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Social Health Insurance: A Quantitative Exploration

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Abstract

We quantitatively explore the economic effects of expanding the public and private components of the US health insurance system. Our analysis uses an overlapping generations model that comprises health risk, labor market risk, and key features of the US health insurance system such as private individual health insurance (IHI), employer sponsored group health insurance (GHI), means-tested public health insurance for low income individuals (Medicaid), and public health insurance for retired individuals (Medicare). Our simulations show that expanding Medicare to all workers—aka universal public health insurance (UPHI)—improves aggregate welfare if the coinsurance rate of UPHI is set to a higher level than the current Medicare coinsurance rate. There exists an optimal coinsurance rate that balances the incentive and insurance trade-off of the UPHI system and maximizes welfare outcomes. Allowing private health insurance to coexist with UPHI plans, lowers the overall fiscal cost of UPHI and results in larger welfare gains. Tax financing instruments matter for welfare outcomes. Using a consumption tax to finance the expansion of public health insurance leads to fewer distortions and improved welfare outcomes compared to income or payroll taxes. If, under the current US system, the government mandates GHI offers to become available to all workers, welfare gains can also be achieved.

JEL: I13, D52, E62, H31

Keywords: Health and income risks; Lifecycle; Incomplete insurance markets; Social insurance; Welfare; Optimal policy; Dynamic general equilibrium.

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1 Introduction

Health risk can be difficult to insure via competitive insurance markets. As pointed out in Rothschild and Stiglitz (1976), information asymmetries between buyers and sellers of private insurance plans can lead to adverse selection and leave large shares of the population uninsured. The principal-agent relationship between healthcare providers and their patents and the highly persistent nature of health risk add further complications to insuring health risk effectively through private insurance markets. These are only some of the arguments used to not only justify government regulation of private health insurance markets but also to call for the direct provision of health insurance by the government to large groups of market participants.[1] As a consequence, today the government is the largest provider of health insurance in almost all developed countries. While the approaches to providing health insurance differ across OECD countries, most of them provide some form of basic universal public health insurance (UPHI). Private health insurance plays a somewhat minor role and typically provides supplementary insurance that facilitates additional access to private clinics, more luxurious care such a single-bed hospital rooms, or services that are not covered by public health insurance such as certain types of vision or dental care (e.g., Carrin and James, 2005).

The US, however, is the exception. The US health insurance system relies heavily on private, employer sponsored, health insurance to cover the working population, while public health insurance predominantly covers the high risk population of retired individuals through Medicare and low income individuals through Medicaid. The US health insurance system is a complex system that not only pools health risk but also redistributes wealth through its various financing mechanisms that tie into the progressive US income tax system. Thus far, relatively little effort has been devoted to quantitatively addressing to what extent the US system is able to reduce the exposure to health risk and how welfare is impacted by the heavy reliance on private health insurance. This paper aims to quantify the social insurance role of the US mixed health insurance system by exploring the welfare benefits or losses of adjustments to the current system by either expanding the public or private components.

We use a general equilibrium, overlapping generations model with idiosyncratic income risk and incomplete markets similar to Bewley (1986) and Aiyagari (1994), idiosyncratic exogenous health risk similar to Jeske and Kitao (2009) and Pashchenko and Porapakkarm (2013), and key elements of the US health insurance system such as private individual health insurance (IHI) plans, employer-sponsored group health insurance (GHI) plans, Medicaid, and Medicare. The fact that individuals are exposed to medical expenditure shocks induces demand for health insurance. Individuals have access to private and public health insurance plans which can partially insure their medical spending risk. In addition, they use precautionary saving and labor supply to smooth consumption spending. Health insurance choice is thus jointly determined with consumption, savings and labor supply over the lifecycle.

We calibrate the model to US data and match the lifecycle patterns of income, labor supply, and asset holdings. In addition, the model successfully reproduces the lifecycle profiles of insurance take-up rates for Medicaid, IHI and GHI. Finally, our model replicates important macroeconomic aggregates from national income accounts (NIPA). Our benchmark model therefore embeds the lifecycle structure of health risk in conjunction with income risk as observed in the data.

In the benchmark version of the model, the two types of idiosyncratic risks (wage income shocks and health

[1] Note that the provision of public health insurance can also be justified by high administrative costs of private health insurance systems, altruism, free riding issues, optimal taxation problems, equity reasons including redistribution of wealth and health capital across and within age cohorts (e.g., Blomqvist and Horn 1984; Besley 1988; Culyer and Wagstaff 1993; Cremer and Pestieau 1996; Zweifel and Manning 2000; Nyman 2003).

shocks) are not fully insurable as individuals are borrowing constrained and markets are not complete. Meanwhile, the health insurance system is segmented and a large share of workers remains uninsured. In the model the limited insurance coverage of health risk directly impacts the effectiveness of the limited set of market instruments (i.e., household savings and adjustments to labor supply) to insure against income risk. This induces demand for more social health insurance in order to reduce consumption variance over the lifecycle. There are two channels through which social health insurance is provided in the current US health insurance system. A public health insurance channel via universal public health insurance for retirees (Medicare) and means-tested public health insurance targeting the poor (Medicaid) and a private health insurance channel that includes insurance premium regulations and subsidies via tax deductions of employer-sponsored GHI premiums. In order to quantify the social insurance role of each channel we study several alternative designs of health insurance such as the expansion of Medicare and the expansion of GHI. In these experiments, the government adjusts either a progressive income tax, a payroll tax, or a consumption tax to balance its budget.

We first focus on the effects of switching to an exclusive public health insurance system without any private health insurance options. Specifically, we expand Medicare to include all workers which effectively turns Medicare into a universal public health insurance (UPHI) program. We also remove the IHI and GHI plans from the model. This UPHI reform leads to significant reductions in labor supply and household savings due to crowding-out effects (a move from self-insurance via savings to government insurance) and tax distortions. As a result the economy produces less and households have lower income which leads to welfare losses. However, the UPHI system also eliminates adverse selection issues and improves risk sharing which both lead to welfare gains. Overall our quantitative results indicate that welfare losses caused by incentive effects dominate welfare gains due to insurance and redistribution effects, when the UPHI coinsurance rate is set at the current Medicare level.[2]

The levels of the welfare gains or losses depend critically on generosity of the UPHI system, which is determined by the coinsurance rate.[3] By lowering the coinsurance rate of UPHI the government can shift the financial burden of medical care from high risk individuals to the tax paying public. On the other hand, higher coinsurance rates require households to contribute more out-of-pocket to finance their health expenditures and leaves them more exposed to idiosyncratic health risk. Thus, the coinsurance rate provides a redistribution mechanism that can be used to support individuals who are exposed to a high degree of health risk. Yet, the level of coinsurance rate determines the relative size of the incentive and insurance effects. We find that when the UPHI coinsurance rate is set to a higher level than the current Medicare coinsurance rate, welfare gains can be achieved. We then solve for the optimal coinsurance rate that balances out the opposing effects and maximizes overall welfare outcomes. We find that the optimal design of a UPHI system financed by a progressive income tax is achieved when the coinsurance rate is set at around 54 percent. While some household types experience welfare losses from this reform, overall we measure a welfare gain of about 0.21 percent of CEV. When the same UPHI system is financed by a consumption tax, the optimal coinsurance rate is lower at 42.6 percent and the welfare gains increase to around 2.7 percent of CEV. This result indicates that if the government finances the UPHI system with a less distortive tax, it can offer more generous coverage at a lower fiscal cost and thereby achieve higher welfare gains.

The tax burden caused by the UPHI system can be further lessened by allowing private health insurance plans

[2]Our welfare measure is compensating equivalent consumption variation (CEV) that is measured as the percent of lifetime consumption that a newborn individual gains or loses in the new (post-reform) steady state compared to the benchmark (pre-reform) steady state.

[3]The coinsurance rate is defined as the fraction of the medical bill that the patient has to pay out-of-pocket. Linear coinsurance, where insurers pay the same fraction of the health care cost irrespective of the expenditure level, has a long tradition of being studied in the health insurance literature (e.g., Zeckhauser 1970; Feldstein 1973).

concurrently. We next examine a UPHI system where workers can decide to purchase IHI or GHI plans instead. We assume that premiums for IHI and GHI are set according to current US regulations as in the benchmark model. The option to purchase private health insurance is only relevant if the UPHI coinsurance rate exceeds the coinsurance rates offered by private health insurance plans. Individuals will then consider whether buying more generous private health insurance is worth the premium.[4] Yet, allowing some workers to form their own insurance pools decreases the size of the government-run UPHI system, which in return results in smaller fiscal distortions from the required tax increases. The optimal UPHI coinsurance rate in this scenario is around 49 percent when the progressive income tax is used to finance the UPHI system. At this rate about a third of workers decide to stay in private GHI plans which lowers the fiscal cost of the UPHI expansion and income tax revenue increases by "only" 14 percent as opposed to 28 percent in the UPHI reform without any private insurance options. Overall the UPHI system in this environment leads to larger welfare gains of 1.5 percent of CEV. More importantly, the optimal UPHI system with private health insurance plans results in welfare gains for all income groups, which translates into higher overall welfare gains compared to the optimal UPHI system with no private options.

We then explore a reform that would strengthen the private health insurance component of the current US insurance system. In this reform we simulate a government mandate that would force all employers to offer GHI. This removes the risk of a worker being paired with an employer that does not offer GHI as is often the case under the current US system. We find that this reform leads to a large increase in the fraction of workers with GHI from 62 percent to about 91 percent. The experiment shows that mandating GHI offers to all workers and allowing premiums to be tax deductible can help reduce adverse selection. In addition, while offering GHI to all working age individuals increases the labor force participation rate, it does lower the average hours worked and the capital stock. The latter is a direct result of workers moving from self-insurance via household savings to tax deductible private health insurance plans. Overall, the reform leads to moderate average welfare gains of about 0.22 percent of CEV. This experiment demonstrates that further regulation of private health insurance markets (i.e., mandating GHI offers for all workers) can generate welfare gains and improve the social insurance role of the US health insurance system.[5]

In our sensitivity analysis we show that tax financing instruments matter for aggregate welfare outcomes. For instance, if the government uses a consumption tax to finance the UPHI program (as opposed to income or payroll taxes), the tax induced distortions in the labor market are more moderate. This allows the government to support more generous public health insurance with a lower coinsurance rate.

Finally, as an extension we consider two additional healthcare reforms: (i) lowering the Medicare eligibility age from 65 to either 60 or 50 and (ii) extending GHI to all individuals (including retirees), while removing all other forms of health insurance. We find that both reforms result in welfare gains. More specifically, the results from the first reform show that the Medicare expansion not only benefits the newly eligible workers but also younger workers. As the 60–64 age cohort leaves the private GHI pool and moves into Medicare, the remaining GHI pool is younger and has lower expected health expenditures. GHI premiums now decrease which directly benefits younger workers with GHI offers from their employers. The second reform removes public health insurance and therefore any tax distortions associated with financing Medicare and Medicaid. In addition, this reform mandates GHI offers

[4]The choice between UPHI and a private health insurance plan is trivial if the coinsurance rate of UPHI is lower than the coinsurance rates of IHI and GHI plans as UPHI is fully financed by taxes and does not charge a premium in our setup.

[5]Similarly, in a slightly more parsimonious model with inelastic labor supply Jeske and Kitao (2009) find that removing the GHI subsidy (i.e., abolishing the tax deductibility of GHI premiums) leads to a partial collapse of the GHI market, reduces the number of insured workers and results in welfare losses.

to all workers and retirees which improves risk pooling via private insurance markets. The observed overall welfare gains from this reform are the result of the welfare gains from removing fiscal distortions being dominant over the welfare losses suffered by individuals previously covered under Medicare or Medicaid.

Related studies. Our paper contributes to a large macroeconomics and public finance literature analyzing the welfare benefits of public transfer programs in quantitative dynamic general equilibrium models (e.g., Auerbach and Kotlikoff 1987; Hansen and Imrohoroglu 1992; İmrohoroğlu, İmrohoroğlu and Joines 1995; Conesa and Krueger 1999; Fuster, Imrohoroglu and Imrohoroglu 2007). More recently, Braun, Kopecky and Koreshkova (2017) assess the welfare effects of means-tested social insurance for the older population. We follow a similar modeling approach but focus on the social insurance role and welfare benefits of remodeling the US health insurance system.

There is a growing macro-health literature that studies the implications of health and healthcare reforms in the US. The most closely related papers to our study are Jeske and Kitao (2009), Pashchenko and Porapakkarm (2013), Hansen, Hsu and Lee (2014), Jung and Tran (2016), and Zhao (2017).[6] While many of these papers cover aspects of US healthcare policy reforms in computational macro frameworks, our model is unique in that it combines detailed aspects of the US healthcare system in a model with exogenous health risk and insurance choice while focusing on a healthcare systems comparison across steady states. The closest to this paper is our own work in Jung and Tran (2016) where we analyze the long-run effects of the Affordable Care Act in the US. The current paper addresses a broader question concerning the overall welfare benefits of the US health insurance system relative to alternative health insurance designs. We demonstrate since the mixed US system fails to insure a large share of the population, welfare improving health insurance reforms are possible but depend on the trade off between positive insurance effects and negative tax distortions.

Our paper is related to the broader literature on incomplete markets macroeconomic models with heterogeneous agents as pioneered by Bewley (1986) and extended by Huggett (1993) and Aiyagari (1994). These models have been widely applied to quantify the welfare effects of public insurance for idiosyncratic income and longevity risks (e.g., Hubbard and Judd 1987; Golosov and Tsyvinski 2006; Heathcote, Storesletten and Violante 2008; Conesa, Kitao and Krueger 2009; Huggett and Parra 2010; Krueger and Perri 2011). This literature shows that if the ability of risk sharing in private markets is limited, then publicly provided risk sharing mechanisms can improve the allocation of risk, smooth non-medical consumption and increase welfare. In these models earning shocks are the sole source of uncertainty and they typically focus on modeling non-medical consumption variation. We introduce health risk as additional source of idiosyncratic variation into an otherwise similar Bewley framework.

Our paper is also connected to the literature on optimal insurance and government redistribution (e.g., Blomqvist and Horn 1984; Rochet 1991; Cremer and Pestieau 1996) as well as the literature on mixed public-private health insurance systems (e.g., Besley 1989; Selden 1997; Blomqvist and Johansson 1997; Petretto 1999; Chetty and Saez 2010). These studies analytically investigate the optimal structure of mixed insurance systems in terms of efficiency and equity in highly stylized models. Different from this literature we provide a quantitative analysis using a more realistic model.

The paper is structured as follows. Section 2 presents the full dynamic model. Section 3 describes our calibration strategy. Section 4 describes the main results. Section 5 concludes.[7]

[6]Additional macro-health related studies include Suen (2006), Hall and Jones (2007), De Nardi, French and Jones (2010), Feng (2010), Hugonnier, Pelgrin and St-Amour (2013), Scholz and Seshadri (2013), Zhao (2014), Capatina (2015), Yogo (2016), Ozkan (2017), Jung, Tran and Chambers (2017), Conesa et al. (2018), Cole, Kim and Krueger (2018), Fonseca et al. (2021), and Heer and Rohrbacher (2021).

[7]We provide a more detailed description of the data sources as well as additional numerical and graphical results in an online appendix.

2 Model

We formulate an overlapping generations model with idiosyncratic income and health risk. The economy is populated with utility-maximizing households that are able to buy private health insurance contracts. Profit-maximizing firms produce a final consumption good and a government provides consumption insurance for low income households, Social Security, Medicare, and Medicaid.

2.1 Demographics

The economy is populated with overlapping generations of individuals who live to a maximum of J periods. Individuals are allowed to work for a maximum of J^W periods. In each period individuals of age j face an exogenous survival probability $\pi_j\left(\varepsilon^h\right)$ that depends on their exogenous health state ε^h. 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 μ_j of the entire population at any point in time. The relative sizes of the cohorts alive μ_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 $\mu_j = \sum_{\varepsilon^h} \frac{\pi_j(\varepsilon^h)}{(1+\mathfrak{n})^{years}} \mu_{j-1}\left(\varepsilon^h\right)$ and $\tilde{\mu}_j = \sum_{\varepsilon^h} \frac{1-\pi_j(\varepsilon^h)}{(1+\mathfrak{n})^{\text{years}}} \mu_{j-1}\left(\varepsilon^h\right)$, where years denotes the number of years per model period and $\mu_j\left(\varepsilon^h\right)$ is the mass of individuals with health ε^h.

2.2 Preferences

The period utility function $u\left(c_j, \ell_j; \bar{n}_j \cdot 1_{[0\leq n_j]}\right)$ depends on consumption (c), leisure (ℓ), and labor-force participation status which is only equal to 1 if labor supply is positive. Parameter $\bar{n}_j$ denotes age-dependent fixed cost of working. Individual value leaving bequests via function $b(a_j)$ which is increasing in asset holdings a_j.

2.3 Health status and health expenditure

Health status ε^h evolves exogenously over the lifecycle. Health status follow a Markov process that depends on age and the permanent income group so that conditional transition probabilities are elements of matrix $\Pi^h(j,\vartheta)$. A specific level of health expenditures $m\left(j,\vartheta,\varepsilon^h\right)$ is linked to health status and fluctuates accordingly. In addition, the permanent income type and age affect this exogenous health expenditure.

2.4 Endowments

In each period households are endowed with one unit of time that can be used for work ℓ or leisure. Conditional on labor force participation, a household earns before-tax wage income $y_j = w \times e_j\left(\vartheta, \varepsilon^n, \varepsilon^h\right) \times n_j$ at age j, where w is the wage rate, and e_j is a labor productivity endowment that depends on age j, a permanent income group ϑ, an idiosyncratic productivity shock ε^n, and idiosyncratic health state ε^h. Labor shocks follow a Markov process with transition probability matrix Π^n.

2.5 Health insurance

Workers can buy two types of private health insurance policies: a group health insurance plan (GHI) via their employer or an individual health insurance plan (IHI). In the US setting, GHI is not only more strictly regulated than IHI but also subsidized via the US tax system via tax deductible premium payments. This makes GHI a particularly attractive form of health insurance. Individuals are required to buy insurance before the realization of their health state and the associated medical expenditures and insurance needs to be renewed each period.

GHI can only be bought by workers who receive a GHI offer from their employer. Let ε^{GHI} be a binary random variable that indicates the state of the GHI offer from the employer. The GHI offers follow a Markov process summarized as the 2 state transition matrix $\Pi^{\text{GHI}}(j,\vartheta)$ that depends also on age and an individuals permanent income group. A fraction $\psi \in [0,1]$ of the insurance premium for GHI, $\text{prem}_j^{\text{GHI}}$, is paid for by the employer, the remainder of the premium $\widehat{\text{prem}}_j^{\text{GHI}} = (1-\psi)\,\text{prem}_j^{\text{GHI}}$ is tax deductible and paid by the worker. This premium is group rated so that insurance companies are not allowed to screen workers by their individual-specific health state; however, they are allowed to have some adjustments for younger age groups who have lower average healthcare costs so that

$$\text{prem}_j^{\text{GHI}} = \begin{cases} \phi_j^{\text{GHI}} \times \text{prem}^{\text{GHI}} & \text{if } j \leq J^{\text{GHI}}, \\ \text{prem}^{\text{GHI}} & \text{otherwise,} \end{cases}$$

where $0 < \phi_j^{\text{GHI}} \leq 1$ is a scaling factor and J^{GHI} is the cutoff age for premium adjustments.[8]

The fact that younger workers pay lower GHI premiums on average—that is on average across age groups not necessarily within a firm—is documented in the Kaiser Annual Report 2010 (Claxton et al. 2010).[9] Since we are not explicitly modeling firm heterogeneity with respect to the age of the work force and the associated group premiums that a firm might be able to negotiate with an insurance company, allowing for lower group premiums of younger workers aligns the model with the data.

If a worker is not offered GHI by their employer, the worker can buy IHI. In this case the insurance premium is not tax deductible and the insurance company screens the workers by age and health status, $\text{prem}^{\text{IHI}}\left(j,\varepsilon^h\right)$.[10]

In addition, there are two public health insurance programs: Medicaid for the poor workers and Medicare for retirees. To be eligible for Medicaid, agents are required to pass an income and asset test. After retirement $(j > J^W + 1)$ all agents are covered by public health insurance which is a combination of Medicare and Medicaid. Let in_j denote the insurance state which can take on the following values:

$$\text{in}_j = \begin{cases} 0 & \text{if not insured,} \\ 1 & \text{if individual health insurance (IHI),} \\ 2 & \text{if group health insurance (GHI),} \\ 3 & \text{if Medicaid (MAid)/Medicare(MCare).} \end{cases}$$

The out-of-pocket health expenditure depends on whether the agent has insurance or not

$$o_j(m) = \begin{cases} m & \text{if in}_j = 0, \\ \gamma^{\text{in}} \times m & \text{if in}_j > 0, \end{cases} \tag{1}$$

[8] When $\phi_j^{\text{GHI}} = 1$, there is no adjustment. In our calibration section, we set $J^{\text{GHI}} = 25$ and $\phi_j^{\text{GHI}} = 75\%$ in order to better match the GHI take-up rate for young workers.

