of household's "good health" and "bad health". The results from HRS are reported in Table 1 (lower panel). The key difference is that these are bi-annual transition rates, so the comparison is not immediate. From MEPS we can construct bi-annual rates and compare them to HRS. For example,

$$\Lambda^h_{e,j}\left(h^b,h^b\right)^2=\Lambda^h_{e,j}\left(h^b,h^b\right)\Lambda^h_{e,j}\left(h^b,h^b\right)+\Lambda^h_{e,j}\left(h^b,h^g\right)\Lambda^h_{e,j}\left(h^g,h^b\right).$$

Focusing on the oldest group among the low-educated, we obtain that $\Lambda^h_{l,65+}\left(h^b,h^b\right)^2=$ 0.76 in MEPS and 0.79 in HRS. Overall, the similarity across the two samples is considerable, which gives us confidence in combining the two datasets.

To calibrate the effect of health status on survival probabilities, we exploit the longitudinal dimension of HRS and model the probability of dying as a function of age, gender and health status through a Probit model.[11] As expected, the probability of dying increases with age and it is lower for women. Being in good health decreases considerably the probability of dying. Figure 3 shows that this good health premium is less than 1% at age 25 but it increases quickly up to 3.5% at age 65. After age 65 we have extrapolated the premium based on a quadratic function.

In light of these findings, we adjust our conditional survival rates as follows. Let the good health premium on survival rates at age j be denoted by $survprem_j$. Let $\bar{\pi}^{e,j}$ be the average survival rate, and $\bar{\Lambda}^h_{e,j}$ be the distribution of health status for group e at age j . Then, given values for $survprem_j$, $\bar{\pi}^{e,j}, \bar{\Lambda}^h_{e,j}\left(h^b\right)$, and $\bar{\Lambda}^h_{e,j}\left(h^g\right)$, the two equations

$$\begin{aligned} \bar{\pi}_{e,j} &= \bar{\Lambda}^h_{e,j}\left(h^b\right)\pi_{e,j}\left(h^b\right) + \bar{\Lambda}^h_{e,j}\left(h^g\right)\pi_{e,j}\left(h^g\right) \\ survprem_j &= \pi_{e,j}\left(h^g\right) - \pi_{e,j}\left(h^b\right) \end{aligned}$$

allow us to determine the two unknowns $\left\{\pi_{e,j}\left(h^g\right), \pi_{e,j}\left(h^b\right)\right\}$ for each education and age (e, j) pair. When we project survival rates in the final steady-state, consistently with the strategy outlined above, we keep constant the estimated good health premium.

Medical expenditures and insurance: Table 2 reports the distribution of adult-equivalent household medical expenditures computed from MEPS by age class and health status. In order to keep the sample size large enough, we have grouped ages into ten-year intervals 20-29, 30-39, and so on until 65+. We have also chosen to approximate the distribution by a histogram with bins corresponding to the 1st-60th percentile, 61th-95th percentile and 96th-100th percentile. Within each interval, we compute the average value, and use it for our three-point grid. This approximation is guided by the findings in French and Jones (2004) who show that the vast majority of households do not spend much, but the distribution has a thin and very long tail which is generated by a small number of catastrophic events.

The table shows that, on average, old spend more than young. For example, at age 65+ households spend about four times more than at age 25. A household in good health faces \$1,260 of annual medical expenses at age 25, but around \$6,000 at age 65+. Moreover, households in bad health spend more than twice as much as those in good health. A household of age 50 in bad health has expenditures around \$3,500 when in

[11] We also experimented with richer specifications, which entered non linear terms in age and interactions between age and health status. Possibly because of the limited amount of data we have, these interactions did not turn out to be significant.

good health, but if health deteriorates medical expenses jump to \$8,700 per year. The table also shows a great skewness in the distribution: with a small probability, households face extremely large medical expenditure shocks.

It is well known that MEPS significantly underestimates medical expenditures at the aggregate level compared to those reported in the National Health Accounts (NHA). Selden et al. (2001) report that the MEPS estimate of total expenditures in 1996 was \$550 billion, while the NHA estimate exceeded \$900 billion in the same year. NHA rely on the providers' surveys while MEPS statistics are based on households' surveys, which tend to underreport the spending and utilization of medical services. The two sources also differ in covered population and services. For example, NHA include expenditures by individuals in institutions (e.g. nursing homes), foreign visitors and military personnel, all of which are out of scope in MEPS. MEPS also excludes some sizeable service categories such as certain types of long-term mental hospital cares, and skilled nursing facilities.[12]

It is important that we adjust the expenditure data from MEPS to be consistent with the data at the national level so that we can correctly assess the effect of the increase in medical expenditures on macroeconomic and fiscal variables. Therefore we choose to proportionally adjust the individual expenditures of MEPS by a factor of 1.48 to achieve aggregate medical expenditures equal to 13% of GDP in the initial steady-state economy, based on the National Health Expenditure Accounts (NHEA) data in 2004.

From MEPS data, we are able to compute the coverage rates κ^w, κ^{ret}, and κ^{med} representing, respectively, the fraction of medical expenditures covered by private insurance for workers and retirees, and by Medicare for retirees. We estimate $\kappa^w = 0.70$, $\kappa^{ret} = 0.30$ and $\kappa^{med} = 0.50$. We also verify that, in equilibrium, under our estimated Medicare coverage, Medicare costs are 2.4% of GDP, close to the U.S. data for 2004.

The annual Medicare premium for Part B was \$938 in 2005, or about 2.24% of income per capita, which puts $p^{med} = 0.0224$ according to our normalization. Since, by law, the premium is scheduled to increase enough to cover a constant fraction of Medicare Part B expenditures, we choose to adjust p^{med} in the new steady state proportionally to the average medical expenditures of Medicare beneficiaries.[13] Finally, we set the fraction of

[12]For more details on the discrepancy between the two sources, see Selden et al. (2001) and Keehan et al. (2004).

[13]The implicit assumption we are making is that the fraction of total Medicare expenditures associated to Part B remains constant over time. In 2005 revenues from the premia covered 8% of average medical expenditures of retirees.

the retiree's insurance premium paid by the employer $\bar{\xi}^{ret}$ to 0.6, based on Buchmueller et al. (2006).

We normalize $q = 1$ in the first steady-state and we set $q = 1.6$ in the final steady-state, which implies a medical cost inflation rate of 0.63% per year over the next 75 years above general inflation and productivity growth, both normalized to zero in our economy. We will verify the sensitivity of our findings to the value chosen for this key parameter.

The estimates of the administrative costs associated with the private health insurance vary in the literature and we set the parameter ϕ to 0.1 based on Kahn et al. (2005). Medicare administrative expenses account for 1.4% of total expenditures according to SSA and we set ϕ^{med} to this value.

Individual productive efficiency: The deterministic age/education-specific component $\varepsilon_{e,j}$ and the health-dependent component $\omega^e(h)$ can be all estimated from MEPS. We first split the sample into two groups based on educational attainment. Then, we run a cross-sectional regression of individual hourly wages on a constant, a cubic function of age, and the individual health status indicator.

The results are reported in Figure 4. College education has a wage premium of 45% and bad health significantly reduces individual productivity. A year of bad health reduces hourly wages by 10.6% for the college graduates and by 19.8% for the non college graduates, relative to the earnings of workers in good health in the same education class.[14]

Government taxes, debt and social security: Government expenditures G are set to 20% of GDP, that is the share of government consumption and gross investment excluding transfers, at the federal, state and local levels (The Economic Report of the President, 2004). The ratio of federal debt held by the public D to GDP is set at 40%, which is the value at the end of 2006. We fix the consumption tax τ^c at 5.7%, and the capital income tax τ^r at 40% based on Mendoza et al. (1994).

The minimum consumption floor $\bar{c}$ is set to 10% of income per capita. This implies $\bar{c} = 0.10$ since income per capita is normalized to one in the first steady state. The social security replacement rate ρ_e is set to 0.40 for the low educated and 0.30 for the

[14] This education gap in the marginal effect of bad health on wages may be attributable to the different type of diseases experienced by the two groups: the low-skilled may experience illnesses which are more detrimental for work. Moreover, productivity in manual occupations, which are more common among low-educated workers, tends to be more sensitive to health deterioration.

high educated, reflecting the progressivity of the system. The implied total social security outlays as a fraction of GDP are 4.5% in 2005.

4 Results

We start by contrasting the "initial steady state" calibrated to the current U.S. economy to a "final steady state", representing the U.S. economy in 2080. The final steady state differs in two important aspects: 1) the demographic structure (which in our model is summarized by the rate of growth of the population and the survival rates), and 2) the cost of health care. We will focus on changes in the labor income tax τ^w that balances the government budget, in equilibrium prices (wages and interest rates), in the saving rate, and in output. Since demographic trends worsen the budgetary position of the government with respect to both social security and Medicare, in one experiment we keep the social security outlays constant (as a fraction of GDP) to disentangle the two sources of expenditures and assess their relative importance.

We report the sensitivity of our baseline results to the key parameters. Given the uncertainty surrounding the evolution of health care costs, we consider alternative scenarios for q, and we simulate the final steady-state under different assumptions for population growth in 2080.

We also run a set of simulations where the interest rate (and therefore the wage) is exogenously fixed, implicitly determined in the world financial markets. Given the high degree of financial integration across countries, and the fast emergence of large open economies (like Russia, China and India) which reduce the weight of the U.S. in the world economy, we view this set of experiments as a relevant alternative benchmark.

We then consider a set of policy experiments where the government tries to alleviate the fiscal pressure created by Medicare. In particular, we consider: (i) an increase in the Medicare premium p^{med} (above what is already scheduled to happen), (ii) a reduction in coverage rate κ^{med}, and (iii) an increase in retirement age. We report the welfare gains of these policy reforms relative to the benchmark where only the labor income tax τ^w adjusts to balance the government budget constraint.

Lastly, we report two sets of robustness analysis with respect to the labor supply elasticity and generosity of the social assistance provided by the government.

4.1 Baseline simulation

The second column of Table 3 report the results of the baseline simulation of the final steady state (the values for the initial steady state are in the first column). Besides the different demographics which raise the dependency ratio from 20% in 2005 to 32.3%, in the final steady state it is assumed that the cost of health care will be 60% higher ($q = 1.6$) than in the initial steady state. There are no policy changes, either in the provision of health insurance or in the provision of public pensions.[15] The government adjusts the taxation of labor income to satisfy the budget constraint.

As a consequence of the changes in these "fundamentals" between the two steady states, households accumulate more capital. The capital-output ratio jumps from 3.0 to 3.15. This change occurs for two reasons. First, households live longer and must save more for retirement. Second, because of their increased longevity and the rise in health care costs, they plan to spend more for their medical bills, especially after retirement. And thus savings increase both to cover these additional costs and to build a larger precautionary buffer stock of wealth to confront uncertainty in medical expenditures over the longer retirement period. Prices adjust accordingly: the interest rate falls by half percentage point and the wage rises.

From the point of view of government outlays, social security benefits grow from 4.5% of output to 7.0% and Medicare costs rise from 2.4% to 5.3%.[16] Also social assistance costs rise, especially because of the larger fraction of poor retirees who, when hit by a large shocks, have not enough resources to pay their bills and resort to Medicaid. The social assistance recipients among retirees increase from 1% in 2005 to 5% in 2080. Turning to government revenues, the rise in capital stock and the fall in the rate of return offset each other in terms of revenues from capital income taxation. The taxation of labor must therefore increase from 23% to 36% to balance the budget.

It is interesting to note that average hours worked are 12% higher in the new steady state, in spite of the substantial rise in the labor income tax. The increase in labor supply occurs for two reasons. First of all, the wage rises too in equilibrium, which mitigates the

[15]However, recall that the Medicare premium adjusts mechanically so that the fraction of Medicare expenditures collected as a premium is constant.

[16]The SSA projects Medicare costs to rise up to 12% as a fraction of GDP for 2080. Our number is smaller for three reasons. First, we did not include Part D in our calculation, due to lack of data in MEPS. Second, our cost-inflation assumption in the baseline ($q = 1.6$) is more conservative than the SSA assumption. Third, as discussed, MEPS underestimate long-term care costs which are projected to rise very sharply.

adverse effect of the rising tax on labor supply. Second, under our preference specification, income effects slightly dominate substitution effects and, as a result of a smaller after-tax wages, hours worked rise. Compared to the large increase in average hours worked, the change in aggregate (or per capita) efficiencyunits of labor are moderate. The shift in the age distribution of the working age population towards older age classes induces a fall in average labor efficiency.