[9] This empirical observation is partly due to the institutional change from community rating to experience rating in the 1960s when the last Blue Cross plan gave up community rating (Morrisey 2007). At that time many health insurance companies switched to experience rating where insurance companies began to offer lower premiums to employers with a low past claims experience. In the late 1960s Blue Cross and Blue Shield were forced to switch from community rating to experience rating as they would otherwise have been stuck with the employers with the highest-cost employees, that is employers with an older workforce. More recently, the Affordable Care Act codifies an allowable degree of age discrimination in employer sponsored health insurance contracts (Fernandez, Rosso and Forsberg 2018).

[10] This has been changed by the ACA. Post ACA, insurers in the IHI markets are not allowed to discriminate by health status anymore.

where $0 \leq \gamma^{\text{in}} \leq 1$ are the coinsurance rates of the different insurance types $\gamma^{\text{in}} \in \left\{\gamma^{\text{IHI}}, \gamma^{\text{GHI}}, \gamma^{\text{MAid}}, \gamma^{\text{MCare}}\right\}$.

2.6 Insurance companies

We abstain from modeling insurance companies as profit maximizing firms and simply impose a zero profit condition. Since insurance companies in the individual market screen customers by age and health, we impose separate clearing conditions for each age-health type, so that premiums, $\text{prem}^{\text{IHI}}(j,h)$, adjust to balance

$$\text{prem}^{\text{IHI}}\left(j,\varepsilon^h\right) = \frac{\mu_{j+1}\int\left[1_{\left[\text{in}_{j+1}(x)=1\right]}\left(1-\gamma^{\text{IHI}}\right)m_{j+1}(x)\times P\left(\varepsilon^h_{j+1}|\varepsilon^h_j\right)\right]d\Lambda\left(x_{j+1,-\varepsilon^h}\right)}{R\times\mu_j\int\left(1_{\left[\text{in}_{j,h}(x)=1\right]}\right)d\Lambda\left(x_{j,-\varepsilon^h}\right)} \tag{2}$$

where γ^{IHI} is the coinsurance rate, $x_{j,-\varepsilon^h}$ is the state vector for cohort age j not containing health state ε^h since we do not want to aggregate over the health state vector ε^h in this case. The clearing condition for the group health insurances is simpler as only one price, prem^{GHI}, adjusts to balance

$$\begin{aligned} &\sum_{j=2}^{J^W}\mu_j\int\left[1_{\left[\text{in}_j(x)=2\right]}\left(1-\gamma^{\text{GHI}}\right)m_j(x)\right]d\Lambda(x) \\ = \;& R\sum_{j=1}^{J^W-1}\mu_j\int\left(1_{\left[\text{in}_j(x)=2\right]}\left(1_{\left[j\leq J^{\text{GHI}}\right]}\phi^{\text{GHI}}+1_{\left[j>J^{\text{GHI}}\right]}\right)\text{prem}^{\text{GHI}}\right)d\Lambda(x), \end{aligned} \tag{3}$$

where γ^{GHI} is the coinsurance rate and ϕ^{GHI} is a scale factor that lowers the effective group premium for young workers below age J^{GHI}. The respective left-hand-sides in the above expressions summarize aggregate payments made by insurance companies whereas the right-hand-sides aggregate the premium collections one period prior. Since premiums are invested for one period, they enter the capital stock and we therefore multiply the term with the after tax gross interest rate R.

2.7 Technology and factor prices

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

$$\max_{\{K,\,N\}}\left\{F(K,N)-q\times K-w\times N\right\}, \tag{4}$$

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

Similarly to Jeske and Kitao (2009) we assume that a firm offering GHI to its workers subsidizes a fraction ψ of the premium cost. The firm passes these costs on to its employees by lowering the efficiency wage. To ensure the zero profit condition the firm subtracts the cost c_E from the wage rate, which is just enough to cover the total premium cost of the firm. The effective wage rate received by the household with a GHI offer is therefore

$\widehat{w} = \left(w - 1_{[\varepsilon^{\text{GHI}}=1]} \times c_E\right)$. The zero profit condition implies that the wage reduction equals

$$c_E = \frac{\psi \times \sum_{j=1}^{J^W} \mu_j \int \left(1_{[\text{in}_{j+1}(x)=2]} \times \text{prem}_j^{\text{GHI}}\right) d\Lambda(x)}{\sum_{j=1}^{J^W} \mu_j \int \left(1_{[\varepsilon_j^{\text{GHI}}=1]} \times e\left(\vartheta, \varepsilon^n, \varepsilon^h\right) \times n_j(x)\right) d\Lambda(x)}.$$

In this scenario high productivity workers effectively pay higher contributions towards financing the employer contribution to GHI as their wage deductions are larger in absolute terms. The remaining share of the GHI premium $\widehat{\text{prem}}^{\text{GHI}} = (1-\psi) \times \text{prem}^{\text{GHI}}$ is income tax deductible and paid by the worker directly.

2.8 Fiscal policy

The government collects the following taxes: a progressive labor income tax on taxable income y_j^{T} denoted $T^y(y_j^{\text{T}})$, payroll taxes $T^{\text{SS}}\left(y_j^{\text{SS}}; \bar{y}^{\text{SS}}\right)$ and $T^{\text{MCare}}\left(y_j^{\text{SS}}\right)$ for Social Security and Medicare respectively collected on eligible labor income y_j^{ss}, a consumption tax τ^c, and a tax τ^{Beq} on bequests B^{Beq}. Payroll tax eligible labor income y_j^{SS} is essentially labor income minus GHI premiums which are income and payroll tax deductible. In addition,the payroll tax for Social Security is proportional only up to the maximum taxable earnings of $\bar{y}^{\text{SS}}$.

With these tax revenues, the government runs the following spending programs: Social Security, Medicare, Medicaid, lump-sum transfers b^{SI} to low income earners that guarantee a minimum consumption level $c_{\min}$, and residual (unproductive) government consumption.

Households receive Social Security benefits after the eligibility age $\left(j > J^W\right)$, and the amount of benefits paid depends on the average earnings history of a permanent income type $\bar{y}^{\vartheta}$.[11] In addition, households become eligible for Medicare after age $j > J^W$ at which point they also start paying a Medicare premium $\text{prem}^{\text{MCare}}$ every period.

Finally, households are eligible for Medicaid payments if they pass the income and asset tests $y_j < \bar{y}^{\text{MAid}}$ and $a_j < \bar{a}^{\text{MAid}}$, respectively. We assume that Social Security, Medicare, and Medicaid are part of the overall budget constraint.[12] This implies that the surplus of both programs (which can be negative) enters the overall government budget constraint so that

$$\text{surplus}^{\text{SS}} = \int T^{\text{SS}}\left(y_j^{\text{SS}}(x); \bar{y}^{\text{SS}}\right) d\Lambda(x) - \int_{j>J^W} b^{\text{SS}}\left(\bar{y}_{\vartheta}\right) d\Lambda(x), \tag{5}$$

and

$$\text{surplus}^{\text{MCare}} = \int \left[T^{\text{MCare}}\left(y_j^{\text{SS}}(x)\right) + 1_{[j>J^W]}\text{prem}^{\text{MCare}}\right] d\Lambda(x) - \int_{j>J^W} \left[\gamma^{\text{MCare}} \times m_j(x)\right] d\Lambda(x). \tag{6}$$

[11] In reality 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 then a function of AIME.

[12] It is often assumed that Social Security's budget is balanced every period (e.g., Huggett and Ventura 1999; İmrohoroğlu, İmrohoroğlu and Joines 2003; Zhao 2014 and many others) due to disagreement over whether Social Security trust fund assets are "real" and increase national saving. Smetters (2003) presents empirical evidence suggesting that trust fund assets have actually reduced national saving. We assume that ultimately the government will pay for any shortfall in Social Security, Medicare, or Medicaid with general tax revenue.

are added to

$$C_G + \overbrace{\int \left[1_{[\text{MAid}]}\gamma^{\text{MAid}} \times m_j(x)\right] d\Lambda(x)}^{\text{Medicaid Payments}} + \overbrace{\int b^{\text{SI}}(x)\, d\Lambda(x)}^{\text{Social Transfers}} = \int \left[\tau^c \times c(x) + T^y\left(y^{\text{T}}(x)\right)\right] d\Lambda(x) + \tau^{\text{Beq}} B^{\text{Beq}} + \text{surplus}, \tag{7}$$

where C_G is unproductive government spending and surplus $=$ surplus$^{\text{SS}}$ $+$ surplus$^{\text{MCare}}$ is the total surplus/deficit from Medicare and PAYG Social Security.

2.9 The household problem

Working households. The state vector of a working at a particular age is defined as $x_j = \left\{\vartheta, a_j, \text{in}_j, \varepsilon_j^n, \varepsilon^h, \varepsilon_j^{\text{GHI}}\right\} \in \{1,2,3\} \times R^+ \times \{0,1,2,3\} \times \{1,2,3,4,5\} \times \{1,2,3,4,5\} \times \{0,1\}$, where ϑ denotes the permanent income group of no-high-school, high-school and college types, a_j denotes the beginning-of-period assets, in_j denotes the health insurance state, ε_j^n denotes the labor shock, and ε^h denotes the exogenous health state, and $\varepsilon_j^{\text{GHI}}$ is the employer (with group health insurance) matching shock. After the realization of the state variables, agents simultaneously chose from their choice set

$$\mathscr{C}_j \equiv \left\{(c_j, \ell_j, a_{j+1}, \text{in}_{j+1}) \in R^+ \times R^+ \times R^+ \times \{0,1,2,3\}\right\}$$

where c_j is consumption, ℓ_j is leisure, a_{j+1} are asset holdings for the next period, and in_{j+1} is the health insurance state for next period in order to maximize their lifetime expected 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. The household problem of the working household can be recursively written as

$$V(x_j) = \max_{\left\{c_j, \ell_j, a_{j+1}, \text{in}_{j+1}\right\}} \left\{u(c_j, \ell_j) + \beta\left(\pi_j\left(\varepsilon^h\right) \times \mathbb{E}\left[V(x_{j+1}) \,|\, x_j\right] + \left(1 - \pi_j\left(\varepsilon^h\right)\right) b(a_{j+1})\right)\right\} \text{ s.t.} \tag{8}$$

$$\begin{aligned}(1+\tau^c)\, c_j + a_{j+1} + o_j(m_j) + 1_{\left\{\text{in}_{j+1}=1\right\}}\text{prem}^{\text{IHI}}\left(j, \varepsilon^h\right) + 1_{\left\{\text{in}_{j+1}=2\right\}}\text{prem}_j^{\text{GHI}} \\ = (1+r)\, a_j + y_j^n + b_j^{\text{SI}} + \left(1 - \tau^{\text{Beq}}\right) b^{\text{Beq}} - \text{Tax},\end{aligned} \tag{9}$$

where β is a time preference factor, $\pi_j\left(\varepsilon^h\right)$ is the age and health state dependent survival probability, w is the market wage rate, r is the interest rate, $o(m_j)$ is out-of-pocket medical spending, prem^{in} is the insurance premium paid. The indicator functions are defined as $1_{[true]} = 1$ and $1_{[false]} = 0$. Accidental bequests b^{Beq} are redistributed to surviving households in a lump-sum fashion.[13] Labor income y_j^n, total taxable income y_j^{T}, and payroll tax eligible

[13]This parsimonious modeling choice of bequest redistribution is standard in this literature (e.g., Jeske and Kitao 2009; İmrohoroğlu and Kitao 2009; Pashchenko and Porapakkarm 2013) but does imply implicit insurance as every household receives these payments. İmrohoroğlu, İmrohoroğlu and Joines (1995) and Zhao (2017) among others provide results of pension policy experiments based on alternative redistribution methods such as a complete elimination of accidental bequests, folding bequests into annuity payments, or redistributing all bequests to newborn households only. A less ad-hoc, but computational more burdensome way, would be to explicitly model the timing of leaving bequests and the family structure in a dynastic framework as in De Nardi and Yang (2014).

income y_j^{ss} are defined as

$$y_j^n = \overbrace{\widehat{w} \times e_j \left(\vartheta, \varepsilon_j^n, \varepsilon^h\right)}^{\text{Health-dependent income}} \times (1 - \ell_j), \tag{10}$$

$$y_j^{\mathrm{T}} = y_j^n + r \times a_j - 1_{\{\mathrm{in}_{j+1}=2\}} \mathrm{prem}_j^{\mathrm{GHI}} - \max\left[0, o\left(m_j\right) - 0.075 \times \left(y_j^n + r \times a_j\right)\right],$$

$$y_j^{ss} = y_j^n - 1_{\{\mathrm{in}_{j+1}=2\}} \mathrm{prem}_j^{\mathrm{GHI}}, \tag{11}$$

where private GHI premiums are tax deductible as are out-of-pocket health expenses that exceed 7.5 percent of adjusted gross income.[14]

Consumption is taxed with rate τ^c, lump-sum bequests b^{Beq} are taxed at rate τ^{Beq} and the remaining taxes are defined as

$$\begin{aligned}
\mathrm{Tax} &= T^y\left(y_j^{\mathrm{T}}\right) + T^{\mathrm{SS}}\left(y_j^{\mathrm{SS}}; \bar{y}^{\mathrm{SS}}\right) + T^{\mathrm{MCare}}\left(y_j^{\mathrm{SS}}\right), \\
T^{ss}\left(y_j^{\mathrm{SS}}; \bar{y}^{\mathrm{SS}}\right) &= \tau^{\mathrm{SS}} \times \min\left[y_j^{\mathrm{SS}}; \bar{y}^{\mathrm{SS}}\right], \\
T^{\mathrm{MCare}}\left(y_j^{\mathrm{SS}}\right) &= \tau^{\mathrm{MCare}} \times y_j^{ss},
\end{aligned}$$

where T^y is a progressive income tax function of taxable household income y_j^{T}, τ^{SS} is the social security payroll tax levied on "social security wages"—essentially wages minus GHI premiums—and an upper contribution limit of $\bar{y}^{\mathrm{SS}}$, and T^{MCare} is a Medicare payroll function with the same tax base but without an upper limit.[15] Social transfers are defined as

$$\begin{aligned}
b_j^{\mathrm{SI}} &= \max\left[0,\ c_{\min} + o\left(m_j\right) - y_j^{\mathrm{AT}} - a_j - b^{\mathrm{Beq}}\right], \\
y_j^{\mathrm{AT}} &= y_j^n + r \times a_j - \mathrm{Tax},
\end{aligned}$$

and ensure a minimum consumption floor $c_{\min}$ after medical expenses and taxes are paid for. A household consuming at the lower bound cannot save into the next period or purchase private insurance.

Average past labor earnings for each permanent income group ϑ follow

$$\bar{y}^{\vartheta} = \int_{j \le J^W} y_j^n\left(x\left(\vartheta\right)\right) d\Lambda\left(x\left(\vartheta\right)\right)$$

where $x\left(\vartheta\right)$ is the mass of households belonging to permanent income group ϑ.

Fully retired households. Households can stop working at any time, however they receive Social Security benefits and qualify for Medicare starting at age $j > J^W$. If they will withdraw from the labor force then and retirement becomes an absorptive state. The state vector of a fully retired household at a particular age is defined

[14]Compare Schedule A (Form 1040), Itemized Deductions at: https://www.irs.gov/forms-pubs/about-schedule-a-form-1040

[15]Employers contribute 50 percent of Medicare and Social Security taxes. For simplicity, we assume that employees pay 100 percent of all payroll taxes.

as $x_j = \left\{\vartheta, a_j, \varepsilon^h\right\} \in \{1,2,3\} \times R^+ \times \{1,2,3,4,5\}$. The household optimization problem reduces to

$$V(x_j) = \max_{\left\{c_j, a_{j+1}\right\}} \left\{u(c_j) + \beta \left(\pi_j\left(\varepsilon^h\right) \times \mathbb{E}\left[V(x_{j+1})\,|\,x_j\right] + \left(1 - \pi_j\left(\varepsilon^h\right)\right) b(a_{j+1})\right)\right\} \tag{12}$$

$$s.t.$$

$$(1+\tau^c)\,c_j + a_{j+1} + o_j(m_j) + \text{prem}^{\text{MCare}} = (1+r)\,a_j + b_j^{\text{SS}} + b_j^{\text{SI}} + \left(1-\tau^{\text{Beq}}\right) b^{\text{Beq}} - T^y\left(y_j^{\text{T}}\right),$$

where taxable income y_j^{T} is defined as

$$y_j^{\text{T}} = r \times a_j + b_j^{\text{SS}} - \max\left[0,\, \left(o_j(m_j) + 1_{[j>J^w]}\text{prem}^{\text{MCare}}\right) - 0.075 \times \left(r \times a_j + b_j^{\text{SS}}\right)\right].$$

For retirees out-of-pocket expenses plus Medicare premiums that exceed 7.5 percent of gross income are tax deductible.[16] Social insurance transfers are defined as

$$b_j^{\text{SI}} = \max\left[0,\; c_{\min} + o_j(m_j) + \text{prem}^{\text{MCare}} + T^y\left(y_j^{\text{T}}\right) - (1+r)\,a_j - b_j^{\text{SS}} - b^{\text{Beq}}\right].$$

Since we force every retired individual into the combined Medicare/Medicaid program, the social insurance transfers include the Medicare premium.

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

2.10 Competitive equilibrium

Given the transition probability matrices $\left\{\Pi_j^n, \Pi_j^h\right\}_{j=1}^{J}$, the survival probabilities $\left\{\pi_j\left(\varepsilon^h\right)\right\}_{j=1}^{J}$ and the exogenous government policies $\left\{\tau^c, T^y, \tau^{\text{SS}}, \tau^{\text{MCare}}, b^{\text{SI}}, b^{\text{SS}}, \gamma^{\text{MCare}}, \gamma^{\text{MAid}}, C_G\right\}_{j=1}^{J}$, a competitive equilibrium is a collection of sequences of distributions $\Lambda(x)$ of individual household decisions $\{c(x), \ell(x), a(x), \text{in}(x)\}$, aggregate stocks of physical capital and effective labor services $\{K, N\}$, factor prices $\{w, q, R\}$, and insurance premiums $\left\{\text{prem}^{\text{IHI}}\left(j, \varepsilon^h\right), \text{prem}^{\text{GHI}}\right\}$ such that:

(a) $\{c(x), \ell(x), a(x), in(x)\}$ solves the consumer problem (8,9),

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

$$\begin{aligned} w &= \frac{\partial F(K,N)}{\partial N}, \\ q &= \frac{\partial F(K,N)}{\partial K}, \\ R &= 1 + q - \delta = 1 + r, \end{aligned}$$

(c) markets clear

[16] Details about the tax deductibility of out-of-pocket expenses and Medicare premiums can be found in IRS (2010).

$$K = \int a(x) + \text{Prem}^{\text{GHI}}(x) + \text{Prem}^{\text{IHI}}(x)\, d\Lambda(x) \tag{13}$$

$$N = \int e(x)\,(1 - \ell(x))\, d\Lambda(x). \tag{14}$$

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

(d) the aggregate resource constraint holds

$$C_G + \int (c(x) + m(x) + a(x))\, d\Lambda(x) = Y + (1-\delta)K,$$

(e) the government programs clear so that (5), (6), and (7) hold,

(f) the budget conditions of the insurance companies (2) and (3) 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

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

3 Calibration

We calibrate the model to match data of the U.S. economy between 1999–2009. Macroeconomic data moments include capital accumulation, patterns of labor supply and health insurance take-up rates over the life cycle. 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. *Internally calibrated* parameters are assigned values so that model-generated data match a given set of targets from U.S. data. These parameters together with model generated data moments and target moments from U.S. data are juxtaposed in Table 3. Additional performance measures (not calibration targets) are shown in Table 4.[17]

3.1 Demographics

One model period is defined as one year. We model households from age 21 to age 95 which results in $J = 75$ periods. Once the individual enters period $J_{r+1} = 46$, i.e. age 65, she is forced to retire. We set the population growth rate to $\mathfrak{n} = 0.01$, and we take the age and health specific survival probabilities from İmrohoroğlu and Kitao

[17] The online appendix provides more detailed information about the data sources used.