Social security vs. Medicare: An interesting question to ask is the extent to which our results are driven by the fiscal pressure imposed by social security vs Medicare. Both programs create a burden for the government budget, given the projected demographic trends. To isolate the effect of Medicare, we run a simulation where replacement rates ρ_e adjust so that the amount spent on social security payments to the elderly is kept fixed at 4.5% of GDP in 2080. The results of this simulation are reported in the last column of Table 3. The answer is quite clear: most of the burden is created by Medicare. Freezing expenses on social security reduces the equilibrium labor income tax rate in 2080 from 36% to 32%. In other words, over two thirds of the higher taxation in 2080 is associated to Medicare.

4.1.1 Sensitivity analysis

There is considerable uncertainty over the future evolution of health care inflation and population growth. Here, we analyze how sensitive our findings are with respect to these two key inputs of our experiment.

Health care cost: Recall that in the baseline, we have assumed health-care inflation, in excess of productivity growth and general inflation, of 0.63% per year over the next 75 years. We consider three alternative scenarios. One in which in 2080 q increases to 1.3 (or, 0.35% per year) and one in which it increases to 1.9 (or, 0.86% per year) and one where it grows at the same rate as nominal output ($q = 1$). As expected, larger health-care inflation raises the labor income tax. Overall, we find that every 0.1% of excess health-care annual inflation leads to a rise of 1% in the equilibrium labor income tax rate necessary to balance the budget.

Note that the economy with $q = 1.9$ is the closer to the SSA projection. Under this scenario, τ^w rises to 39%. To appreciate the macroeconomic effects of such a huge rise in medical costs, note that as q rises from 1 up to 1.6 savings go up monotonically for the reasons explained above. However, from $q = 1.6$ to $q = 1.9$ savings fall. The reason is that medical expenditures (and labor taxation) eat up a larger and larger fraction of household earnings who, in turn, are forced to reduce savings. Households are less self-insured and exposed to larger medical expenditure risks. Indeed, the percentage of families who are recipients of social assistance nearly doubles relative to the baseline economy.

Population growth: We solve the model for two scenarios where, in 2080, population does not grow at all and where population grows very fast (1.4% per year). Fast population growth reduces the dependency ratio and alleviates the fiscal burden of social security and Medicare. Under this scenario, the labor income tax needs to increase only to 32%. Under the no population growth scenario, the dependency ratio jumps to 41%, and the equilibrium wage tax must rise to 41%.

4.2 Alternative policy experiments

Changes to the Medicare premium: In the baseline economy, the Medicare premium paid by each retired household is 8.0% of the average medical expenditures of the retirees. These revenues finance 16% of the expenditures on the program, given that Medicare covers 50% of the expenditures. The remaining is financed through the general government budget. In order to alleviate the fiscal pressure, we consider a reform that raises the Medicare premium by factors of 2 and 3, and transfers costs from the working population to the retirees.

As shown in two columns "high med premium (x2)" and "high med premium (x3)" in Table 4, the government will be able to reduce the labor tax rate by 1.3% and 2.5%, respectively, relative to the baseline final steady-state, when we double and triple the premium. Since households anticipate larger spending for the premium after retirement, they accumulate more wealth while at work, which in turn raises the aggregate output and consumption. The labor supply and average hours of work is virtually unaffected since the substitution effect due to the lower labor tax and the income effect due to the increased wealth offset each other. As a result of these reforms, households will be better off under these alternative policies. The last rows of the table shows sizeable welfare gains, in terms of lifetime consumption, for every education type.

Changes to Medicare coverage rate: Reducing the generosity of the Medicare program through the reduction of the coverage rate will directly lower the cost of the program. We consider policies that reduces the coverage rate from 50% to 40% and to 30% in the final steady-state. The results are shown in two columns "lower coverage rate (40%)" and "lower coverage rate (30%)" in Table 4.

The effects of the policy are remarkably similar to those of raising the Medicare premium discussed above. Both policies will reduce the fiscal cost of the program and lower the labor tax rate by a similar magnitude. With a lower coverage rate, households will increase the saving to better self-insure themselves against the higher out-of-pocked expenses after retirement, which also reduces the interest rate in a similar magnitude to the previous experiments.

We have, however, a very different picture in the breakdown of the fiscal outlays. On one hand, reducing the coverage rate to 40% (30%) lowers the expenditures on the Medicare from 5.3% of GDP to 4.2% (3.1%). On the other hand, households are exposed to a higher risk of depleting wealth because of "catastrophic" medical expenditures. Accordingly, the fraction of retirees covered by the social assistance increases from 4.8% to 6.5% (8.7%) in the two experiments. The spending for the social assistance program will rise from 0.67% of GDP to 0.79% (0.99%).

Compare the policy where the premium is tripled to the one where the coverage rate is reduced to 30%. They both induce virtually the same magnitude of a rise in τ^w. However, the welfare effects are very different. While increasing the premium will bring about a welfare gain of 2.11% of lifetime consumption, the welfare gain is only 1.48% if the coverage rate declines to 30%. Although both policy reforms raise the saving and aggregate output and enhance welfare, households are exposed to more uncertainty under the second policy, which makes a difference in the magnitude of the welfare gain.

Changes to retirement age: The last column of Table 4 shows the effect of postponing retirement by two years, from 65 to 67. We assume that households are not eligible for either Medicare or social security until 67, and continue to work until this new retirement age.[17] As a result, the dependency ratio falls from 32.2% to 28.0%. The policy will lower the fiscal outlays of both Medicare and social security, which reduces the labor income tax by 2.5% compared to the baseline final steady-state.

[17] We assume the age-dependent labor productivity is constant from age 64 to age 66.

The aggregate labor supply will increase by about 2% relative to the benchmark final steady state and the aggregate output will rise by about the same magnitude. Since the saving does not change much from the benchmark final steady-state, the reform results in a large increase in the amount of (non-medical) goods and services consumed. Households will be significantly better off, as shown by the welfare gain of 3.1% in terms of consumption equivalence.

4.3 Open economy

In previous work (Attanasio, Kitao and Violante, 2006; 2007), we have argued that the extent to which capital will flow in and out of the U.S. in the next 80 years is crucial in understanding the budgetary, macroeconomic and welfare implications of demographic trends. In a financially integrated economy, where the world financial markets set the interest rate, prices do not adjust (or adjust very little) to demographic changes in the U.S. economy alone, since the world demographic trends are unsynchronized. For example, large economies like China and India are at a much earlier stage of the demographic transition.