(2012). For the purpose of survival probabilities $\pi\left(h\left(\varepsilon^{h}\right)\right)$ we distinguish between healthy and sick individuals which we define in Section 3.4 below. Panel [5] in Figure 1 shows the health state dependent survival probabilities.

3.2 Preferences

We specify period utility as

$$u\left(c_{j},\ell_{j};\bar{n}_{j}\right)=\frac{\left(c_{j}^{\eta}\times\left[\ell_{j}-\bar{n}_{j}\cdot 1_{\left[0\leq n_{j}\right]}\right]^{1-\eta}\right)^{1-\sigma}}{1-\sigma}.$$

The fixed cost of working $\bar{n}_j$ is set to match the average work hours by age group from PSID. We set the relative risk aversion parameter σ to 3, and the intertemporal discount factor β to 0.99 to match the capital-output ratio target in equilibrium. The consumption intensity parameter η is 0.275 to match average labor hours of the working population. The resulting Frisch labor elasticity is age dependent can be calculated as[18]

$$\varepsilon_{\text{Frisch}}:=\frac{\left(1-n_{j}-\bar{n}_{j}\cdot 1_{\left[0\leq n_{j}\right]}\right)}{n_{j}}\times\frac{\left(1-\eta\left(1-\sigma\right)\right)}{\sigma}. \tag{15}$$

Our calibration results in values the Frisch elasticity between 1.5–3.5, with higher values for older individuals. These values are well within the Macro estimates based on Fiorito and Zanella (2012) and Peterman (2016) or the summary of empirical literature about labor supply elasticities in Whalen and Reichling (2017).

The warm-glow bequest function is

$$b\left(a_{j}\right)=\theta_{1}\frac{\left(a_{j}+\theta_{2}\right)^{(1-\sigma)\eta}}{1-\sigma},$$

where θ_2 determines the curvature of the function. This functional form is similar to the one in French (2005).[19] Parameter θ_1 is a scaling parameter that is set to match the asset holdings of retired individuals.

3.3 Health status and health expenditure

We use data from MEPS 1999–2009 to estimate the magnitude of the age dependent health expenditure shocks $m\left(j,\vartheta,\varepsilon^{h}\right)$ as well as the Markov transition probability matrix $\Pr\left(\varepsilon_{j+1}^{h}|\varepsilon_{j}^{h}\right)$. We group individuals into five health groups $\varepsilon^{h}\in\{1,2,3,4,5\}$ by self-reported health status: 1. excellent health, 2. very good health, 3. good health, 4. fair health, and 5. poor health. We then calculate average medical spending of each health group by age and education level to determine the magnitude of the health spending shocks $m\left(j,\vartheta,\varepsilon^{h}\right)$. Since MEPS only accounts for about 65–70 percent of health care spending in the national accounts (see Sing et al. 2006; Bernard et al. 2012) we scale up the medical spending profiles for individuals older than 65 similar to Pashchenko and Porapakkarm (2013). The resulting spending profiles are shown in Panels [2]–[4] of Figure 37.[20]

We next estimate an ordered logit model to determine the conditional probability of moving to a specific health

[18]The Frisch labor supply elasticity is defined as $\varepsilon_{\text{Frisch}}:=u_{n}\times\left[n\times\left(u_{nn}-\frac{\left(u_{cn}\right)^{2}}{u_{cc}}\right)\right]^{-1}$.

[19]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 increase the computational complexity.

[20]We also present figures showing the distribution of health groups by age and the associated distribution of medical spending shocks by health group and age in the online appendix.

group $\varepsilon^h_{j+1,t+1}$ in year $t+1$ conditional on being a member of health group $\varepsilon^h_{j,t}$ at time t and age j using a fourth order age polynomial.[21]

3.4 Endowments

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

$$e_j\left(\vartheta, \varepsilon^n, \varepsilon^h\right) = \bar{e}_j\left(\vartheta, h\left(\varepsilon^h\right)\right) \times \varepsilon^n_j, \tag{16}$$

where $\bar{e}_j\left(\vartheta, h\left(\varepsilon^h\right)\right)$ depends on age j, education level ϑ, and health state ε^h. The education level is permanent and fixed at age 20.

Using 1999–2009 MEPS data we construct cohort adjusted and bias corrected wage profiles for each education-health subgroup $\left(\vartheta, h\left(\varepsilon^h\right)\right)$ limiting the sample to heads of health insurance eligibility units (HIEU) with labor incomes larger than \$400.[22] We distinguish between three permanent educational groups

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

and two health states

$$h\left(\varepsilon^h\right) = \begin{cases} \text{healthy} & \text{if } \varepsilon^h \in \{\text{excellent, very good, good}\}, \\ \text{sick} & \text{if } \varepsilon^h \in \{\text{fair, poor}\}. \end{cases}$$

These are standard definitions for healthy and sick in the health macro literature. Panel [6] in Figure 5 depicts the fraction of healthy individuals and Table 2 shows the relative cohort sizes of healthy/sick types by permanent income group.

We then deflate hourly wage observations with the urban CPI and remove cohort effects. We then follow the procedure in Rupert and Zanella (2015) and Casanova (2013) and estimate a selection model to remove the selection bias that is typically associated with wage observations to get an average wage offer rate for each $\left(\vartheta, h\left(\varepsilon^h\right)\right)$ subgroup. We finally smooth the wage profiles with a second degree polynomial in age.[23]

The income shock component is modeled as an auto-regressive process so that

$$\ln\left(\varepsilon^n_j\right) = \rho \times \ln\left(\varepsilon^n_{j-1}\right) + \varepsilon, \tag{17}$$

with persistence parameter ρ and a white-noise disturbance $\varepsilon \sim N\left(0, \sigma^2_\varepsilon\right)$. To calibrate the stochastic component ε^n, we use $\rho = 0.977$ and $\sigma^2_\varepsilon = 0.0141$ based on estimates in French (2005) who uses PSID data and controls for cohort effects and health states. 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).

[21] The conditional transition probabilities between the health states by age are shown in the online appendix.

[22] Labor income follows the definition in PSID and comprises wage income (variable WAGEP) and 75 percent of business income (variable BUSNP).

[23] The online appendix contains more details about the procedures to remove cohort effects and wage biases.

3.5 Healthcare insurance

Group insurance offer. We estimate a Markov process that governs the group insurance offer probability using MEPS which contains information about whether agents have received a group health insurance offer from their employer i.e. offer shock $\varepsilon^{\text{GHI}} = \{0,1\}$ where 0 indicates no offer and 1 indicates a group insurance offer. Since the probability of a GHI offer $\Pr\left(\varepsilon_{j+1}^{\text{GHI}} | \varepsilon_{j}^{\text{GHI}}, \vartheta\right)$ is highly correlated with income, we construct the group offer transition matrix $\Pi_{j,\vartheta}^{\text{GHI}}$ by education type ϑ based on estimates of a logit model. [24]

Coinsurance rates. We define the coinsurance rate as the fraction of out-of-pocket health expenditures over total health expenditures. The coinsurance rates used in our model therefore include copayments and other direct out-of-pocket payments.[25] We use MEPS data from 1999–2000 and calculate the average coinsurance rate of heads of HIEUs (population weighted) by age for all four insurance types represented in the model. Consequently we set the coinsurance rates for the different types of insurance plans to $\gamma^{\text{IHI}} = 0.45$, $\gamma^{\text{GHI}} = 0.31$, $\gamma^{\text{MAid}} = 0.11$, and $\gamma^{\text{MCare}} = 0.30$ respectively.

3.6 Insurance companies

IHI premiums $\text{prem}_{j,\varepsilon^h}^{\text{IHI}}$ and GHI premiums $\text{prem}_{j}^{\text{GHI}}$ clear the zero-profit conditions (3) and (3) respectively. When clearing the GHI market we adjust a base premium prem^{GHI} that is then multiplied by an exogenously imposed age dependent scale factor ϕ^{GHI} that scales down the group premium of younger workers aged 20–25 which implies $J^{\text{GHI}} = 6$ as the cutoff age in the model for the GHI scaling. Since data on health insurance premiums that is linked to household characteristics is not readily available, we base our age scaling on calibration where the target is the GHI take-up rate of the 25 year olds who are offered GHI via their employers. The scaling results in a 25 percent lower premium for 20–25 year olds than for their older counterparts in GHI.[26]

3.7 Technology and factor prices

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

$$Y = A \times K^{\alpha} \times N^{(1-\alpha)}, \tag{18}$$

where α is the share of capital in total income. We set the capital share $\alpha = 0.35$ and the annual capital depreciation rate at $\delta = 0.06$ according to new estimates in Koh, Santaeulàlia-Llopis and Zheng, 2020. Total factor productivity A is normalized to unity. Morrisey (2007) reports that premiums paid through direct premium contributions by workers are relatively stable and amount to about 16 percent for single premiums and 26 percent for family premiums. We chose 20 percent so that the employer fraction $\psi = 0.8$ as in Jeske and Kitao (2009).

[24] The data section in the online appendix shows the conditional transition probability graphs for GHI offers.

[25] While the distinction between copayments, deductibles and coinsurance can be important, we do not have adequate data sources to distinguish between them. The distinction is also less important in a model with exogenous health spending where households do not adjust their health spending in reaction to the specifics in the reimbursement structure of health insurance. We therefore use out-of-pocket expenses and total health expenses from MEPS and calculated an "overall" coinsurance rate that includes copayments and deductibles.

[26] This degree of age discrimination in the GHI market is also close to the age scaling pointed out in Fernandez, Rosso and Forsberg (2018) for the post ACA period. More details can be found here: `https://www.cms.gov/CCIIO/Programs-and-Initiatives/Health-Insurance-Market-Reforms/state-rating`.

3.8 Fiscal policy

Taxes. The progressive income tax function has the following specification

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

where $T^y(y)$ denotes net tax revenues as a function of pre-tax income y, τ_1^i is the progressivity parameter, and τ_0^i is a scaling factor to match U.S. income tax revenue.[27] 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. We chose the tax curvature parameter $\tau_1 = 0.053$ following Guner, Lopez-Daneri and Ventura (2016).[28]

The consumption tax rate τ^c is set to 5 percent and the tax on bequests τ^{Beq} is set to 20 percent. This percentage is often used as the flat tax on capital and/or bequests (e.g., De Nardi and Yang 2014).

The Social Security system is partly financed via a payroll tax with a contribution limit. The Social Security payroll tax is $\tau^{\mathrm{SS}} = 10.6$ percent. The Social Security payroll tax is collected on labor income up to a maximum of \$106,800.[29]

The Medicare system is also self-financed via a payroll tax and Medicare premium payments. The Medicare payroll tax is $\tau^{\mathrm{MCare}} = 2.9$ percent. It is not restricted by an upper limit (see SSA, 2007). Overall, the model results in total income tax revenue of 26.0 percent of GDP, Social Security tax revenue of 8.1 percent of GDP and Medicare tax revenue of 1.8 percent of GDP.

Expenditures. The government uses income tax revenue to make lump-sum transfers to maintain a minimum level of consumption $c_{\min}$ of \$3,200. Similarly to Jeske and Kitao (2009) this floor is calibrated to target the 20 percent share of households with net asset worth of less than \$5,000 based on estimates in Kennickell (2003). Residual unproductive government consumption C_G of 15 percent of GDP based on BEA (2009) data.

Social Security. In the model, social security transfers are defined as a function of average labor income per skill type $\bar{y}^{\vartheta}$. Let $T^{\mathrm{ss}}(\vartheta) = \Psi^{\vartheta} \times \bar{y}^{\vartheta}$ be type specific pension payments where $\Psi^{\vartheta} = \{0.66, 0.47, 0.39\}$ is an skill type dependent replacement rate that determines the size of the pension payments.[30] In the model total pension payments amount to 6 percent of GDP. This is close to the number reported in the budget tables of the Office of Management and Budget (OMB) for 2008 which is close to 5 percent.

Medicare and Medicaid for retirees. 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)

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

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

[28] 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.

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

[30] These replacement rates are based on wage indexed average earnings presented in Table 1 in Biggs and Springstead (2008).

was 2.65 percent of GDP.[31] We use data from CMS (Keehan et al., 2011) and calculate that the share of total Medicaid spending that is spent on individuals older than 65 is about 36 percent. Adding this amount to the total size of Medicare results in a combined total of 4.4 percent of GDP of public health insurance reimbursements for the old while the residual Medicaid program that covers workers is about 1.7 percent of GDP.

Since MEPS only accounts for about 65–70 percent of health care spending in the national accounts (see Sing et al. 2006; Bernard et al. 2012), we would not be able to match the aggregate health health spending of the elderly. Based on communication with CMS (Office of the Actuary) we therefore scale up the MEPS based health spending shocks to match the adjusted medical spending over income ratios in Panel [3] of Figure 5. Given the estimated coinsurance rate of γ^{MCare} from MEPS and the exogenous, scaled up, health expenditure shocks, the size of the combined Medicare/Medicaid program in the model is 3.1 percent of GDP. We fix the premium for Medicare at 2.11 percent of per-capita GDP as in Jeske and Kitao (2009). The Medicare tax τ^{Mcare} is set to 2.9 percent.[32]

Medicaid for workers. The Medicaid coinsurance rate $\gamma^{\text{MAid}} = 0.11$ is calculated directly from MEPS data. The income test for Medicaid varies greatly across states. According to Kaiser (2013), 16 states have Medicaid eligibility thresholds below 50 percent of the FPL, 17 states have eligibility levels between 50 and 99 percent, and 18 states have eligibility levels that exceed 100 percent of the FPL. In addition, state regulations also vary greatly with respect to the asset test of Medicaid.[33] In the model we therefore calibrate the Medicaid income eligibility level to $\bar{y}^{\text{MAid}} = 5,500$ USD in order to target the Medicaid eligible working age population between age 20–39. Similarly we calibrate the asset eligibility level to $\bar{a}^{\text{MAid}} = 75,000$ USD in order to match the fraction of workers between age 40–64 insured via Medicaid. Panel [4] of Figure 3 shows the Medicaid coverage by age group in the model vs. MEPS data.

3.9 Model Performance

Figures 2 and 3 and Table 3 show the targeted moments of the calibration. In addition we perform checks of non-targeted data moments in Figures 4 and 5 and Table 4. The model results in medical spending as fraction of GDP of 16.5 percent which is close to the 17.3 percent reported in CMS data for 2010.[34] The Gini coefficient for medical spending in the model is 0.57 compared to 0.60 in MEPS. The interest rate in the model is 5.8 percent which falls within the range of estimated capital returns in Gomme, Ravikumar and Rupert (2011). The model provides a good fit for the lifecycle patterns of work hours, medical spending as fraction of household income and the percent of healthy or sick individuals as shown in the panels of Figure 4. In addition, the model closely traces the lifecycle patterns of labor income of the different household types as shown in the panels of Figure 5.[35]

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

[32] Medicare payroll taxes are 2×1.45 percent on all earnings split in employer and employee contributions (e.g., see SSA, 2007).

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

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

[35] Additional figures showing the lifecycle patterns of work hours and labor participation by education and health status are provided in the model performance section of the online appendix.

4 Quantitative analysis

The social insurance function of the US health insurance system stands on two pillars: (i) public health insurance for the poor (Medicaid) and the old (Medicaid), two groups who are both exposed to high health risk; (ii) premium regulation and tax subsidies for employer provided (private) health insurance which is the largest portion of the private health insurance market. In this section, we quantify the effects of expanding the public and private components of the US health insurance system.

4.1 Expansion of public health insurance

We begin with a large scale reform that expands Medicare which currently insures mostly retirees to all age groups. This program is often referred to as Medicare-for-All or Universal Public Health Insurance (UPHI).[36] This counter factual reform is financed with additional income taxes through the progressive income tax system.

A few issues arise when modeling a UPHI system. First, if we use the progressive income tax to finance the UPHI, should we simultaneously abolish the current Medicare payroll tax? Second, should we abolish the current Medicare premium or assume that the UPHI system universally charges the benchmark Medicare premium? Third, what is the role of private GHI and IHI when the UPHI is introduced?

Concerning the first two issues, we will assume that both, the Medicare payroll tax as well as the Medicare premium is abolished and the UPHI system is exclusively financed by the progressive income tax. Concerning the third issue, if the UPHI is more generous than GHI or IHI (i.e., UPHI has lower coinsurance rate than GHI and IHI), the question of how to handle private health insurance becomes trivial as in our framework all individuals would automatically opt for the "free" (and more generous) UPHI system. However, if UPHI has a higher coinsurance rate (i.e., is less generous) than GHI or IHI, then some individuals may opt out of "free" UPHI and decide to purchase the more generous GHI or IHI instead.

4.1.1 The economic channels

One of the justifications for having public health insurance such as Medicare or Medicaid, is that the adverse selection issue caused by asymmetric information in the private insurance markets excludes many individuals from attaining private health insurance.

In our model adverse selection is present in private health insurance markets via two channels. First, GHI is group rated so that low risk individuals who are not willing to pay the average premium do opt out which results in a GHI take-up rate below 100 percent. While the take-up rate is generally very high, after all GHI is tax deductible, not every worker who is offered GHI chooses to buy into it. This is especially true for some of the younger cohorts.[37] Second, while IHI companies do price discriminate and charge premiums according to the observed age and health status, they do not discriminate by education. Since the health expenditure process is partly driven by the permanent education status (i.e., college educated individuals are less likely to transitions into bad health states

[36] A more limited expansion of the current Medicare program from age 65 to age 50 results in welfare improving. We discuss these the results in detail in Section 4.4.1. Similarly, expansions or cuts to Medicaid have been highlighted in the literature (e.g., Finkelstein et al. 2012; Pashchenko and Porapakkarm 2017; Zhao 2017; Goodman-Bacon 2021). As our model simply reproduces many of these results, we have moved the discussion of changes to Medicaid into the appendix.

[37] Figure 3 shows the insurance coverage type of individuals by education over the lifecycle. In the middle column we plot the GHI offer rates together with the take-up rates and contrast model values with values from MEPS data.

than less educated individuals), an asymmetric information issue arises that can lead to adverse selection.[38]

Government provision of public health insurance essentially circumvents adverse selection which can result in welfare gains due to better risk pooling as well as general redistribution of income. However, while extending insurance coverage generally improves risk sharing, it also weakens precautionary motives. Expanding public health insurance not only crowds out private health insurance but also changes the incentives to work and save over the lifecycle which can lead to reductions in capital stock and output and subsequently affect the overall distribution of income. Moreover, in order to finance a public health insurance system, the government has to increase its tax revenue which additionally distorts the households' labor/leisure and saving decisions.

The experiments in this section thus present a trade-off between the positive effects of better insuring uncertain medical expenses and uncertain income shocks with the negative incentive effects of tax distortions that often lead to negative income effects.[39] This trade-off—we refer to it as the positive insurance/redistribution effects vs. the negative incentive effects—often results in differential welfare effects across worker types. The final welfare outcomes depend on how these opposing effects play out in general equilibrium.

Generosity of public health insurance. The relative size of the incentive and insurance effects is closely related to the overall generosity of public health insurance which is determined by the coinsurance rate. The coinsurance rate is defined as the fraction of the health expenditure bill that an individual pays out-of-pocket. If the coinsurance rate is high, individuals pay for a larger share of their total health expenditure and must therefore either reduce their consumption, work more to generate more income, or save less to account for sudden health related expenditures. On the government side a high coinsurance rate implies a smaller public health insurance program that requires less taxation. All this leaves households more exposed to idiosyncratic health expenditure shocks and also provides less redistribution via government channels. On the other hand, a low coinsurance rate improves risk sharing across different agent types and increases the level of redistribution. However, a more generous program is more costly to finance and requires higher taxes. This in turn leads to more tax distortions and lower output. As such the UPHI coinsurance rate plays a crucial role in shaping the relative strength of the insurance effects as well as overall welfare outcomes.

In order to demonstrate the quantitative importance of the coinsurance rate we consider three alternative designs of the UPHI system without private insurance options, one with a low 25 percent coinsurance rate, one with the current Medicare coinsurance rate of 30 percent and finally a less generous program with a high 75 percent coinsurance rate. The results of these experiments are shown in panel [A] of Table 5. Comparing the columns of panel [A] highlights the fiscal effects of UPHI systems at different levels of generosity. A UPHI with a 25 percent coinsurance rate requires a large increase in income tax revenue of 58 percent. Conversely, a less generous UPHI system with a 75 percent coinsurance rate requires a much lower income tax revenue increase of 9.6 percent. This difference indicates that a higher coinsurance rate effectively reduces the fiscal burden of expanding Medicare into a UPHI system.