Table 5 reports the results of our simulations done under the assumption that the interest rate is fixed at 5%, a value that implies that foreign-owned net assets in the U.S. are roughly 20% of GDP, based on U.S. data for 2005. The main differences with the closed-economy model are two. First, the equilibrium wage tax rate increases only to 31%, relative to 36% in the closed economy. As households increase their savings, their wealth grows as demonstrated by the huge change in the foreign asset position of the economy. However, the interest rate is fixed. As a result, the tax-base for capital income taxation increases significantly. In turn, this allows the government to limit the rise in the labor income tax τ^w. The key assumption behind this result is that U.S. wealth invested in foreign assets is taxed domestically.

Second, the results of the counterfactual experiment where we hold the social security outlays at 4.5% of GDP are strikingly different from the closed economy model. Households raise their savings to finance their retirement. The fact that r does not react to the larger supply of savings pushes capital accumulation even further up, so that the wealth-income ratio reaches 5.4. This is very good news for the government, as revenues from capital income taxation surge, and the equilibrium labor income tax needed to pay for the additional Medicare costs is just 17%, i.e. a substantial drop from the 24% of the initial steady state.

4.4 Robustness analysis

To conclude this section, we report some robustness analysis with respect to (i) the elasticity of labor supply, and (ii) the level of the minimum consumption $\bar{c}$ guaranteed by the social assistance program.

Table 6 summarizes the effect of alternative values θ in (2). Given our preferences specification, and the calibration target for average hours worked, values of θ equal 2, 4 and 8 imply average intertemporal labor supply elasticities of 1.0, 0.5 and 0.25 respectively. Recall that $\theta = 4$ is the benchmark. The numbers in the table represent the percentage changes in aggregate variables in the final steady state relative to the initial steady state. For each model, we recalibrate the parameters so that we match the same calibration targets discussed in section 3.

With a higher labor supply elasticity, hours worked increase even more, and aggregate labor supply will rise by 5.5%, more than twice as in the benchmark. As discussed above, under our parameterization, the income effect dominates the substitution effect and agents respond to the lower after-tax wage by working longer hours. This response is stronger under the higher elasticity of labor supply. Although there is a large difference in the labor supply response, the effect on the labor income tax base is mitigated by the fact that increase on the equilibrium wage rate is lower with a higher elasticity. Overall, the increase in the labor tax in the final steady state is surprisingly similar across parameterizations, ranging from 12% to 13.5% as we change the elasticity from 1.0 to 0.25.

Table 7 explores the role of the generosity of social assistance. Recall that in the baseline calibration $\bar{c}$ is set to 10% of income per capita. When the consumption floor is cut to 5%, the precautionary saving motive is much stronger in the final steady state, and aggregate capital rises by 18.2%, relative to a rise of 10.3% in the benchmark. When social insurance is more generous, and guarantees a minimum consumption of 15% of average income, the fiscal cost of the transition becomes more severe. As a result of the more generous benefits paid by the government, together with the lower precautionary savings which contract the fiscal base for capital taxation, the equilibrium labor income tax τ^w rises from 23% to 40.4%.

5 Conclusions

The model we proposed has important elements of realism, such as the way in which we model Medicare and Medicaid, the uncertain evolution of health status and its effect on productivity, medical costs and mortality. However, our exercise is not without limitations. We should mention here the most important ones: 1) We do not model the choice of private health insurance, either before or after retirement. In particular, before retirement we ignore the possibility that individuals that do not have access to an employer provided insurance could buy private insurance in the market. After retirement, we are ignoring Medigap and other forms of supplemental private insurance not provided by a former employer. 2) We consider households as a monistic unit and do not deal separately with husband and wife, neither in terms of labor supply behavior nor health status. 3) We only compare steady states, rather than computing the transition dynamics toward the final steady state. 4) We treat medical expenditures as exogenously given, while presumably at least some, if not most, of them may be determined endogenously as an optimal choice.

Some of these limitations, and in particular points 1) and 3) could be avoided in more sophisticated versions of our model. Others, such as those in point 2) and 4), would involve a considerable increase in numerical complexity and the implementation would pose more challenges. In any case, we see the exercise presented in this paper as a first step in a more ambitious research agenda.

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Medical Expenditure Panel Survey (MEPS)

Age	Low Education (no college)			High Education (college)		
		Good	Bad		Good	Bad
20-29	Good	0.9546	0.0454	Good	0.9856	0.0144
	Bad	0.4103	0.5897	Bad	0.5833	0.4167
30-39	Good	0.9412	0.0588	Good	0.9757	0.0243
	Bad	0.3281	0.6719	Bad	0.3143	0.6857
40-49	Good	0.9212	0.0788	Good	0.9583	0.0417
	Bad	0.2085	0.7915	Bad	0.2955	0.7045
50-64	Good	0.8734	0.1266	Good	0.9461	0.0539
	Bad	0.1614	0.8386	Bad	0.2250	0.7750
65+	Good	0.8630	0.1370	Good	0.8962	0.1038
	Bad	0.1386	0.8614	Bad	0.2083	0.7917

Health and Retirement Survey (HRS)

Age	Low Education (no college)			High Education (college)		
		Good	Bad		Good	Bad
50-64	Good	0.8942	0.1058	Good	0.9327	0.0673
	Bad	0.2455	0.7545	Bad	0.1764	0.8236
65+	Good	0.8925	0.1075	Good	0.9243	0.0757
	Bad	0.2113	0.7887	Bad	0.1587	0.8413

Table 1: Transition probabilities between good health (Good) and bad health (Bad) from MEPS and HRS, by age group and education level

Medical Expenditure Panel Survey (MEPS)

	Good Health			
Age	1-60 pct	61-95 pct	96-100 pct	Average
20-29	153	1,876	10,192	1,258
30-39	321	2,762	13,482	1,833
40-49	453	2,928	19,606	2,277
50-65	1,002	5,124	22,609	3,525
65+	2,047	8,990	33,190	6,034

	Bad Health			
Age	1-60 pct	61-95 pct	96-100 pct	Average
20-29	484	4,453	23,484	3,023
30-39	758	6,027	40,605	4,595
40-49	1,262	8,243	42,861	5,785
50-65	2,363	12,399	59,730	8,744
65+	3,946	16,194	60,556	11,063

Table 2: Gross medical expenditures (in 2004$) by age and health status. Means of the 1st-60th percentiles, 61st-95th percentiles, 96th-100th percentiles, and distribution average. Source: MEPS

Closed Economy

	Initial SS	Final SS						
	Baseline (q=1.0)	Baseline (q=1.6)	high pop growth (1.4%)	low pop growth (0%)	no med cost increase (q=1.0)	low med cost increase (q=1.3)	high med cost increase (q=1.9)	SS fixed at 4.5% of GDP
labor tax rate (%)	0.230	0.357	0.315	0.411	0.308	0.331	0.388	0.318
interest rate (%)	0.050	0.045	0.046	0.045	0.043	0.044	0.049	0.036
wage rate	1.183	1.212	1.206	1.209	1.224	1.217	1.189	1.265
medical expenditures (% of GDP)	0.130	0.226	0.203	0.254	0.151	0.190	0.263	0.215
avg work hours	0.329	0.368	0.364	0.374	0.340	0.354	0.381	0.368
aggregate capital	3.000	3.301	3.367	3.154	3.146	3.218	3.232	3.772
- % change from the benchmark	-	0.100	0.122	0.051	0.049	0.073	0.077	0.257
aggregate labor input	0.565	0.580	0.599	0.558	0.536	0.558	0.601	0.582
- % change from the benchmark	-	0.026	0.061	-0.012	-0.050	-0.012	0.064	0.030
aggregate output	1.000	1.049	1.079	1.007	0.980	1.014	1.067	1.098
- % change from the benchmark	-	0.049	0.079	0.007	-0.020	0.014	0.067	0.098
aggregate non-medical consumption	0.436	0.370	0.381	0.352	0.417	0.393	0.343	0.378
- % change from the benchmark	-	-0.152	-0.127	-0.193	-0.045	-0.098	-0.213	-0.133
fiscal outlays (all in % of GDP)								
- govt expenditures	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
- debt service	0.0144	0.0150	0.0125	0.0181	0.0142	0.0147	0.0166	0.0116
- medicare benefit	0.0237	0.0529	0.0423	0.0661	0.0354	0.0445	0.0618	0.0505
- social security	0.0451	0.0695	0.0546	0.0882	0.0725	0.0710	0.0680	0.0449
- social assistance (SA)	0.0032	0.0067	0.0060	0.0081	0.0028	0.0041	0.0116	0.0077
fiscal revenues (all in % of GDP)								
- capital tax	0.0680	0.0636	0.0644	0.0641	0.0618	0.0629	0.0671	0.0554
- labor tax	0.1426	0.2121	0.1881	0.2425	0.1906	0.2007	0.2255	0.1900
- cons tax	0.0249	0.0201	0.0201	0.0199	0.0242	0.0221	0.0183	0.0196
- bequests	0.0473	0.0400	0.0362	0.0437	0.0426	0.0415	0.0374	0.0418
- medicare premium	0.0037	0.0083	0.0066	0.0104	0.0056	0.0070	0.0097	0.0079
social assistance recipient								
% of workers (ex age 20)	0.0009	0.0142	0.0128	0.0168	0.0010	0.0038	0.0216	0.0108
% of retired	0.0090	0.0482	0.0380	0.0610	0.0085	0.0234	0.0886	0.0782
dependency ratio (retired/workers)	20.0%	32.2%	25.1%	41.3%	32.2%	32.2%	32.2%	32.2%

Table 3: Results of the closed-economy simulations. Baseline and sensitivity analysis.

Policy Experiments

	Initial SS	Final SS					
	Baseline (q=1.0)	Baseline (q=1.6)	high med premium (x2)	high med premium (x3)	lower coverage rate (40%)	lower coverage rate (30%)	higher retirement age (age 67)
labor tax rate (%)	0.230	0.357	0.344	0.332	0.343	0.331	0.332
interest rate (%)	0.050	0.045	0.042	0.039	0.042	0.039	0.044
wage rate	1.183	1.212	1.229	1.245	1.230	1.244	1.214
medical expenditures (% of GDP)	0.130	0.226	0.222	0.219	0.222	0.219	0.221
avg work hours	0.329	0.368	0.368	0.368	0.368	0.367	0.362
aggregate capital	3.000	3.301	3.452	3.593	3.454	3.580	3.381
- % change from the benchmark	-	0.100	0.151	0.198	0.151	0.193	0.127
aggregate labor input	0.565	0.580	0.580	0.581	0.580	0.581	0.591
- % change from the benchmark	-	0.026	0.028	0.029	0.027	0.028	0.046
aggregate output	1.000	1.049	1.065	1.080	1.065	1.078	1.070
- % change from the benchmark	-	0.049	0.065	0.080	0.065	0.078	0.070
aggregate non-medical consumption	0.436	0.370	0.373	0.375	0.373	0.375	0.381
- % change from the benchmark	-	-0.152	-0.146	-0.140	-0.145	-0.140	-0.126
fiscal outlays (all in % of GDP)							
- govt expenditures	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
- debt service	0.0144	0.0150	0.0138	0.0128	0.0138	0.0129	0.0149
- medicare benefit	0.0237	0.0529	0.0521	0.0514	0.0417	0.0309	0.0465
- social security	0.0451	0.0695	0.0698	0.0700	0.0698	0.0699	0.0599
- social assistance (SA)	0.0032	0.0067	0.0069	0.0073	0.0079	0.0099	0.0063
fiscal revenues (all in % of GDP)							
- capital tax	0.0680	0.0636	0.0609	0.0584	0.0608	0.0586	0.0633
- labor tax	0.1426	0.2121	0.2046	0.1978	0.2039	0.1972	0.1958
- cons tax	0.0249	0.0201	0.0200	0.0198	0.0200	0.0198	0.0203
- bequests	0.0473	0.0400	0.0407	0.0412	0.0402	0.0399	0.0409
- medicare premium	0.0037	0.0083	0.0163	0.0242	0.0082	0.0081	0.0073
social assistance recipient							
% of workers (ex age 20)	0.0009	0.0142	0.0128	0.0120	0.0128	0.0122	0.0125
% of retired	0.0090	0.0482	0.0560	0.0665	0.0647	0.0866	0.0499
dependency ratio (retired/workers)	20.0%	32.2%	32.2%	32.2%	32.2%	32.2%	28.0%
			Welfare change in final SS (relative to baseline)				
cons. equiv. variation: all		0.00%	1.17%	2.11%	0.96%	1.48%	3.10%
cons. equiv. variation: low education		0.00%	1.14%	2.06%	0.91%	1.41%	3.12%
cons. equiv. variation: high education		0.00%	1.25%	2.27%	1.12%	1.77%	3.04%

Table 4: Results of the alternative policy experiments in closed economy compared to the baseline. Welfare changes reported in the last three lines.