Crowding out effect. We next examine a UPHI system in which individuals also have the option to join the UPHI plan or to buy IHI or GHI plans as in the benchmark model.[40] The two columns of panel [B] in Table 5

[38] In some experiments we observe adverse selection spirals where the IHI market completely collapses. More on this later.

[39] Note that, we abstract from ex-post moral hazard issues in this exogenous health model. Jung and Tran (2016) discuss this issue in more detail in an endogenous health model.

[40] We do not model secondary insurance options where private plans can be bought in addition to public plans in order to cover certain

demonstrate the crowding out effect of UPHI on private insurance markets. At $\gamma^{\text{UPHI}} = 0.25$ the coinsurance rate of UPHI is lower than the coinsurance rates of IHI ($\gamma^{\text{IHI}} = 0.45$) and GHI ($\gamma^{\text{GHI}} = 0.31$). In this case an individual in the model trivially chooses the UPHI plan over any of the private plans. UPHI is fully financed by taxes and does not charge an individual premium and is thus the superior choice in our framework. We see this play out in column 1 of panel [B] of Table 5 where all workers move into the UPHI plan. This version of the program leads to welfare losses when income taxes finance the UPHI program and an increase of 55 percent in income tax revenue is required. While this generous version of the UPHI system improves risk sharing and redistribution which, on average, tends to be welfare improving, it also generates costs in terms of high taxes and lower capital accumulation as the precautionary savings motive is weakened. Overall the negative income effects dominate the positive insurance/redistribution effects so that the policy results in overall welfare losses.

The choice between public and private plans becomes more relevant once the coinsurance rate of the UPHI system exceeds the coinsurance rates offered by private health insurance companies. Individuals now have to consider whether they stay with the "free" UPHI plan or whether they buy a private insurance plan with a lower coinsurance rate and thus better health risk coverage. In our experiment a less generous UPHI system with a high coinsurance rate of 75 percent leads to a lower tax burden—income taxes in fact do not rise at all—but also less risk sharing. However, the latter is alleviated through the private health insurance markets that now coexist with UPHI. Some high risk individuals with high enough income are able to afford private health insurance and will opt out of UPHI and buy private insurance with lower coinsurance rates instead.

As shown in column 2 of panel [B] of Table 5, the private insurance markets become viable and about 56.7 percent of workers buy private GHI plans. Since IHI plans have higher coinsurance rates than GHI plans and are also not tax subsidized, IHI plans are still not viable in this scenario. In this policy setting, the government shifts some of the financial burden of medical expenditures to individuals and markets. We also observe that while overall the welfare losses disappear, this is really the result of welfare gains from low and high income households being added to welfare losses suffered by middle income households. As GHI premiums rise by over 16 percent, low risk types begin to move into the free UPHI program. In addition, some of the middle income groups that previously bought GHI follow suite and also accept the less generous UPHI plan which exposes them to higher risk. This lowers their overall welfare compared to the status quo. We also see how transfer payments have to increase by a factor of 4 as more individuals are hitting the consumption lower bound and need assistance to maintain the minimum consumption levels.

In summary, our key lesson here is that the coinsurance rate plays an important role for the overall impact of the UPHI system as it directly determines the relative size of the welfare increasing insurance effects and the welfare decreasing incentive effect. While we are able to demonstrate that it is possible to devise a UPHI system that results in welfare gains for all income groups, it is important to choose the appropriate generosity level that balances the welfare gains and losses.

4.1.2 Optimal UPHI

We next calculate the optimal UPHI coinsurance rate that balances the welfare increasing insurance effects against the welfare decreasing incentive effects and maximizes overall welfare. To do so we follow the approach used in the

types of care (e.g., alternative medicine, higher quality care such as single rooms in hospitals, etc.) or further reduce the out-of-pocket expenses.

optimal taxation literature such as Conesa, Kitao and Krueger (2009). In particular, we assume that the government maximizes the ex-ante expected lifetime utility of an individual born into the stationary equilibrium implied by the chosen coinsurance rate. More formally, the government's objective is defined as

$$\underset{\gamma^{\text{UPHI}}\in[0,1]}{\operatorname{argmax}} \int V\left(x_{j=1};\gamma^{\text{UPHI}}\right) d\Lambda\left(x_{j=1}\right).$$

Notice that the government maximizes the social welfare function over the coinsurance rate only and keeps all other fiscal policy variables unchanged except for the income tax which will adjust to clear the government budget constraint.

When implementing these policy simulations we focus on comparing competitive equilibrium outcomes across steady states. When a reform is implemented the government will typically have to chose a financing instrument to pay for the reform. We first opt for adjustments in the level of the progressive income tax without adjusting the level of tax progressivity itself. In a later section we allow for alternative financing instruments such as a flat payroll tax and a consumption tax.

In the following sections we report the benefits of providing more social health insurance via an expansion of the public pillar of the US health insurance system. When we simulate expansions of public health insurance such as the UPHI system, we assume that the coinsurance rate is set to the optimal level. Table 5 shows two UPHI cases. In column [A] we show the case where we do not allow private health insurance markets and in column [B] we show the case where individuals can chose between UPHI, GHI, and IHI. We first focus on the results from switching to an exclusive UPHI system without private insurance.

Optimal UPHI without private health insurance. Without any available private plans, all individuals opt into the "free" UPHI plans even at the relatively high optimal coinsurance rate of 53.9 percent. The estimates of optimal coinsurance rates in the literature range from 20 percent (Blomqvist 1997) to 60 percent (Feldstein and Friedman 1977; Manning and Marquis 1996). Our estimates fall within this range.

As shown in column [A] in Table 6, the labor market participation rate increases by about 4 percentage points while the average weekly hours worked decreases by 1.6 percent. The capital stock increases significantly by almost 5 percent and output increases by 4 percent. The increase in capital accumulation is partially due to more self insurance via household savings as households are forced to switch more generous private GHI for less generous UPHI which leaves them more exposed to health spending shocks. It should be noted that while the income tax increases by over 28 percent, the payroll tax that formerly financed Medicare is abolished. This restructuring of tax financing contributes to the increase in labor participation and the resulting growth in output.

We also observe a large increase in transfer payments that ensure a minimum consumption floor. Many individuals who were previously on Medicaid with a very low coinsurance rate are now part of the UPHI system with a much higher coinsurance rate. These individuals have now higher out-of-pocket health expenses and are more likely to hit the consumption floor limit. The same is true for individuals who were previously on Medicare or had GHI coverage.

Overall the reform results in moderate welfare gains of 0.21 percent of CEV. This is in contrast to the welfare losses of 0.96 percent of CEV that would be the result of expanding Medicare at the current coinsurance rate of 30 percent as shown in Panel [A] of Table 5 earlier. The welfare gains achieved from the optimal reform are driven by the low income group in poor health (gains of 0.13 percent of CEV) and the high income group in good health (gains of 1.23 percent of CEV). The middle income group experiences welfare losses (-0.68 and -0.46 for the sick and healthy middle income types, respectively). This result indicates that overall the welfare gains associated with the insurance effect dominate the welfare losses associated with the adverse incentive effects. We also find evidence of efficiency gains measured in terms of increases in aggregate labor, capital stock and output. One of the main reasons for the positive welfare effects is the relatively high coinsurance rate.[41]

Optimal UPHI with private health insurance options. In this section we explore the welfare benefits of a more inclusive UPHI system where individuals can choose between public or private health insurance plans. Similar to the previous section, workers again have the option to either join the UPHI plan or to buy IHI or GHI plans instead. We again solve for the optimal UPHI coinsurance rate that maximizes the welfare of a newborn household and show the results in column [B] in Table 6.

The optimal coinsurance rate in this case is lower at 49.4 percent. At this rate about 33 percent of workers decide to remain in their GHI plans and not join the less generous UPHI plan. IHI markets are not viable in this context and individuals who bought IHI plans in the benchmark economy now join the UPHI plan. The gains to output, capital stock, and aggregate consumption are comparable to the gains recorded in the model without a private insurance option in column [A] of Table 6. However, the switch to the optimal UPHI system leads to higher aggregate welfare gains of about 1.49 percent of CEV than a comparable switch in the model without any private health insurance.

First, it should not be surprising that in an environment that allows for additional insurance options, a higher level of welfare can be achieved. Second, the welfare maximizing coinsurance rate in the UPHI is set lower than in the case without private insurance, as the government now factors in the welfare effects of crowding-out private health insurance markets. As the government sets the optimal coinsurance rate it trades off the positive insurance effects against the costs of offering more generous insurance. Whereas before (i.e., in the absence of any private health insurance) a one percentage point decrease in the UPHI coinsurance rate would strongly increase the required tax revenue by about 1.0 percent of the aggregate health spending of all individuals in the economy, a one percent increase of the UPHI coinsurance rate in the presence of private health insurance would only increase the tax burden by a fraction of 1.0 percent of the aggregate health spending because only 67 percent of working age individuals are part of UPHI. The required increase in tax revenue is now "only" 14 percent compared to 28 percent in the model without any private insurance.

Given the smaller footprint of the program—despite the more generous coinsurance rate the program is smaller because not everybody signed up for UPHI—and the associated positive income effects, welfare gains are now observed across all income groups. Still, the largest welfare gains are observed among the sicker low income types and the healthy high income types. Interestingly, allowing for private health insurance plans overturns the negative welfare outcomes of the middle income group (compare column [A] with column [B] in Table 6).

4.2 Expansion of private health insurance plans with premium subsidies

We next focus on the second pillar of the US health insurance system, private health insurance. In the US premiums for employer provided group health insurance (GHI) plans are tax deductible. However, GHI plans are currently

[41] As we have seen in Panel [A] of Table 5 in Section 4.1.1, a UPHI expansion with lower coinsurance rates such as 25 percent would be very expensive, require high taxes and result in large output and welfare losses. This is also true for a UPHI system with the current Medicare coinsurance rate of 30 percent.

not uniformly offered to all workers. For instance, high income individuals are much more likely to be paired with employers that offer group rated health insurance than individuals in the low income group as we can see from the GHI offer rates in Figure 3.

Jeske and Kitao (2009) show that the tax deductibility of GHI premiums is vital for attracting healthy and high income individuals into the GHI market, which subsequently improves risk sharing and voluntary cross-subsidizing of health expenditure risk within the insurance pool. In this section we explore whether the government can exploit this mechanism further in order to improve the social insurance role of the US health insurance system. We specifically consider an experiment where GHI offers are made available to the entire working age population as long as they decide to work, while keeping all other options including IHI, Medicaid and Medicare in the model. The key to the subsidy is that premiums of GHI are tax deductible and group rated while premiums of IHI are not. We report the results of making GHI available to all workers in column [C] of Table 6 and Figure 6.

Extending the availability of GHI has a direct impact on the take-up rates in the private health insurance markets. We observe a large increase in the take-up rate of GHI from 61.6 percent of workers to about 91.4 percent as shown in Table 6. The new take-up comprises primarily previously uninsured individuals and to a lesser extent individuals who have been insured by IHI plans or Medicaid in the benchmark economy. The IHI market essentially collapses, while about 1.4 percent of workers move from Medicaid to GHI plans. The latter is a result of small changes in the income distribution and the resulting shifts in eligibility for Medicaid for some groups.

This result confirms that the premium subsidy via tax deductions helps mitigate the adverse selection issue in private insurance markets and increases the health insurance take-up of workers in the US. However, this market-based approach is not capable of insuring all workers. About 3.5 percent of workers still choose not to buy health insurance despite the fact that GHI premiums are now lower. This is the result of some lower risk types who previously where not offered GHI are now entering the GHI pool. This also benefits the existing members of the GHI pool.

The expansion of the GHI insurance market also leads to an increase in the labor force participation and an overall decrease in income tax revenue. The former is mainly due to the link between GHI offer and employment status; meanwhile, the latter is partially a reaction to the now smaller Medicaid program which reduces the financing needs of the government. In addition, since a higher percentage is now covered by health insurance, fewer workers will hit the consumption lower bound so that transfer payments decrease by almost 36 percent. This also reduces the financing need of the government.

In terms of welfare we can see that the reform benefits the low income individuals in poor health the most. We calculate welfare gains of about 0.22 percent of CEV. Higher income individuals benefit much less or do not benefit at all. These findings highlight that improvements in the welfare benefits of the US health insurance system can be achieved via expanding the GHI insurance market.

4.3 Sensitivity analysis

In this section we conduct robustness and sensitivity experiments to support our main results.

4.3.1 Alternative tax financing instruments

Panels [B.1] and [B.2] in Table 7 show how the choice of an alternative tax financing instrument affects the outcomes of introducing a UPHI system with private health insurance options kept in place. The UPHI coinsurance rate is set at either the low level of $\gamma^{\text{UPHI}} = 25\%$, the high level of $\gamma^{\text{UPHI}} = 75\%$, or the optimal level.

In panel [B.1] we show the results of financing the UPHI system with a payroll tax similar to the current Medicare payroll tax. In this case the optimal coinsurance rate for UPHI is 57.8 percent and the reform results in welfare gains of 0.8 percent of CEV. This is smaller than the welfare gains that were achieved when UPHI was financed by the progressive income tax that we discussed in the previous section (compare panel [B] in Table 6). The payroll tax would have to be 0.88 percent, which is actually lower than the Medicare payroll tax under current US law. The reason why a lower payroll tax can finance the entire UPHI system is that the UPHI coinsurance rate is much higher than the Medicare coinsurance rate of 30 percent in the benchmark model.

The changes to the aggregate variables output, capital, and consumption are larger than the changes in the income tax case. This is a direct effect of the less generous UPHI insurance and the stronger precautionary motive. Overall the payroll tax turns out to be more distorting than the more targeted progressive income tax (which disproportionally targets higher income groups) and the government therefore chooses a less generous UPHI program in the optimum to alleviate the tax distortions. The lower generosity of the system directly translates into smaller welfare gains, especially for middle income workers who previously bought GHI. We clearly see that GHI premiums increase massively compared to the case where the progressive income tax adjusts to finance the UPHI system.

If, on the other hand, the government adjusts the consumption tax rate to finance the UPHI system, we observe large differences to our earlier results. This, of course, has to do with the nature of the tax that does not directly target income or labor income. As such, increases in consumption taxes are felt less in the production sector since labor markets are not directly affected. In addition, the switch to the UPHI system goes hand in hand with abolishing the old Medicare payroll tax, a change that also incentivizes work. From panel [B.2] in Table 7 we see that the less distortive consumption tax allows the government to implement a more generous UPHI system with an optimal coinsurance rate of 42.6 percent which is closer to the 30 percent effective coinsurance rate of Medicare according to MEPS data. However, the lower optimal coinsurance rate leads to even more crowding out and only 9.7 percent of workers remain in GHI plans.

The consumption tax needs to increase from 5 to 11.3 percent to finance the UPHI system which then results in overall welfare gains of 2.73 percent of CEV which are much larger than the gains in the earlier tax regimes. In addition, the more generous UPHI system weakens the precautionary savings motive and the growth of capital stock is less than under the other tax regimes.

In summary, the findings from this section reveal that if the government chooses less distortive financing instruments, it can maintain a more generous UPHI system and achieve larger welfare gains.

4.3.2 Risk aversion and labor elasticity

We next assess the robustness of our results with respect to changes in the Frisch elasticity of labor supply. In our benchmark model the Frisch elasticity is given by expression 15. We now revisit the UPHI experiment without private health insurance markets (compare column [A] in Table 6) but choose alternative parameter values for the preference weight on consumption η (i.e., 0.27 and 0.28 instead of the benchmark value of $\eta = 0.275$) and the risk aversion parameter σ (i.e., 2.5 and 3.5 instead of the benchmark value of $\sigma = 3$). We recalibrate the model by adjusting the discount factor β so that the model exhibits the benchmark capital output ratio of 3 again. We then again solve for the optimal UPHI coinsurance rate as in section 4.1.2 and implement the UPHI system with this optimal coinsurance rate. Table 8 shows the results of the UPHI experiment using these alternative parameter specifications.

We find that the variations in the preference parameters η do barely affect our results. Qualitatively the results are identical and quantitatively the optimal coinsurance rate changes by about 2 percentage points and the aggregate welfare gains change from 0.21 percent of CEV in the benchmark to 0.33 percent if η is lowered from 0.275 to 0.270. Increasing the value of η by the same magnitude leads to even smaller deviations from the benchmark values.

Making individuals less risk averse by lowering parameter σ from 3.0 to 2.5 also do not change the main conclusions qualitatively. However, quantitatively we find that as individuals are less risk averse the optimal UPHI coinsurance rate can be set higher which leads to a smaller tax burden. The government is able to increase the optimal coinsurance rate from 53.9 percent to 62.0 percent and welfare gains increase by about half a percent of CEV. On the flip side, if we make individuals more risk averse by increasing parameter σ from 3 to 3.5, the government's optimal response is to make the UPHI more generous and lower the coinsurance rate from 53.9 to 50.6 percent. The aggregate welfare gains in this case are very close to the welfare gains from our benchmark calibration as can be seen from the last column in Table 8.

4.4 Additional experiments

4.4.1 Extending Medicare to older workers

While sweeping reform proposals such as a switch to Medicare-for-all have been discussed in the public sphere quite prominently, ideas for more incremental expansions of public health insurance have been introduced as well.[42] In the following experiments we address one such idea and instead of allowing all workers to participate in Medicare, we compute the effects of an expansion of the eligibility age for Medicare from currently 65 to 60 and in a follow up experiment from age 65 to 50. In both cases we keep the Medicare coinsurance rate at its current level of 30 percent. Workers also still have access to both types of private health insurance. In order to clear the government budget we again adjust either the progressive income tax (scaling it up or down using parameter τ_0^i while maintaining the level of progressivity of the income tax system), a flat payroll tax τ^{Mcare}, or the consumption tax τ^c. The results of these experiments are reported in Table 9 and Figure 7.

Health insurance. In this experiment the private insurance markets are not able to compete with the more attractive Medicare offers for older workers between age 50–64 who are exposed to higher health risk. Medicare eligible older workers will no longer participate in the IHI and GHI markets and move into Medicare as is demonstrated in Figure 7. This is true across all permanent income types. As this older and therefore higher risk cohort leaves the private health insurance markets, the remaining pool of workers are of lower risk and premiums in private markets decrease by almost 40 percent, in both the IHI and GHI markets. However, the small increase in private insurance take-up of workers aged 20–49 due to lower premiums, is not enough to compensate for the "lost" group of 50–64 year old who moved into Medicare, so that overall the share of privately insured individual decreases significantly. Medicare as a public option crowds out private IHI and GHI markets as shown in the first block of Table 9 and across all panels in Figure 7. The net effect of insurance coverage of workers is positive and more workers are insured in the new steady state as a results of the Medicare expansion.

[42] A very recent proposal by Senator Debbie Stabenow (D-MI) and other Senate Democrats has revived the idea of a Medicare buy-in at subsidized premiums for individuals aged 50–64. Compare the Medicare at 50 Act (2019–2020) available at: https://www.congress.gov/bill/116th-congress/senate-bill/470.

Offering a Medicare buy-in at the current Medicare premium level essentially charges a price below the actuarially fair price as Medicare premiums are in a sense subsidized by payroll taxes. As such the Medicare buy-in option in our model eliminates any adverse selection issue for the eligible age groups and we observe a complete buy-in of the entire eligible age cohort. In other words, Medicare is the preferred option for the group of newly eligible older workers as in our model it can be bought at a price below the actuarially fair premium. This price is also lower than any of the premiums charged by the two private health insurance programs. This result is also in line with Hansen, Hsu and Lee (2014) who demonstrate that the Medicare buy-in only becomes viable if Medicare is subsidized sufficiently.[43] The only way to entice workers in our setup to still buy private health insurance would be to either make Medicare less attractive (e.g., increase Medicare premiums, reduce the generosity of Medicare with higher coinsurance rates, etc.) or make private health insurance more attractive (e.g., increase the subsidies for private health insurance markets).

Aggregates. Medicare eligible workers chose the Medicare option, including the ones previously on Medicaid as Medicare is going to be free for them. Since unlike Medicaid, Medicare is not tied to an income test, the expansion of Medicare removes the adverse work incentives of Medicaid. This in return encourages older workers to be more active in the labor market. We observe small increases in the labor force participation rate as can be seen across all experiments of Table 9. Also, while overall hours worked decrease slightly, the hours worked of the population older than 50 increase.