Open Economy

	Initial SS	Final SS						
	Baseline (q=1.0)	Baseline (q=1.6)	high pop growth (1.4%)	low pop growth (0%)	no med cost increase (q=1.0)	low med cost increase (q=1.3)	high med cost increase (q=1.9)	SS fixed at 4.5% of GDP
labor tax rate (%)	0.242	0.310	0.288	0.349	0.250	0.282	0.404	0.170
medical expenditures (% of GDP)	0.130	0.234	0.209	0.264	0.159	0.198	0.264	0.241
avg work hours	0.330	0.364	0.362	0.368	0.334	0.349	0.382	0.354
aggregate wealth/saving (% of GDP)	2.800	3.758	3.460	3.945	3.933	3.828	2.798	5.409
- % change from the benchmark	-	0.342	0.236	0.409	0.405	0.367	-0.001	0.932
- U.S. owned foreign asset (% of GDP)	-0.200	0.758	0.460	0.945	0.933	0.828	-0.202	2.409
- capital (% of GDP)	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
aggregate labor input	0.567	0.572	0.595	0.547	0.527	0.550	0.603	0.556
- % change from the benchmark	-	0.009	0.049	-0.035	-0.071	-0.030	0.064	-0.019
aggregate output	1.000	1.009	1.049	0.965	0.929	0.970	1.064	0.981
- % change from the benchmark	-	0.009	0.049	-0.035	-0.071	-0.030	0.064	-0.019
aggregate non-medical consumption	0.430	0.389	0.391	0.380	0.440	0.413	0.334	0.440
- % change from the benchmark	-	-0.096	-0.093	-0.117	0.023	-0.040	-0.223	0.023
fiscal outlays (all in % of GDP)								
- govt expenditures	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
- debt service	0.0144	0.0171	0.0142	0.0200	0.0171	0.0171	0.0171	0.0171
- medicare benefit	0.0237	0.0550	0.0435	0.0689	0.0373	0.0464	0.0619	0.0566
- social security	0.0452	0.0691	0.0543	0.0877	0.0719	0.0705	0.0680	0.0454
- social assistance (SA)	0.0033	0.0052	0.0053	0.0055	0.0026	0.0035	0.0138	0.0039
fiscal revenues (all in % of GDP)								
- capital tax	0.0640	0.0832	0.0772	0.0869	0.0881	0.0846	0.0640	0.1162
- labor tax	0.1496	0.1833	0.1711	0.2048	0.1540	0.1701	0.2346	0.1001
- cons tax	0.0245	0.0220	0.0212	0.0224	0.0270	0.0243	0.0179	0.0256
- bequests	0.0447	0.0492	0.0410	0.0571	0.0539	0.0512	0.0345	0.0721
- medicare premium	0.0037	0.0086	0.0068	0.0108	0.0059	0.0073	0.0097	0.0089
SA recipient								
% of workers (ex age 20)	0.0009	0.0105	0.0108	0.0108	0.0007	0.0028	0.0264	0.0043
% of retired	0.0099	0.0309	0.0285	0.0345	0.0057	0.0152	0.1058	0.0211
dependency ratio (retired/workers)	20.0%	32.2%	25.1%	41.3%	32.2%	32.2%	32.2%	32.2%

Table 5: Results of the open-economy simulations. Baseline and sensitivity analysis.

Sensitivity Analysis with Respect to θ

Value of preferences parameter θ	2	4	8
Frisch elasticity of labor supply	1.00	0.50	0.25
Labor tax rate (%-pts)	0.120	0.127	0.135
Wage rate	0.020	0.024	0.026
Average hours worked	0.149	0.118	0.084
Aggregate capital	0.121	0.100	0.074
Aggregate labor input	0.055	0.026	-0.006
Aggregate output	0.076	0.049	0.020
Aggregate non-medical consumption	-0.114	-0.152	-0.195

Table 6: Robustness analysis on the preferences parameter θ and on labor supply elasticity. Each column reports percentage changes in the aggregate variables in the final steady state with respect to baseline economy.

Sensitivity Analysis with Respect to $\bar{c}$

Value of $\bar{c}$ (% of GDP per capita)	5	10	15
Labor tax rate (%-pts)	0.118	0.127	0.174
Wage rate	0.046	0.024	-0.028
Average hours worked	0.126	0.118	0.077
Aggregate capital	0.182	0.100	-0.080
Aggregate = labor input	0.030	0.026	0.002
Aggregate output	0.078	0.049	-0.026
Aggregate non-medical consumption	-0.139	-0.152	-0.207
Social assisstance recipients: % workers	0.004	0.013	0.069
Social assistance recipient: % retirees	0.008	0.039	0.171

Table 7: Robustness analysis on the consumption floor parameter $\bar{c}$. Each column reports percentage changes in the aggregate variables in the final steady state with respect to baseline economy.

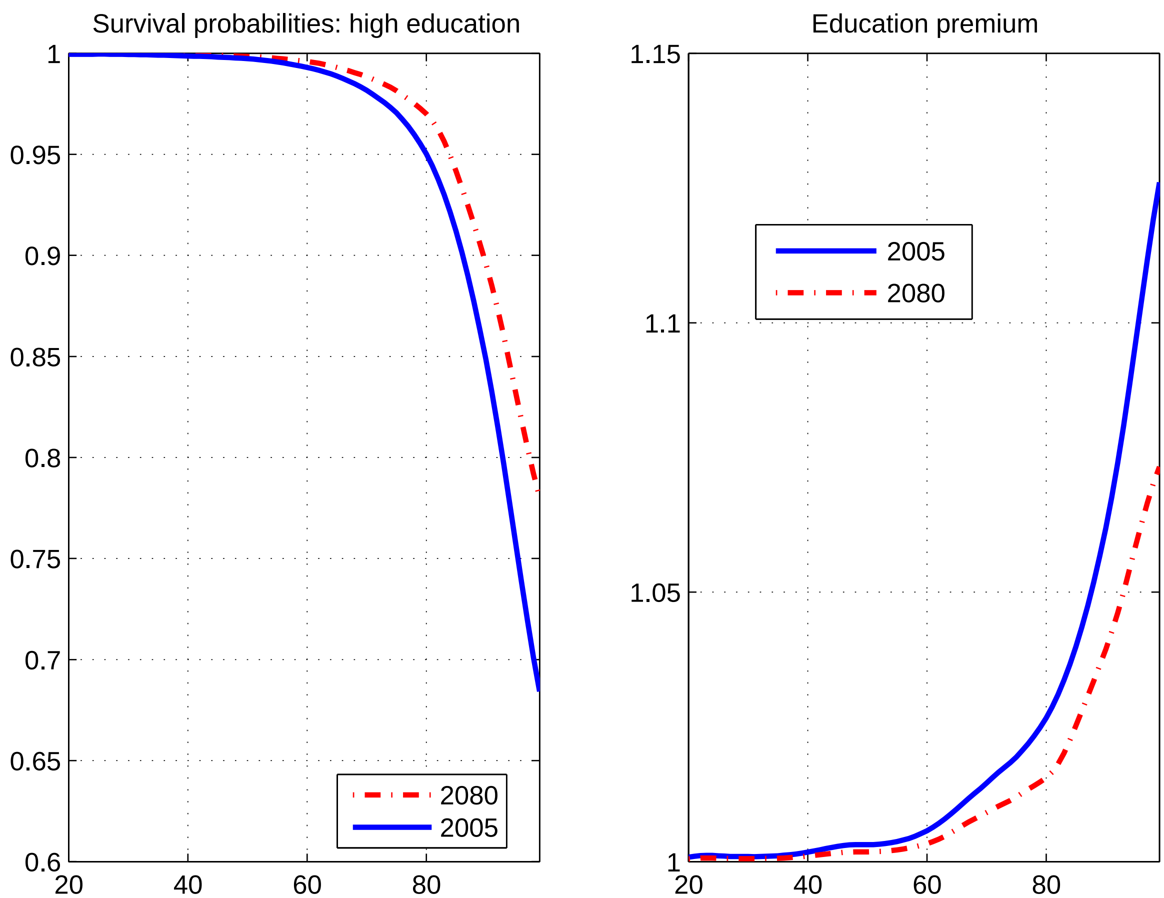

Figure 1: Left-panel: survival rates by age for the college graduates in 2005 (data) and 2080 (projected). Right panel: Ratio of survival rates of college graduates to non college graduates by age in 2005 and 2080.

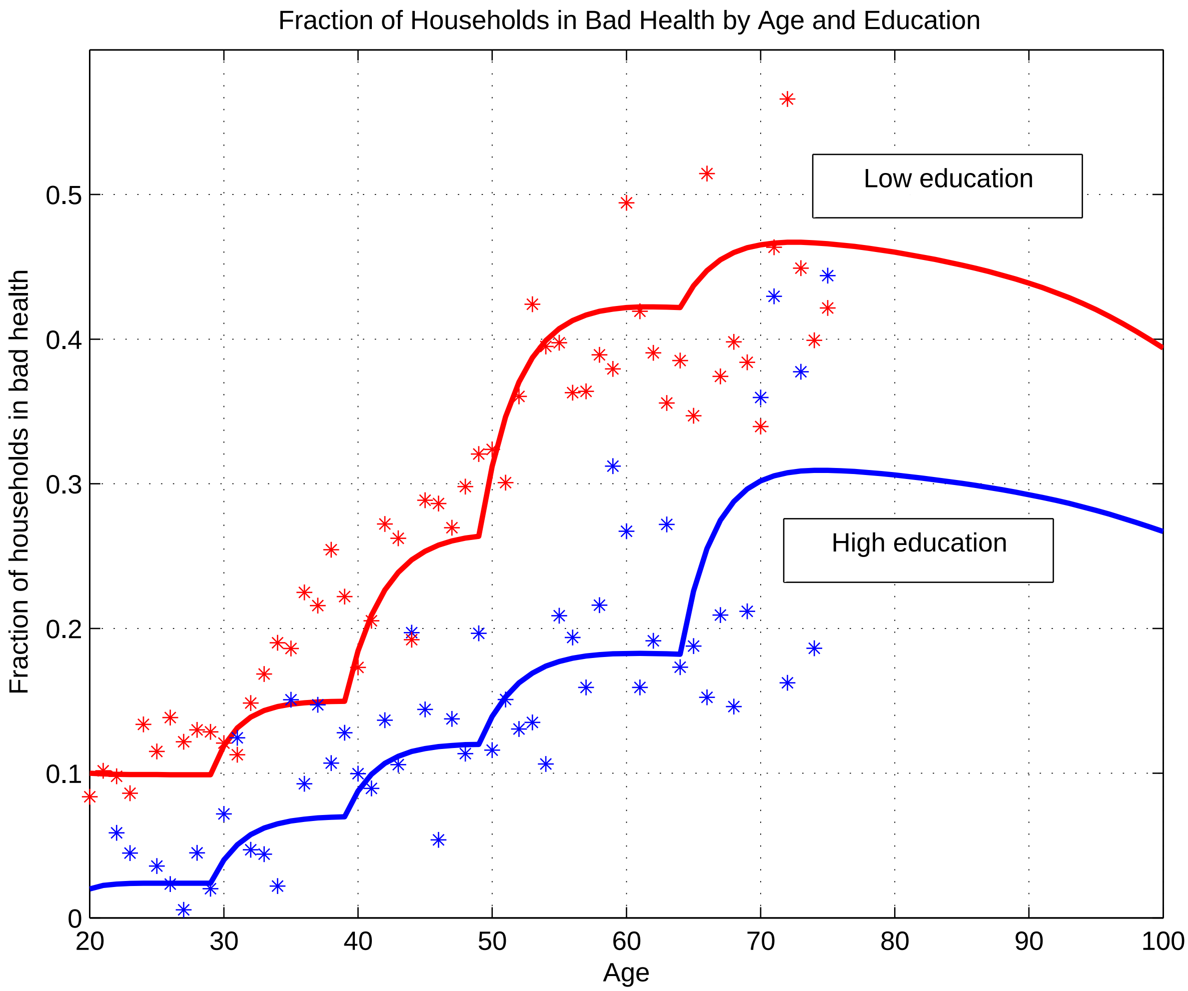

Figure 2: Fraction of individuals in bad health. Stars represents estimates from various waves, solid lines are model-implied fractions from the estimated transition probabilities of Table 1. Source: MEPS