On the other hand, the expansion of Medicare to age 50 leads to decreases in capital accumulation due to higher income or payroll taxes. From columns [D.1] and [D.2] of Table 9 we clearly see how the capital stock decreases when either the progressive income tax or the flat payroll tax adjust to finance the Medicare expansion. However, the adverse effects on the capital stock do not manifest in column [D.3] which reports the identical experiment but with a consumption tax financing the reform. We also see that if the expansion of Medicare is large and includes everybody from age 50 and older, then the financing needs are larger and the tax distortions become more pronounced. Output losses are therefore more severe in the columns reporting large expansions as opposed to the more moderate expansion that only includes everybody from age 60 an up.

In fact, if Medicare is expanded moderately to include everyone from age 60 onward, we even observe very small increases in output. This is true across all three financing options. In general, when the consumption tax adjusts to clear the government budget the aggregate effects tend to be positive, i.e., increases in capital and output, as this tax is the least distortive financing option (compare column [D.3] of Table 9).

In terms of fiscal cost, the small expansion of Medicare—age 60 an up—requires either an increase in income tax revenue from the progressive income tax of 4.6 percent, a payroll tax increase from 2.9 to 3.6 percent, or a consumption tax increase from 5 to 5.9 percent. A large expansion of Medicare—age 50 and up—requires a large increase of 15 percent of additional income tax revenue, or an increase in payroll taxes from 2.9 to 5.3 percent, or an increase in consumption taxes from 5 percent to 8.3 percent.

Welfare. The small expansion of Medicare to the age of 60 leads to overall welfare gains of 0.28 to 0.46 percent of CEV depending on which tax is used to finance the reform (compare the Welfare in CEV row across columns [D.1]–[D.3] in Table 9). While we observe welfare gains across all income and health types, these gains are larger

[43] Hansen, Hsu and Lee (2014) show that adverse selection is so severe that an unsubsidized Medicare buy-in market for older workers would not be viable in a model where Medicare premiums alone would finance the expansion. Differently from their setup where the reform is financed by group based premiums that essentially make the expansion self-financed, our Medicare expansion is financed by taxes and the Medicare premiums are kept at current levels. This makes it similar to their subsidized version of a Medicare buy-in program that is a viable option.

for higher income individuals. One explanation is that higher income individuals are more likely to benefit from lower private insurance premiums which more than compensates them for the higher taxes they are charged.

If we further expand the eligibility age for Medicare to age 50, we find even larger welfare gains between 0.38 to 1.41 percent of CEV. A larger Medicare program leads to even more crowding-out of private health insurance markets. As a result private health insurance premiums decrease even further as Medicare siphons off the older (and higher risk) types from the pool of privately insured individuals. What is different in this case though is that the main source of welfare gains can be attributed to the lower income groups. This is not surprising. First, as private health insurance premiums drop even further, some of the middle and lower income individuals are able to purchase private health insurance. On the flip side, higher income individuals are more heavily hit by the higher taxes. We clearly see that if the progressive income tax or the payroll tax is used as a financing instrument, the welfare gains of the high income group do not change and even slightly decrease (if payroll taxes are used) as the Medicare program expands further and includes everybody from age 50 and up.

This result suggests that under the current health insurance regulations, Medicare expansions to some older worker groups is welfare improving. The presented reforms result in a more effective trade-off between the welfare gains of high income groups who benefit from lower private health insurance premiums (as higher risk older workers move into Medicare) and the welfare losses caused by higher taxes. When the payroll tax is used to finance the expansion of the Medicare eligibility age the welfare effects are very similar (see columns [D.2] of Table 9). However, when the consumption tax is used instead (see columns [D.3] of Table 9) the positive welfare outcomes are much larger. The reason is that the consumption tax is less distortive and results in lower financing costs.

Thus, lowering the age threshold of Medicare eligibility improves risk sharing and leads to welfare gains across all income groups in the long-run.[44] We notice that as the size of the Medicare program grows, the taxes needed to finance the program need to increase which causes more severe fiscal distortions. This observation raises the question whether there is a limit to the expansion beyond which the fiscal distortions become so severe that they overpower the positive welfare effects from risk pooling and redistribution so that the reform results in overall welfare losses. In the next section discusses some of these issues.

4.4.2 GHI for all with no public option

We finally consider an alternative design of a GHI expansion. Specifically, we allow for all individuals to have access to both the IHI and GHI markets while both Medicare and Medicaid are removed from the model. This experiment is equivalent to a full privatization of the US health insurance system. In this experiment all retirees will be offered GHI plans. If they decide to purchase a GHI plan, the group rated premium is income tax deductible. If they decide to buy an IHI plan, the premium is not tax deductible and will also depend on their health state and age.

We find that unlike the UPHI system from the previous sections, this pure private health insurance system fails to provide universal coverage (see Table 10 and Figure 8) and also falls short in providing as much coverage as the mixed system where Medicare and Medicaid is kept in place but the GHI offers are expanded to all working age individuals (compare column [C] in Table 6). About 11 percent of workers remain uninsured and about 9 percent

[44] These results are somewhat similar to studies on social insurance using dynamic general equilibrium models. Hansen and Imrohoroglu (1992) for instance report that the introduction of a targeted unemployment insurance program results in welfare gains. More recently, Braun, Kopecky and Koreshkova (2017) demonstrate the welfare benefits of means-tested social insurance programs.

of retirees remain uninsured. As more of the retirees move into GHI plans, premiums in GHI markets increase dramatically by over 53 percent. However, removing public health insurance from the US mixed health insurance system results in large growth effects due to two main reasons. First, taxes can be lowered significantly as the government has fewer programs to finance and in fact income tax revenue decreases by 27 percent. Second, capital accumulation increases as individuals rely more on self insurance. Without Medicare, the older generation ends up with higher health spending risk and higher health insurance premiums. This leads to higher capital accumulation. In addition, without Medicaid workers have a stronger work incentive which generates additional growth effects. GDP grows by almost 4 percent in this scenario.

Taken all this together we see that despite the large growth in GHI premiums individuals are actually able and willing to buy the more expensive plans. The tax deductibility of GHI plans is of course an additional factor that makes this type of plan attractive. Similarly, we find that workers pick up more of the IHI plans, especially the young workers below age 30 so that average premiums in IHI markets drop. On the flip side, IHI markets are not viable for the older population. They are not group rated and their premiums are simply too high to be attractive, especially compared with GHI plans that we assume are universally available to all retirees. Therefore, individual private health insurance markets collapse due to adverse selection for individuals older than 65.

Overall, welfare gains from removing fiscal distortions (from shutting down Medicare and Medicaid and associated taxes) and aggregate efficiency gains dominate welfare losses due to lack of insurance and risk sharing. The income effects are so strong that welfare outcomes are positive for all income groups, even the low income groups that loses insurance via Medicaid.

This result is similar to findings in Conesa et al. (2018). They calculate that abolishing Medicare leads to large output growth effects and subsequent welfare gains when comparing across steady states. Once they factor in transitions, however, abolishing Medicare leads to welfare losses.

Finally, this result is also related to a classic result from the social security literature that uses dynamic general equilibrium models to analyze reforms of the US pay-as-you-go (PAYG) social security system (e.g., İmrohoroğlu, İmrohoroğlu and Joines 1995; Conesa and Krueger 1999; Fuster, Imrohoroglu and Imrohoroglu 2007). This literature consistently finds positive welfare effects after removing the PAYG pension system. The logic is that the general equilibrium channels magnify the adverse effects of PAYG social security on incentives and aggregate efficiency losses. A similar mechanism is at work in our steady state analysis using an exogenous health expenditure model.

5 Conclusions

We build a dynamic general equilibrium model with a healthcare sector and study the implications of alternative approaches to insuring health risk over the lifecycle. We specifically quantify the welfare benefits of several healthcare reforms that alter the degree of government involvement in the US health insurance system such as: (i) the provision of more public health insurance by expanding Medicare to all workers and (ii) the provision of more regulated and premium-subsidized private health insurance by expanding GHI offers to all workers. Our results highlight a number of policy reforms that can strengthen the social insurance channels of the existing US health insurance system.

First, extending Medicare to include all workers, i.e. universal public health insurance (UPHI), can be welfare improving if the coinsurance rate is set sufficiently high. At current Medicare coinsurance rates, the universal expansion of Medicare would lead to overall welfare losses. The coinsurance rate plays an important role in balancing the positive insurance and redistribution effects with the negative incentive effects. Solving for optimal coinsurance rates that maximize the expected lifetime utility of a newborn individual we show that a UPHI system with an optimally chosen coinsurance rate leads to significant overall welfare gains. However, these welfare outcomes are not homogeneous across household types. Low income households benefit more from the UPHI system than high income households. Embedding private health insurance options into the UPHI health insurance system can further reduce fiscal distortions and result in additional welfare gains.

Second, making GHI insurance accessible to all workers also improves the social insurance role of the US system as the tax deductibility of GHI premiums fosters (voluntary) cross-subsidizing of health risk between low and high risk types. Finally, lowering the Medicare eligibility age to include older workers in their 50s and 60s insures more workers and is welfare improving.

Several modeling extensions are possible and left for future work. The optimality of insurance contracts is currently restricted to the analysis of a single policy instrument (i.e., coinsurance rates with a tax adjusting to balance the public insurance program). More general instruments (i.e., differential premiums, age dependent tax rates, etc.) can be investigated to describe optimal equilibrium outcomes. The large state space of the model and computational constraints prevent us from providing a description of the transition dynamics.

The main focus of this paper is on the quantitative importance of the social insurance role of the US health insurance system. However, there are other elements in our model that could potentially influence the social insurance function of the health insurance system, including high administrative costs, price markups due to inefficiencies of private insurance markets, firm heterogeneity, concerns about equity in health outcomes, and other forms of social insurance provided through Social Security, minimum consumption floors and progressive taxes. We leave these issues for future research.

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Figures

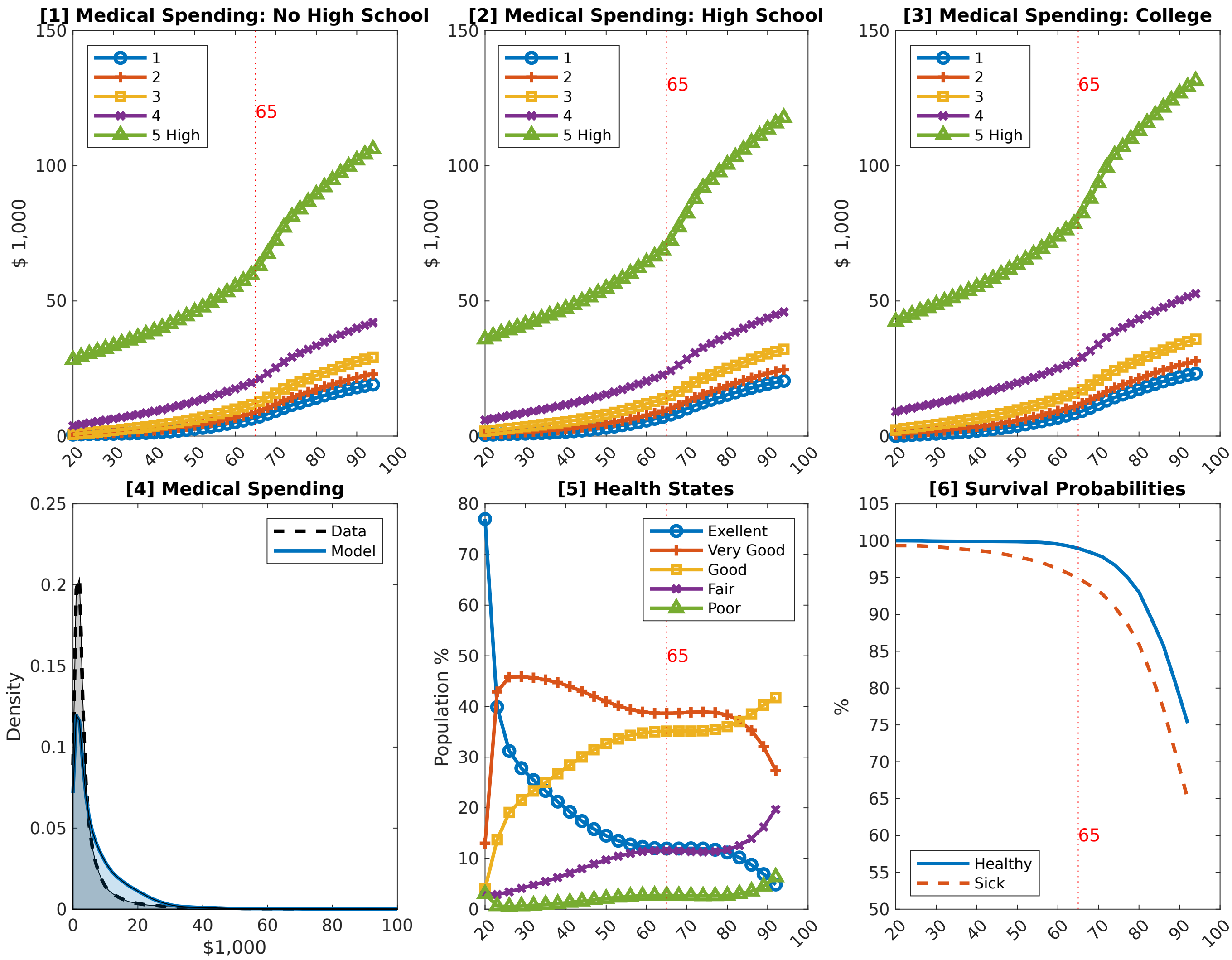

Figure 1: **Exogenous data inputs**

Notes: Healthy is defined as an individual reporting either Excellent, Very Good, or Good health. Sick is defined as Fair or Poor health. Data source is MEPS 1999–2009. The observational unit is the head of a Health Insurance Eligibility Unit (HIEU) which is a subset of a household. We apply population weights.

The survival probabilities in panel [6] are from İmrohoroğlu and Kitao (2012) who base their estimates on data from the Health and Retirement Study and life table estimates in Bell and Miller (2005).

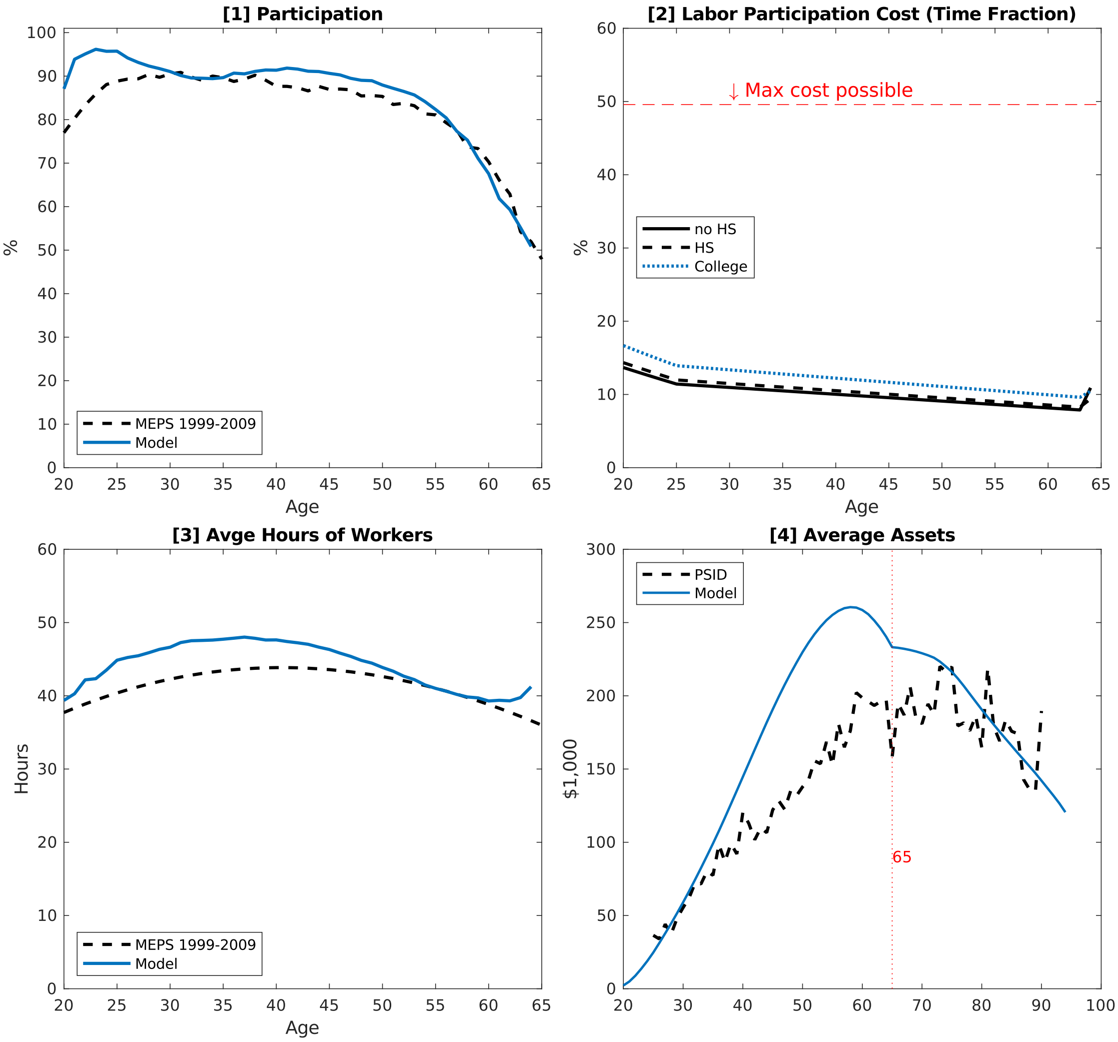

Figure 2: **Calibration targets I – labor participation and asset holdings of the old**

Notes: Panel [1] and average work hours 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] depict the model performance in terms of matching labor income profiles by permanent income group and health state.
Data source is MEPS 1999–2009, heads of HIEU, population weighted.

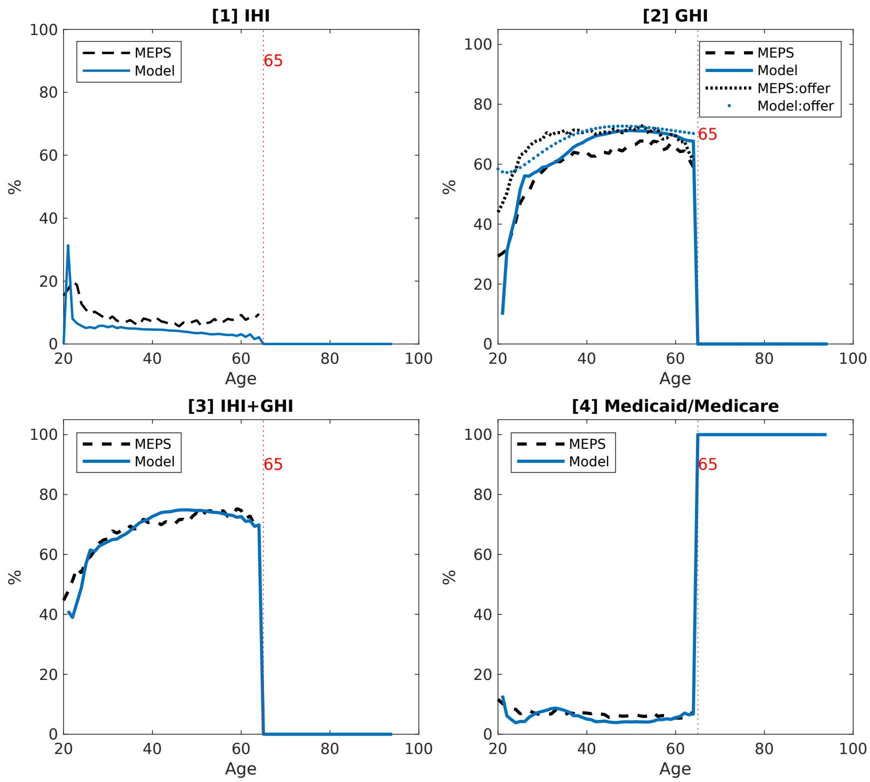

Figure 3: **Calibration targets II – insurance status**

Notes: We target GHI take-up of 25 year olds in panel 2 and Medicaid take-up in panel 4. The remaining panels are performance measures and not targets.
Data source is MEPS 1999–2009, heads of HIEU, population weighted.

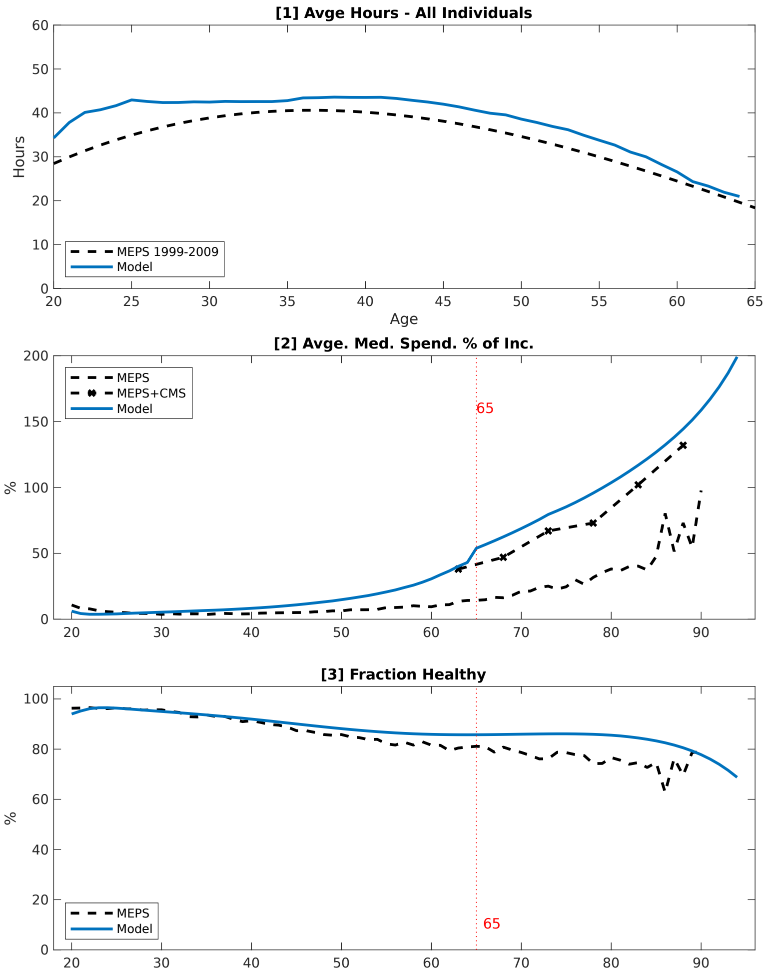

Figure 4: **Model performance I – lifecycle profiles**

Notes: These are not calibration targets. Data sources: is MEPS 1999–2009, heads of HIEU, population weighted. For asset data we use PSID 1999–2009.

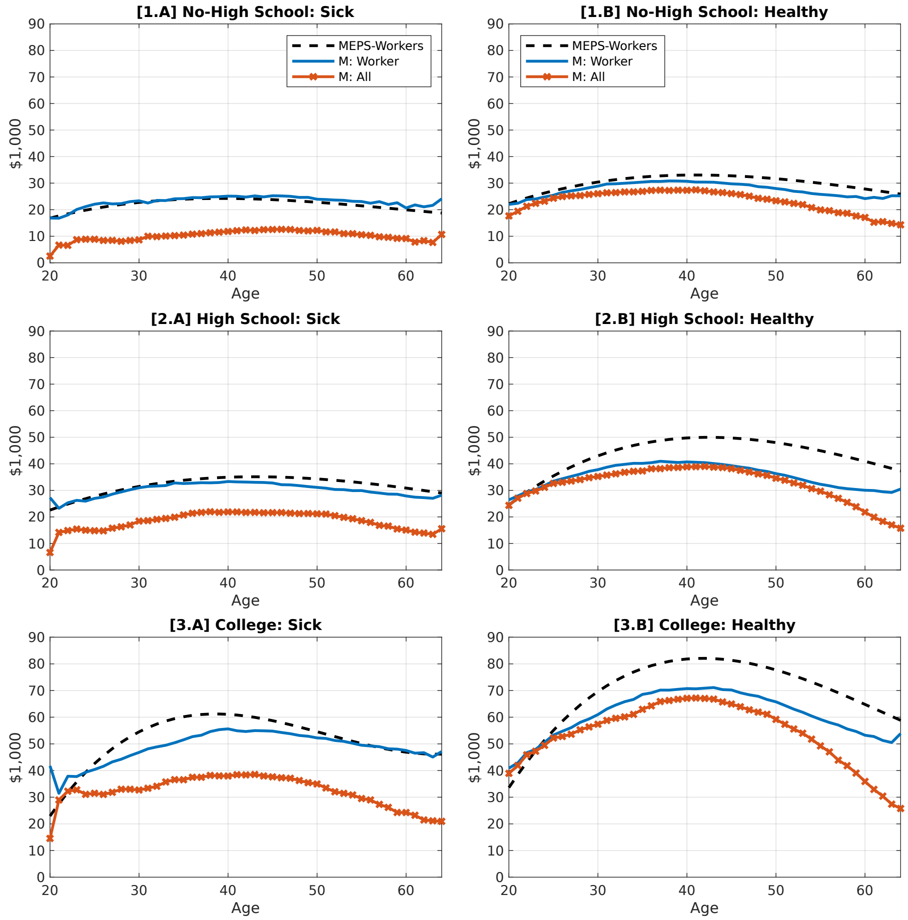

Figure 5: **Model performance II – labor income by education and health**

Notes: Cohort adjusted labor income profiles by permanent income group and health state. These are not calibration targets. Data source is MEPS 1999–2009, heads of HIEU, population weighted.

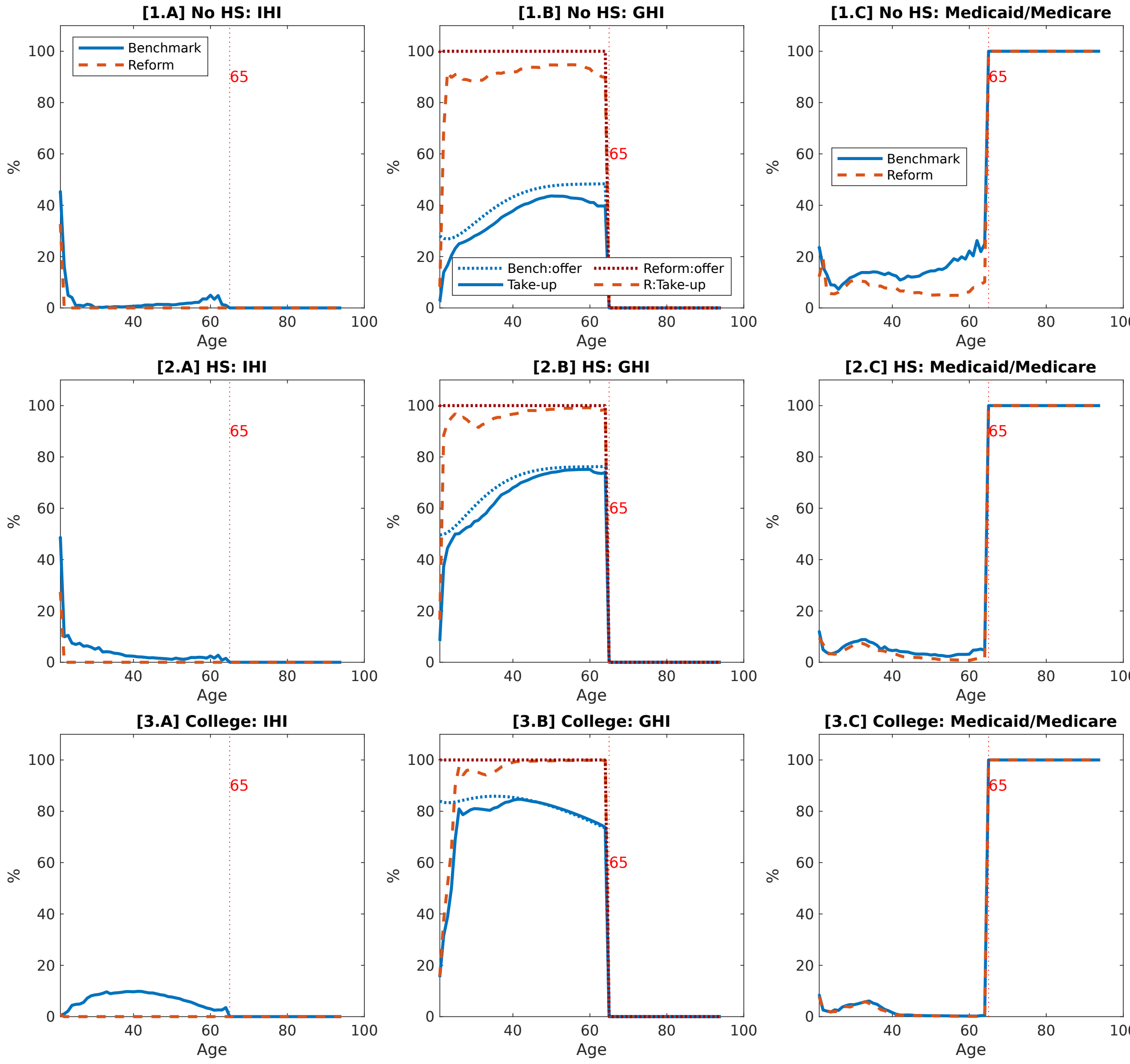

Figure 6: **Extending GHI offers to all workers**

Notes: GHI is offered to all working age individuals. The income tax adjusts to clear the government budget constraint.

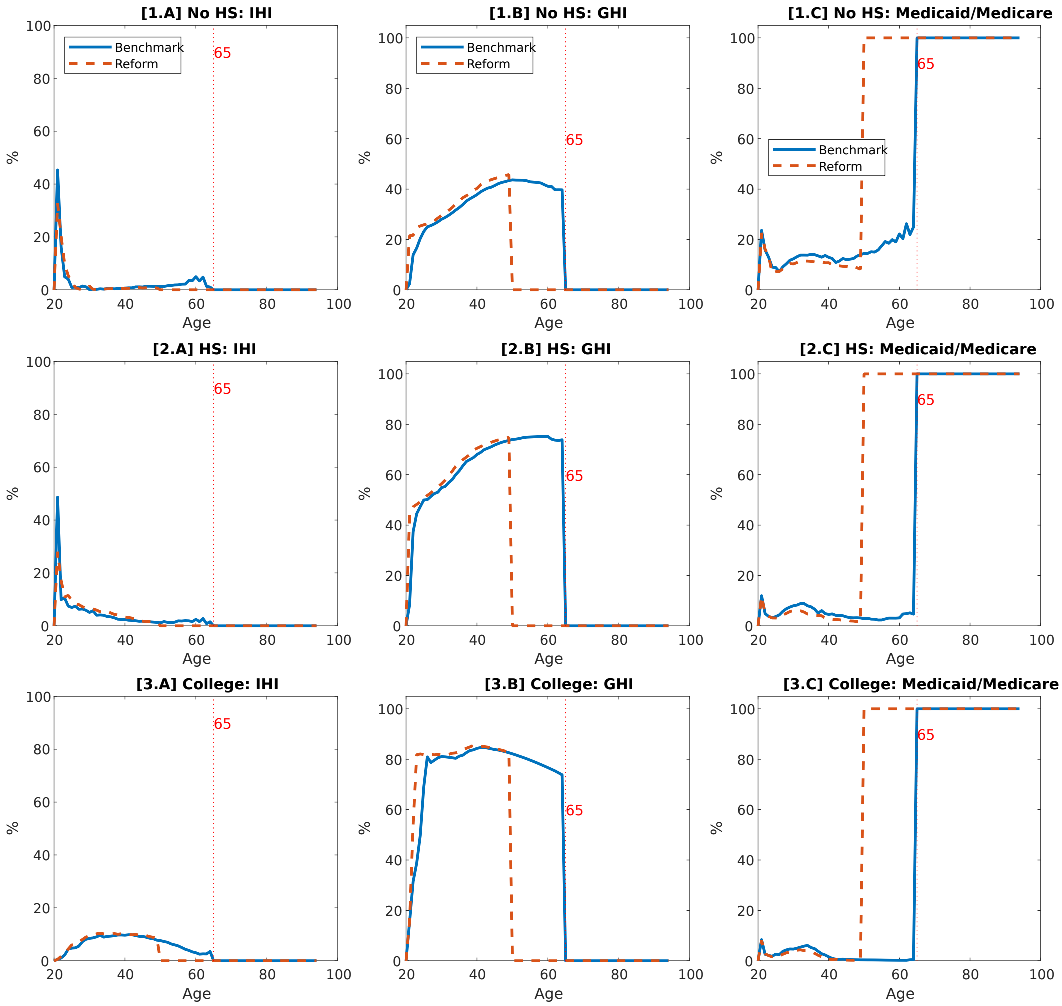

Figure 7: **Expansion of Medicare to age 50**

Notes: Expansion of Medicare eligibility age from age 65 to age 50. The income tax adjusts to clear the government budget.

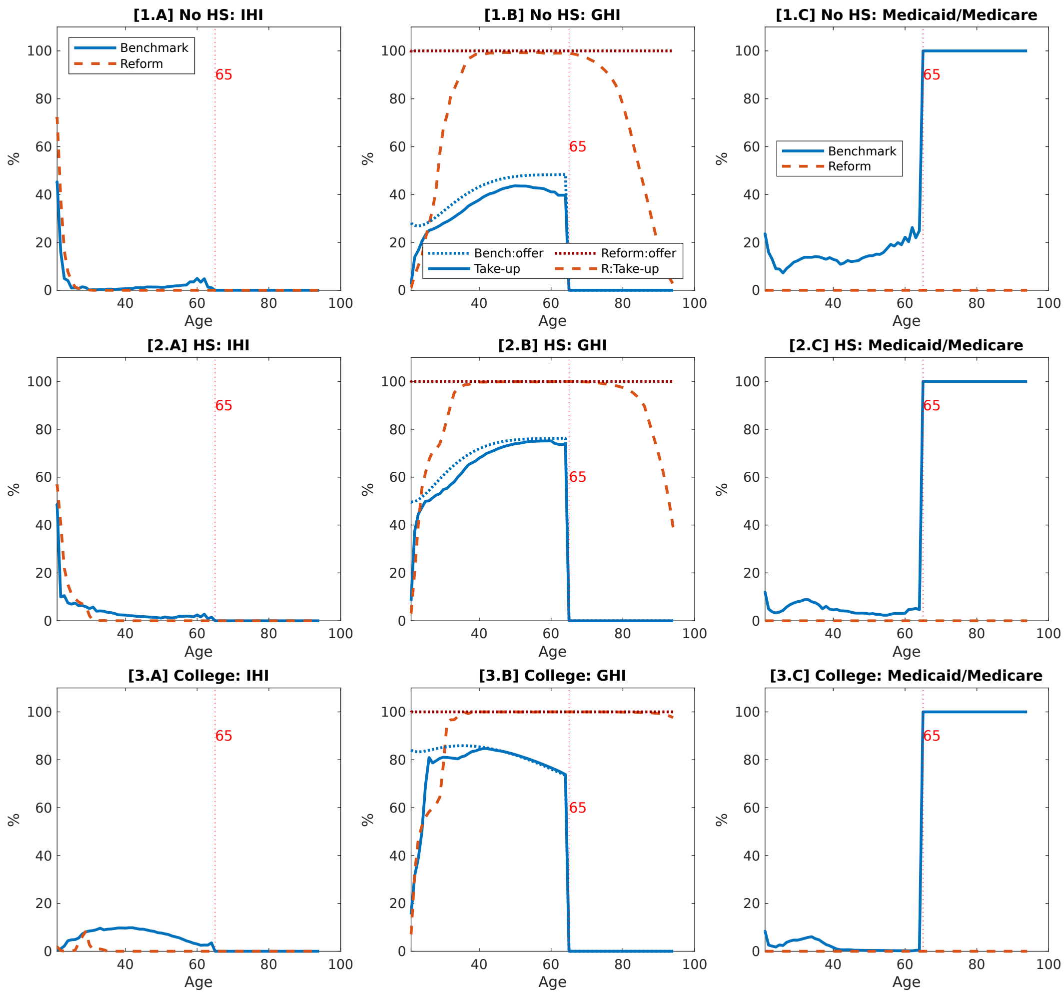

Figure 8: **Removing public health insurance and extending GHI offers to all individuals (incl. retirees)**

Notes: GHI is offered to all individuals and Medicare and Medicaid are abolished. The income tax adjusts to clear the government budget constraint.

Tables

Table 1: **External parameters**

Parameter description	Parameter values	Source
Periods	$J = 75$	
Work periods	$J^W = 45$	Age 20–64
GHI scaling cutoff age	$J^{\text{GHI}} = 6$	Age 25
Years modeled	years $= 75$	Age 20–95
Population growth rate	$n = 1.0\%$	CMS 2010
Total factor productivity	$A = 1$	Normalization
Capital share in production	$\alpha = 0.36$	Koh, Santaeulàlia-Llopis and Zheng (2020)
Capital depreciation	$\delta = 6\%$	Koh, Santaeulàlia-Llopis and Zheng (2020)
Firm share of prem$^{\text{GHI}}$	$\psi = 0.8$	Jeske and Kitao (2009)
Relative risk aversion	$\sigma = 3$	Standard values between $2.5 - 3.5$
Survival probabilities	$\pi_j\left(h\left(\varepsilon^h\right)\right)$ see online appendix	İmrohoroğlu and Kitao (2012)
Health Shocks	ε_j^m see online appendix	MEPS 1999–2009
Health transition prob.	Π_j^m see online appendix	MEPS 1999–2009
Persistent labor shock autocorrelation	$\rho = 0.977$	French (2005)
Variance of transitory labor shock	$\sigma^2_{\varepsilon_1} = 0.0141$	French (2005)
Bias adjusted wage profile	$\bar{e}_j\left(\vartheta, h\left(\varepsilon^h\right)\right)$ see online appendix	MEPS 1999–2009
Private insurance coinsurance	$\gamma^{\text{IHI}} = 0.45$, $\gamma^{\text{GHI}} = 0.31$	MEPS 1999–2009
Medicaid coinsurance	$\gamma^{\text{MAid}} = 0.11$	MEPS 1999–2009
Medicare coinsurance	$\gamma^{\text{MCare}} = 0.30$	MEPS 1999–2009
Consumption tax	$\tau^C = 5\%$	IRS
Bequest tax	$\tau^{\text{Beq}} = 20\%$	De Nardi and Yang (2014)
Bequest parameter	$\theta_2 = \$500,000$	De Nardi (2004); French (2005)
Payroll tax Social Security	$\tau^{\text{SS}} = 10.6\%$	IRS
Payroll tax Medicare	$\tau^{\text{MCare}} = 2.9\%$	SSA (2007)
Government consumption/Y	$C_G/Y = 15\%$	BEA 2009
Tax progressivity parameter	$\tau_1^i = 0.053$	Guner, Lopez-Daneri and Ventura (2016)
Pension progressivity parameter	$a_1 = 0.567$	SSA 2010

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

Table 2: **Group size of permanent income groups by health state**

Moments	Model=Data
Sick-No High School	5.1%
Sick-High School	6.1%
Sick-College	1.4%
Healthy-No High School	16.2%
Healthy-High School	47.9%
Healthy-College	23.4%

Notes: Weighted data from MEPS 1999–2009. Sick are individuals who report having fair or poor health. Healthy are individuals who report excellent, very good, and good health.

Table 3: **Internal (calibrated) parameters**

Parameters	Values	Calibration target	Model	Data	Source
Discount factor	$\beta = 0.99$	$\frac{K}{Y}$	3	3	Standard value
Pension scale parameter	$a_0 = 0.34$	Size of Social Security$/Y$	5.0%	5%	OMB 2008
Fixed time cost of labor	$\bar{n_j}$ Fig. 2	Labor participation by age	Panel 1, Fig. 2	Panel 1, Fig. 2	MEPS 1999–2009
Pref. cons. vs. leisure	$\eta = 0.275$	Avge. work hours workers	Panel 3, Fig. 2	Panel 3, Fig. 2	MEPS 1999–2009
Bequest parameter	θ_1	Asset holding of old	Panel 4, Fig. 2	Panel 4, Fig. 2	PSID 1999–2009
GHI prem. scaling	$\phi^{\text{GHI}} = 0.75$	GHI take-up of 25 year olds	Panel 2, Fig. 3	Panel 2, Fig. 3	MEPS 1999–2009
Medicaid asset test	$\bar{a}^{\text{MAid}} = \$75,000$	Workers age 40–64 on Medicaid	Panel 4, Fig. 3	Panel 4, Fig. 3	MEPS 1999–2009
Medicaid income test	$\bar{y}^{\text{MAid}} = \$5,500$	Workers age 20–39 on Medicaid	Panel 4, Fig. 3	Panel 4, Fig. 3	MEPS 1999–2009
Consumption floor	$c_{\min} = \$3,200$	Frac. net-assets<USD 5,000	20%	20%	Jeske and Kitao (2009)

Notes: We choose internal parameters so that model generated data matches data from MEPS, CMS, and NIPA.