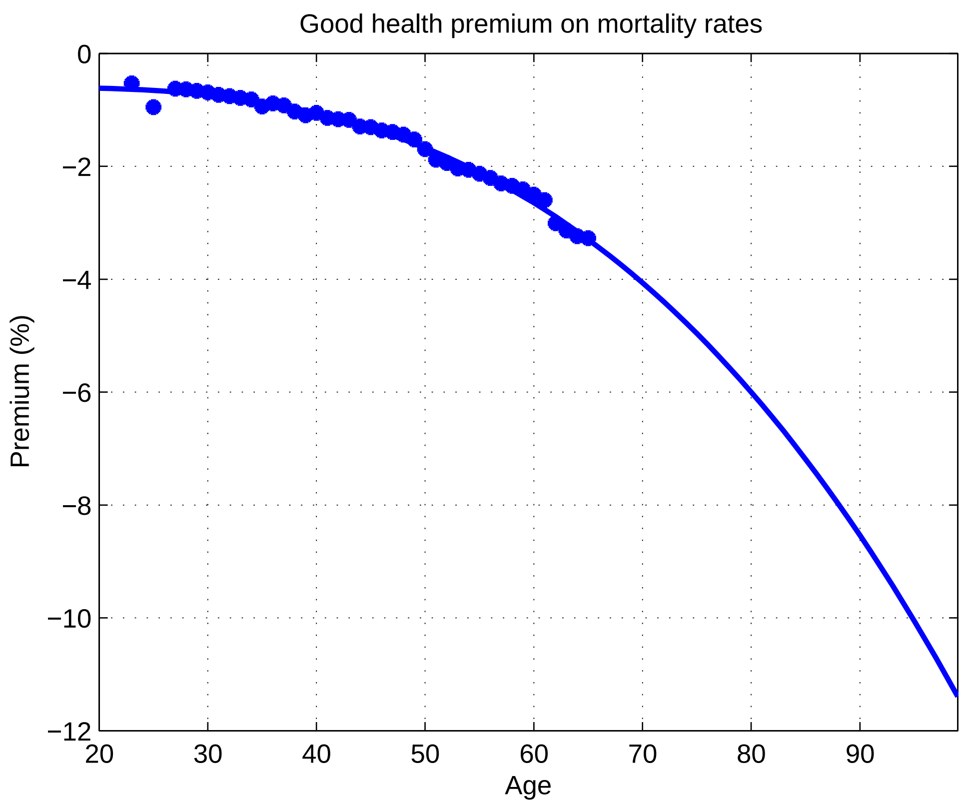

Figure 3: Percentage decrease in mortality rates for an individual in good health relative to an individual in bad health, by age. Dots are data, solid line is a polynomial fit. Source: HRS

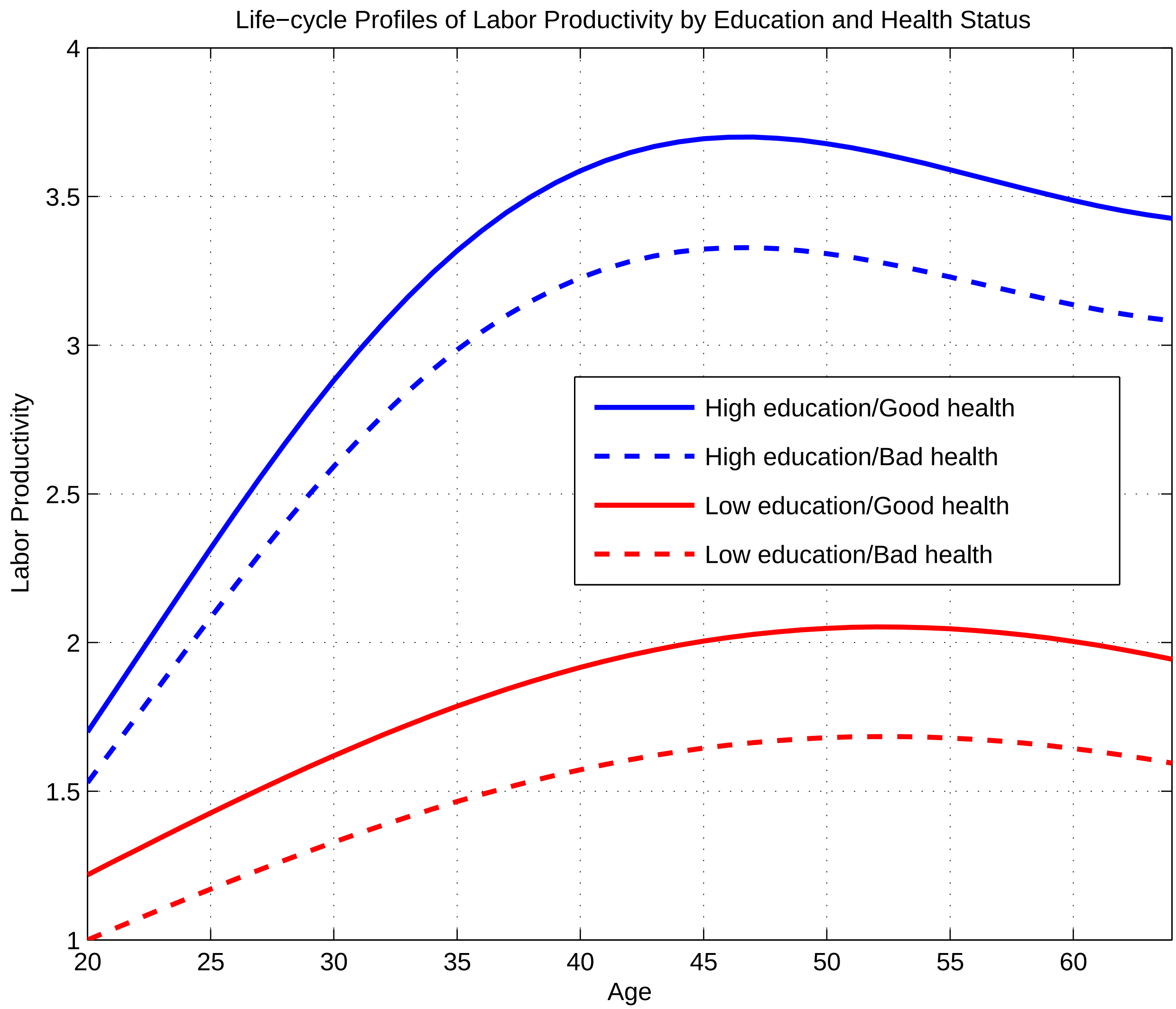

Figure 4: Hourly wage-age profiles for high and low educated individuals in good and bad health status. Estimates from MEPS.