Table 4: **Model performance**

Moments	Model	Data	Source
Medical expenses$/Y$	16.5%	17.3%	CMS communication
Gini medical spending	0.57	0.60	MEPS 1999–2009
Interest rate: r	5.8%	$5.2-5.9\%$	Gomme, Ravikumar and Rupert (2011)
Size of Medicare$/Y$	5.5%	$4.4\%\,(3.47\%)^{*}$	NHEA (2010)
Size of Medicaid$/Y$	0.68%	$1.7\%\,(2.65\%)^{**}$	NHEA (2010)

Notes: These are not calibration targets.

* We do not distinguish between Medicare and Medicaid for the population older than 65. We therefore compare the size of Medicare in the model to the spending of Medicare plus Medicaid on individuals older than 65 to capture the out-of-pocket spending of the older generation more realistically without explicitly modeling Medicaid past the age of 65. Aggregate Medicare spending in 2010 was approximately 3.47 percent of GDP. More details are provided in Section 3.8.

** Medicaid in the model refers to the portion of Medicaid that targets the working age population. Aggregate Medicaid payments for individuals younger than 65 in 2010 was approximately 1.7 percent of GDP. More details are provided in Section 3.8.

Table 5: **Expansion of public health insurance: UPHI**

	Bench.	Experiments				
		[A] UPHI only γ^{UPHI}			**[B] UPHI + IHI & GHI** γ^{UPHI}	
		Low 25%	Medicare rate 30%	High 75%	Low 25%	High 75%
Insured workers (%)	72.62	100	100	100	100	100
• IHI (%)	5.25	0	0	0	0	0.01
• GHI (%)	61.58	0	0	0	0	56.72
• Medicare (%)	5.79	0	0	0	0	43.26
Insured retirees						
• Medicare (%)	100	100	100	100	100	100
Avge. GHI premiums	100	NA	NA	NA	NA	116.41
Output (Y)	100	94.36	96.30	109.06	94.40	107.99
Capital (K)	100	88.49	91.66	114.37	88.53	113.51
Consumption (C)	100	95.98	97.80	108.27	95.98	107.44
Labor participation rate (%)	71.26	72.07	73.03	75.38	72.09	76.41
Weekly hours	100	97.04	97.13	98.16	99.06	98.63
Wages	100	96.55	97.32	102.65	96.55	102.83
Income tax revenue	100	**157.97**	**120.13**	**109.57**	**155.02**	**97.79**
Payroll tax rate (%)	2.9	0	0	0	0	0
c_{min} transfers	100	41.35	54.76	619.14	42.67	530.82
Welfare in CEV (%)	0	-1.59	-0.96	-0.31	-1.64	+0.43

Notes: This table presents the effects of introducing a UPHI system with and without private health insurance as well as an expansion of private GHI to all workers. The UPHI coinsurance rate is set at either the low level of $\gamma^{\text{UPHI}} = 25\%$, the current Medicare level $\gamma^{\text{UPHI}} = \gamma^{\text{MCare}} = 30\%$, or the high level of $\gamma^{\text{UPHI}} = 75\%$. The progressive income tax adjusts to balance the government budget constraint in all cases. The Medicare payroll tax is abolished when the system switches to UPHI so that all the additional financing comes through the income tax.

Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are indexed to normalized values of the benchmark case. Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual.

Table 6: **Expansion of public health insurance**

	Bench.	**Experiments**		
		[A] Opt. UPHI $\gamma^{\text{UPHI}}_{\text{opt}} = 53.9\%$	**[B] Opt. UPHI + IHI & GHI** $\gamma^{\textbf{UPHI}}_{\textbf{opt}} = 49.4\%$	**[C] GHI expansion** $\gamma^{\text{Mcare}} = 30\%$ & $\gamma^{\text{GHI}} = 31\%$
Insured workers (%)	72.62	100	100	96.48
• IHI (%)	5.25	0	0	0.77
• GHI (%)	61.58	0	33.02	91.36
• Medicaid/Medicare (%)	5.79	0	66.98	4.35
Insured retirees				
• Medicare (%)	100	100	100	100
Avge. GHI premiums	100	NA	150.90	95.12
Output (Y)	100	104.14	103.53	97.74
Capital (K)	100	105.35	105.04	99.58
Consumption (C)	100	104.37	104.47	99.80
Labor participation rate (%)	71.26	75.60	75.73	72.36
Weekly hours	100	98.41	97.78	98.79
Wages	100	100.62	100.08	99.90
Income tax revenue	100	127.75	114.06	98.47
Payroll tax rate (%)	2.9	0	0	2.90
$c_{\min}$ transfers	100	235.69	170.02	64.42
Welfare in CEV (%)	0	**+0.21**	**+1.49**	**+0.22**
• Income group 1–sick (%)	0	+0.13	+2.51	+1.35
• Income group 2–sick (%)	0	-0.68	+1.01	+0.47
• Income group 2–healthy (%)	0	-0.46	+1.21	+0.16
• Income group 3–healthy (%)	0	+1.23	+1.33	−0.23

Notes: This table presents the effects of introducing a UPHI system with and without private health insurance, [A] and [B] respectively, as well as an expansion of private GHI to all workers [C]. The coinsurance rate for public insurance is set at the optimal level $\gamma^{\text{UPHI}}_{\text{opt}}$ in the two UPHI regimes. The progressive income tax adjusts to balance the government budget constraint in all cases. The Medicare payroll tax is abolished when the system switches to UPHI so that all the additional financing comes through the income tax.

Data in rows marked with the % symbol are either fractions in percent or tax rates in percent. The other rows are indexed to normalized values of the benchmark case. Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual.

Table 7: **UPHI with private health insurance options: Alternative tax financing**

	Bench.	[B] UPHI + IHI and GHI					
		[B.1] Payroll Tax γ^{UPHI}			[B.2] Consumption Tax γ^{UPHI}		
		Low 25%	Optimal 57.82%	High 75%	Low 25%	Optimal 42.64%	High 75%
Insured workers	72.62	100	100	100	100	100	100
• IHI (%)	5.25	0	0.0	0.0	0	0	0.0
• GHI (%)	61.58	0.01	14.29	56.60	0	9.65	57.1
• Medicare (%)	5.79	99.98	85.70	43.34	100	90.35	42.9
Insured retirees							
• Medicare (%)	100	100	100	100	100	100	100
Avge. GHI premiums	100	97.96	432.32	116.27	NA	216.6	115.30
Output (Y)	100	94.44	105.25	107.76	99.88	103.83	107.34
Capital (K)	100	92.08	107.92	112.79	101.62	104.16	112.16
Consumption (C)	100	93.79	105.37	107.35	99.25	104.40	114.92
Labor participation (%)	71.26	70.10	76.90	76.44	72.46	75.27	76.96
Weekly hours	100	97.44	97.47	98.83	96.91	97.62	98.68
Wages	100	98.55	101.47	102.62	101.00	101.78	102.39
Payroll tax rate (%)	2.9	11.88	0.88	−1.06	0	0	0
Consumption tax rate (%)	5	5	5	5	21.08	11.30	3.15
Welfare in CEV (%)	0	**-2.07**	**+0.80**	**+0.27**	**+1.66**	**+2.73**	**+0.41**
• Income group 1–sick (%)	0	+0.54	+1.41	+0.40	+4.11	+3.90	+0.50
• Income group 2–sick (%)	0	−1.42	+0.06	−0.92	+2.43	+2.05	−0.83
• Income group 2–healthy (%)	0	−1.69	+0.24	−0.68	+1.85	+2.50	−0.54
• Income group 3–healthy (%)	0	−3.94	+1.22	+1.54	+0.26	+2.45	+1.66

Notes: This table presents the effects of introducing a UPHI system while leaving private IHI and GHI in the model. The UPHI coinsurance rate is set at either the low level of $\gamma^{\text{UPHI}} = 25\%$ or the high level of $\gamma^{\text{UPHI}} = 75\%$. Either aflat payroll tax or the consumption tax adjusts to balance the government budget constraint. We also solve for the optimal coinsurance rage $\gamma^{\text{UPHI}}_{\text{opt}}$ for each tax financing regime. The Medicare payroll tax is abolished when the income tax or the consumption tax are used to finance the UPHI system.
Data in rows marked with the % symbol are fractions in percent. The other rows are indexed to normalized values of the benchmark model case. Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual.

Table 8: **UPHI reforms with different preference parameters**

	[A] UPHI without private health insurance				
	Benchmark - optimal $\eta = 0.275$ $\sigma = 3.0$	**[A.1]** $\eta = 0.27$ $\sigma = 3.0$	**[A.2]** $\eta = 0.28$ $\sigma = 3.0$	**[A.3]** $\eta = 0.275$ $\sigma = 2.5$	**[A.4]** $\eta = 0.275$ $\sigma = 3.5$
Opt. UPHI coinsurance (%): $\gamma^{\text{UPHI}}_{\text{Opt}}$	53.93	51.96	52.87	62.03	50.59
Welfare in CEV (%)	**+0.21**	+0.33	+0.22	+0.69	+0.19
• Income group 1–sick (%)	**+0.13**	+0.35	+0.23	+0.06	+0.58
• Income group 2–sick (%)	**-0.68**	−0.42	−0.62	−0.63	−0.60
• Income group 2–healthy (%)	**-0.46**	−0.24	−0.40	−0.22	−0.48
• Income group 3–healthy (%)	**+1.23**	+1.17	+1.14	+2.29	+0.98

Notes: The optimal coinsurance rate for a UPHI system without any private health insurance markets is 53.9 percent as reported in column [A] of Table 6. The progressive income tax adjusts to balance the government budget constraint. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual in the new steady state with UPHI fully implemented.

Table 9: **Extending Medicare eligibility age**

	Bench.	**[D] US system + lower Medicare age**					
		[D.1] Income tax		**[D.2] Payroll tax**		**[D.3] Consumption tax**	
		Age $\geq$ 60	Age $\geq$ 50	Age $\geq$ 60	Age $\geq$ 50	Age $\geq$ 60	Age $\geq$ 50
Insured workers (%)	72.62	74.14	79.03	74.30	81.47	74.18	81.17
• IHI (%)	5.25	3.77	4.77	3.91	5.07	3.83	5.00
• GHI (%)	61.58	58.09	45.46	58.11	45.55	58.08	45.36
• Medicaid+Medicare (%)	5.79	12.28	30.83	12.28	30.85	12.26	30.81
Insured retirees							
• Medicare (%)	100	100	100	100	100	100	100
Avge. IHI premiums	100	95.46	59.67	94.89	60.03	96.28	60.97
Avge. GHI premiums	100	89.91	66.57	88.90	66.54	89.27	67.39
Output (Y)	100	100.35	99.78	100.37	99.89	100.68	100.90
Capital (K)	100	99.90	98.31	100.10	99.11	100.68	101.60
Consumption (C)	100	100.80	100.83	100.75	100.57	100.96	101.91
Labor participation rate (%)	71.26	72.77	73.08	72.71	72.83	72.84	73.27
Weekly hours	100	99.10	98.68	99.10	98.72	99.08	98.61
Wages	100	99.73	99.15	99.84	99.53	100.00	100.08
Income tax revenue	100	104.61	115.18	101.52	104.15	101.71	104.86
Payroll tax rate (%)	2.9	2.9	2.9	3.57	5.31	2.9	2.9
Consumption tax rate (%)	5	5	5	5	5	5.93	8.32
Welfare in CEV (%)	0	**+0.28**	**+0.38**	**+0.30**	**+0.41**	**+0.46**	**+1.00**
• Income group 1–sick (%)	0	+0.03	+0.39	+0.04	+0.43	+0.22	+1.05
• Income group 2–sick (%)	0	+0.07	+0.12	+0.09	+0.14	+0.26	+0.78
• Income group 2–healthy (%)	0	+0.27	+0.30	+0.30	+0.34	+0.45	+0.90
• Income group 3–healthy (%)	0	+0.39	+0.46	+0.40	+0.45	+0.57	+1.11

Notes: This table presents the effects of lowering the Medicare eligibility age from 65 to 60 and 50, respectively, while keeping all other features of the benchmark health insurance system unchanged. Data in rows marked with the % symbol are fractions in percent. The other rows are indexed to normalized values of the benchmark case. Each column presents steady-state results. CEV values are reported as percentage changes in terms of expected lifetime consumption of a newborn individual. Either the progressive income tax, a flat payroll tax, or the consumption tax adjust in order to clear the government budget constraint.

Table 10: **Private health insurance option for all (incl. retirees)**

	Benchmark	**[E] IHI+GHI only** (No Medicare or Medicaid)
Insured workers (%)	72.62	88.76
• IHI (%)	5.25	4.73
• GHI (%)	61.58	84.03
• Medicaid (%)	5.79	0
Insured retirees (%)	100	90.87
• Medicare (%)	100	0
• IHI (%)	0	0
• GHI (%)	0	90.87
Avge. IHI premiums	100	12.19
Avge. GHI premiums	100	153.64
Output (Y)	100	104.06
Capital (K)	100	107.91
Consumption (C)	100	106.47
Labor participation rate (%)	71.26	75.89
Weekly hours	100	97.58
Wages	100	102.27
Income tax revenue (%)	100	72.97
Payroll tax rate (%)	2.9	0
Welfare in CEV (%)	0	**+4.32**
• Income group 1–sick (%)	0	+4.13
• Income group 2–sick (%)	0	+3.60
• Income group 2–healthy (%)	0	+4.12
• Income group 3–healthy (%)	0	+4.59

Notes: We remove Medicare and Medicaid from the model and allow all workers and retirees to buy IHI or GHI plans. The **income tax** adjusts in order to clear the government budget constraint in all experiments.
Data in rows marked with the % symbol are fractions in percent. The other rows are indexed to normalized values of the benchmark model case. Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual.

Online appendix (not for publication)

A Model performance - additional graphs

A.1 Health state and health shock distributions

Figure A.1 and A.2 show the health state distribution and the histogram of health spending shocks by 5-year age group. They are the result of feeding the health spending profile from Figure 1 and C.5 as well as the Markov transition probabilities from Figure C.6 into the model and solving for a steady state equilibrium.

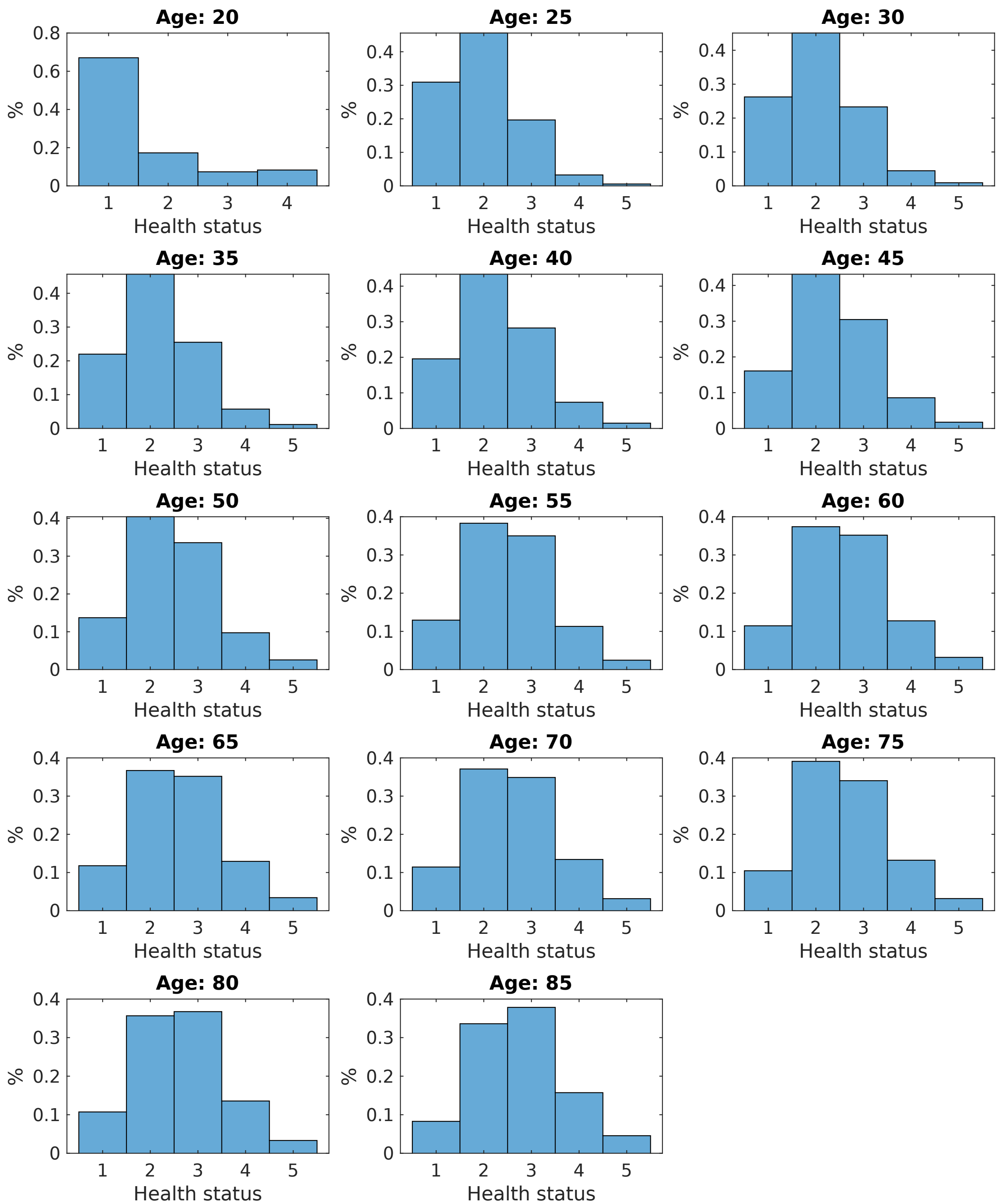

Figure A.1: **Health state distribution**

Notes: 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 1999–2009, heads of HIEU, population weighted.

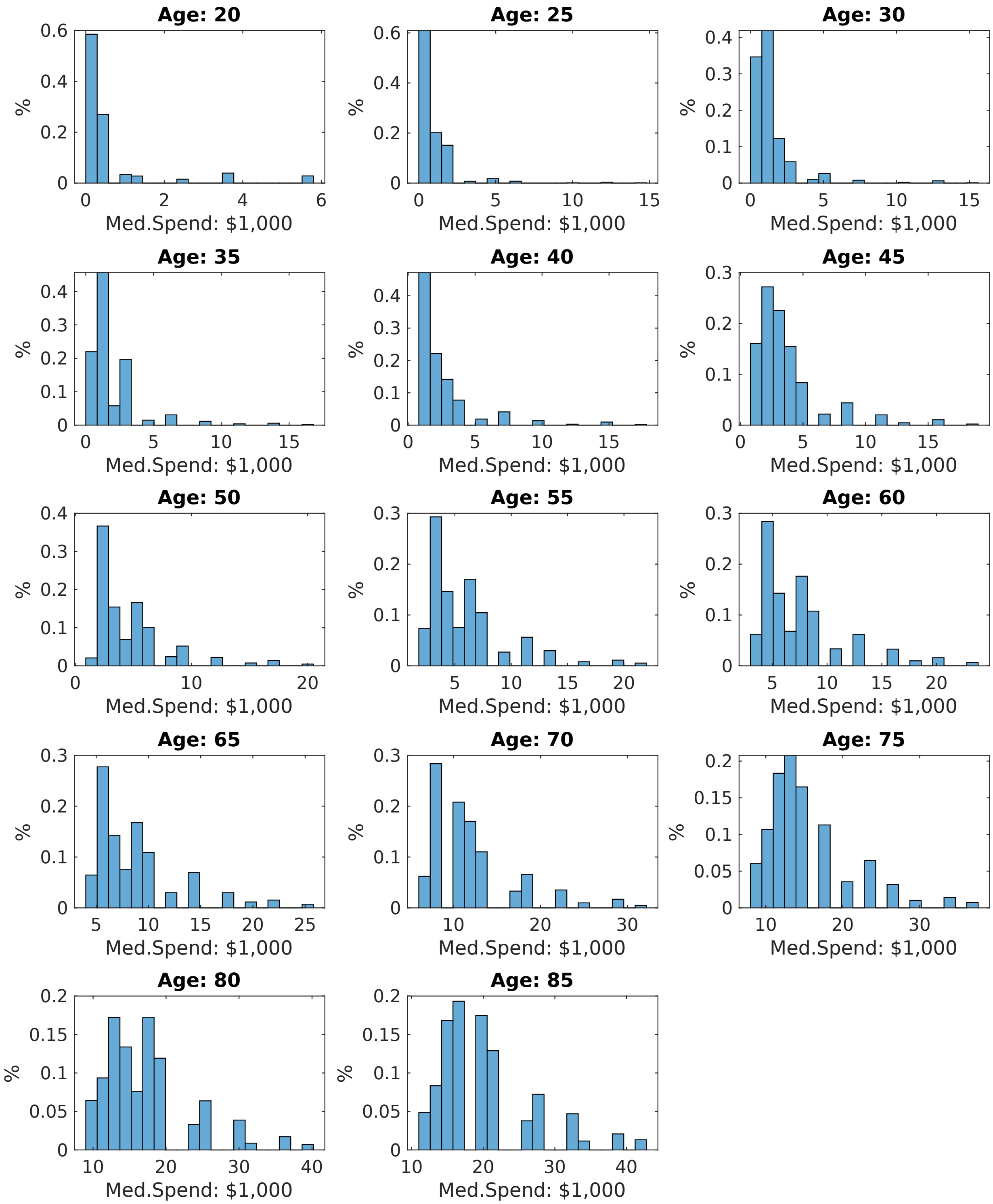

Figure A.2: **Exogenous medical spending distribution**

Notes: 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 1999–2009, heads of HIEU, population weighted.

A.2 Labor market profiles

Figure A.3 shows the labor market profiles of hours worked conditional on working as well as the the hours worked unconditional of the work status. Figure A.4 shows the labor participation rates. We present these measures by by permanent income type and by health status (sick/poor). These are calibration targets of our model.

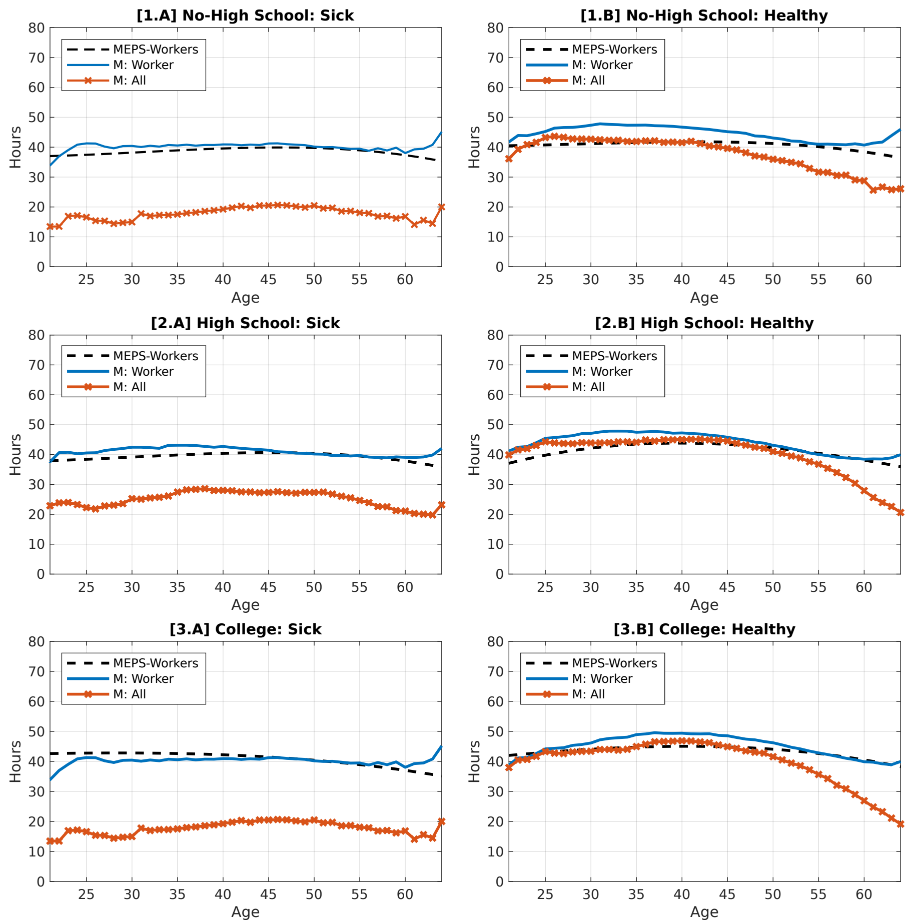

Figure A.3: **Model performance IV – work hours by education and health**

Notes: Weekly, cohort adjusted, work hours by permanent income group and health state. These are not calibration targets. Data source is MEPS 1999–2009, heads of HIEU, population weighted.

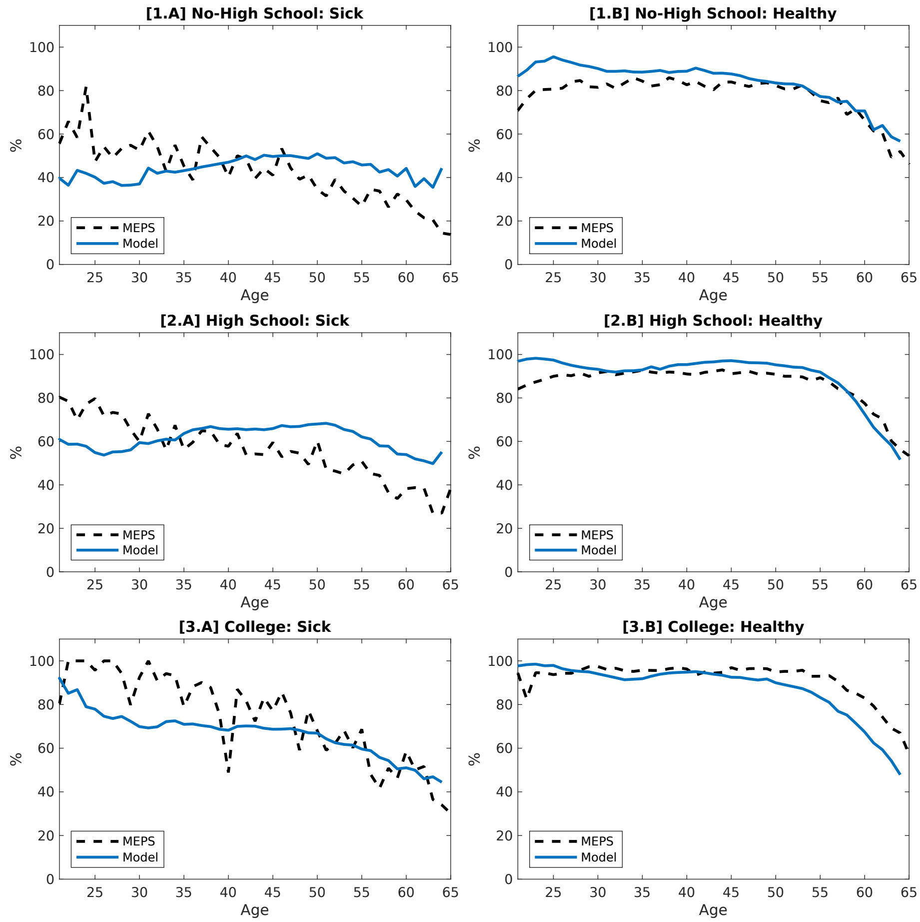

Figure A.4: **Model performance V – work participation rates by education and health**

Notes: Work participation rates by permanent income group and health state. These are not calibration targets. Data source is MEPS 1999–2009, heads of HIEU, population weighted.

B Expansion of Medicaid — more public health insurance for the poor

The US Medicaid system is an important source of social insurance and redistribution as it targets low income individuals. It is financed by a combination of federal and state income taxes. In this section we investigate whether there is room for welfare improvements by further expanding Medicaid. Medicaid is a means-tested social health insurance program. In order to become eligible for Medicaid, individuals must pass an income and asset test. We consider two Medicaid reforms: (i) relaxing the income and asset tests to increase the number of Medicaid recipients (extensive margin); and (ii) increasing the generosity of Medicaid via lowering the Medicaid coinsurance rate (intensive margin).[45] Both policies will augment the size of Medicaid either via including more people into Medicaid or via increasing the payments to individuals already on Medicaid. We let the consumption tax adjust to clear the government budget constraint and report the results of these two experiments in Table B.1.

Relaxing the asset test. As shown in column [F.1] of Table B.1, relaxing (i.e., increasing) the asset test threshold to 125 percent of the benchmark level increases the Medicaid take-up rate by 0.8 percent (extensive margin). This policy increases the eligible group of Medicaid recipients. The fractions of workers insured by IHI and GHI decrease slightly by about 0.7 percent and 0.2 percent, respectively. This result indicates the presence of a crowding-out effect of Medicaid as the private health insurance markets lose a combined market share of about 0.9 percent. Overall, this Medicaid expansion improves risk sharing among workers and results in redistribution effects that are potentially welfare improving. However, the Medicaid expansion entices low income types to abandon self-insurance via savings and labor supply which adds to the decrease in capital accumulation and labor force participation. In addition, the Medicaid expansion causes additional tax distortions (i.e., the income tax revenue increases by 0.74 percent) which has implications for output and welfare. The Medicaid expansion comes at a cost of about 0.4 percent of GDP, which lowers income. Welfare losses manifest across all income groups, except for the sick individuals at the low end of the income distribution. Overall, the expansion of the asset test results in a welfare loss of 0.15 percent of CEV. This implies that the negative incentive effect dominates the positive insurance effect when the asset test level is raised to 125 percent of the benchmark level. The mechanism at work here is similar to the one in Pashchenko and Porapakkarm (2017) who find welfare gains when lowering the asset test threshold. Zhao (2017) also reports welfare gains after removing Medicaid.

Lowering the Medicaid coinsurance rate. Instead of changing the eligibility rules that either remove or add individuals to Medicaid, we now change the generosity of Medicaid for individuals who already qualify for it (intensive margin). In order to accomplish this we calculate the effects of lowering the Medicaid coinsurance rate from 11 to 5 percent and summarize the result in column [F.2] of Table B.1. In this scenario the Medicaid transfer payments increase by about 6 percent. The consumption tax is increased by 0.56 percent which creates tax distortions that lead to a decrease in capital stock of about 0.8 percentage points and resulting output losses of 0.4 percent of GDP. The negative welfare outcomes are realized across all income types, except for the sick with low income. The overall welfare loss is about 0.22 percent of CEV.

Thus, in both Medicaid expansion experiments we found welfare gains for low income households but welfare losses for everybody else including welfare losses at the aggregate level. While the insurance effects of expanding

[45] Alternatively, we could also extend the income test threshold (extensive margin). The results are qualitatively identical to the extension of the asset test but quantitatively the welfare effects are smaller by a factor of about 2.5 on average. Detailed results for this version of the Medicaid expansion are available upon request.

Medicaid are positive for those that qualify, the associated tax increases needed to finance the larger public health insurance program are so severe that overall welfare losses are realized across most income groups. This is consistent with findings from the macro health literature (e.g., Pashchenko and Porapakkarm 2017; Zhao 2017). Not surprisingly, welfare gains are only realized for the sick and poor group which is the target group of Medicaid. This is in line with findings in the empirical health literature such as Finkelstein et al. (2012). Different from regression based approaches our analysis adds the price feedback effects from general equilibrium channels and presents long-run results and is thus complementary to the empirical health literature.[46]

Table B.1: **Medicaid expansion**

	[0] Benchmark	**[F] US System + Medicaid expansion**	
		[F.1] Asset test to 125%	**[F.2] Coinsurance rate to 5%**
Insured Workers (%)	72.62	72.71	73.21
• IHI (%)	5.25	4.94	5.58
• GHI (%)	61.58	61.18	60.95
• Medicaid (%)	5.79	6.59	6.68
Insured Retirees			
• Medicare (%)	100	100	100
Output (Y)	100	99.60	99.36
Capital (K)	100	99.50	99.22
Consumption (C)	100	99.50	99.20
Labor participation rate (%)	72.73	70.63	70.35
Weekly hours	100	100.29	99.91
Wages	100	99.96	100.013
Consumption tax rate (%)	5	5.376	5.56
Welfare in CEV (%)	0	**-0.153**	**-0.225**
• Income Group 1-Sick (%)	0	+0.002	+0.172
• Income Group 2-Sick (%)	0	−0.171	−0.074
• Income Group 2-Healthy (%)	0	−0.168	−0.257
• Income Group 3-Healthy (%)	0	−0.352	−0.352

Notes: In column F.1 the asset test is increased by a factor of 1.25 and in column F.2 the coinsurance rate is lowered from 11 percent to 5 percent. Data in rows marked with the % symbol are fractions in percent. The other rows are indexed to normalized values of the benchmark case. Each column presents steady-state results. CEV values are reported as percentage changes in terms of lifetime consumption of a newborn individual. In both cases the **consumption tax** adjusts to clear the government budget constraint.

[46] A rare exception is Goodman-Bacon (2021) who presents long-run effects of Medicaid on a group of individuals who newly qualified back in 1966–1970 in an empirical setting.

C Data appendix

C.1 Medical expenditure panel survey (MEPS)

C.1.1 Summary statistics

We primarily use data from the Medical Expenditure Panel Survey (MEPS) from the years 1999–2009 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 20–95 who are the head of the HIEU.

A variable in a MEPS survey of year t is typically represented three times as either VARNAME13, VARNAME24, and VARNAME35, where 13 indicates that this variable is either a response of a first round interview of an individual who entered the survey in year t or the third round interview of an individual who entered the survey in year $t-1$. Similarly 24 indicates that this response is the second interview response of the individual who entered in year t or the fourth round response of the individual who entered the previous year $t-1$. Finally, 35 indicates that this variable is the response from the third interview of an individual who entered in year t or the final fifth round interview response from an individual who entered in the prior year $t-1$ and then subsequently exits the survey.

Summary statistics of the unweighted sample are presented in Table C.1.1 and a histogram of the age distribution is presented in Figure C.1. All dollar values are denominated in 2010 dollars using the OECD CPI for the US for all monetary measures.[47]

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

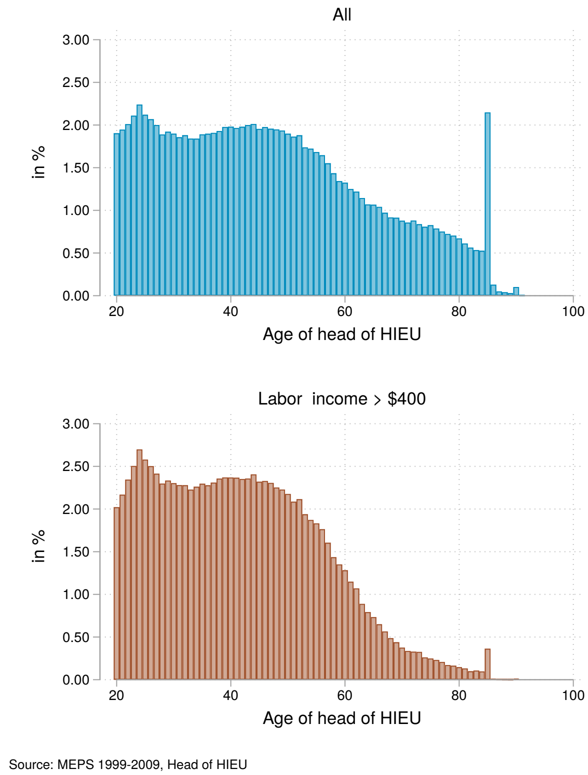

Figure C.1: **Age distribution**

Notes: Data source is MEPS 1999–2017, heads of HIEU, population weighted.

Table C.1: **MEPS - Summary Statistics**

	(1) All mean/sd	(2) LaborIncome>$400 mean/sd
Year	2004.249	2004.217
	(3.074)	(3.090)
Age of head of HIEU	46.825	41.866
	(17.714)	(14.204)
Five-year age groups	5.980	4.982
	(3.559)	(2.848)
Female	0.442	0.396
	(0.497)	(0.489)
Married/Partnered	0.417	0.444
	(0.493)	(0.497)
Black	0.145	0.134
	(0.352)	(0.341)
Years of education	12.003	12.488
	(4.017)	(3.740)
Avge hourly wage over 3 waves	17.841	17.895
	(12.503)	(12.521)
Labor income (in $1,000)	25.467	35.215
	(31.239)	(31.720)
Labor income of HH (in $1,000)	46.762	58.495
	(48.387)	(48.591)
Pre-government HH income (in $1,000)	56.634	65.018
	(49.985)	(51.746)
Pre-government HIEU income (in $1,000)	43.964	52.159
	(45.821)	(48.203)
Total health expenditures (in $1,000)	3.837	2.522
	(8.707)	(6.323)
healthExpenditureHIEU	6.197	4.876
	(12.891)	(11.066)
Total health expenditures HIEU (in $1,000)	8.165	6.684
	(15.714)	(14.176)
Out-of-pocket health exp	0.679	0.527
	(1.644)	(1.286)
OOPExpenditureHIEU	1.110	0.979
	(2.190)	(1.948)
Total OOP expenditure HIEU ($1,000)	1.417	1.273
	(2.542)	(2.309)
No high school degree	0.286	0.230
	(0.452)	(0.421)
High school degree	0.511	0.537
	(0.500)	(0.499)
College or higher degree	0.193	0.224
	(0.395)	(0.417)
Insured	0.797	0.778
	(0.402)	(0.415)
Public health insurance	0.207	0.098
	(0.405)	(0.298)
Private health insurance	0.590	0.680
	(0.492)	(0.466)
d_H_excellent	0.173	0.206
	(0.378)	(0.404)
d_H_very_good	0.377	0.424
	(0.485)	(0.494)

d_H_good	0.300	0.288
	(0.458)	(0.453)
d_H_fair	0.116	0.071
	(0.320)	(0.258)
d_H_poor	0.033	0.010
	(0.178)	(0.100)
Observations	169543	122684

Notes: Unweighted summary statistics of heads of Health Insurance Eligibility Units (HIEU) based on MEPS 1999–2009.

C.1.2 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., Jung and Tran (2014)). The literature (e.g., Kaplan (2012)) suggests to conduct separate analyses once controlling for the cohort effect and in a repeat exercise controlling for the time effect in order to assess modeling implications. In this work we explicitly control for cohort effects of wages, income, wealth and health expenditures by regressing the log of the output variable on a set of age and cohort dummies. We focus on controlling of cohort effects because Jung and Tran (2014) show that 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 cohort-adjusted variables with the birth cohort 1945–1954 as reference group.

C.1.3 Unbiased wage profiles

We follow Rupert and Zanella (2015) and Casanova (2013) and estimate a selection model to remove biases in self reported wages. Rupert and Zanella (2015) use PSID and CPS data and then employ a Tobit 2-step procedure based on Wooldridge (1995) to estimate selection corrected wage profiles. They find that once wage profiles are bias corrected they tend to be very flat which contradicts the often used hump-shaped wage profiles. Similarly, Casanova (2013) uses HRS data and finds evidence of flat wage profiles but no selection bias.

In our selection model we include fourth order polynomials in age, a health status variable, whether someone lives with a partner, family size, schooling, gender, and an indicator for part-time work. We use indicator variables for whether an individual is older than 62 and a second indicator variable for whether an individual is older 65 in the selection equation as is customary in this literature. These two indicator variables are exclusion restrictions and not included in the outcome equation of the selection model. Figure C.3 shows the wage profiles for healthy and unhealthy types and the three educational groups.

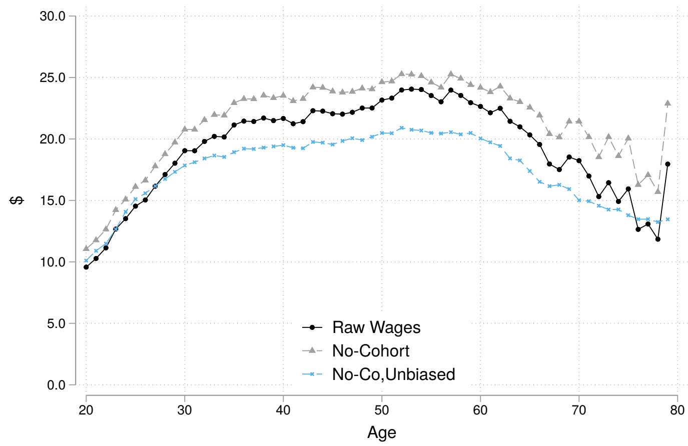

Figure C.2: **Raw wages vs. unbiased and cohort adjusted wage profiles**

Notes: Data source is MEPS 1999–2009, heads of HIEU, population weighted. We report raw hourly wages, cohort adjusted wages, and cohort adjust unbiased wages. Unbiased wages are based on a selection model. The latter is used as wage efficiency input. We use a dummy variable approach to estimate unbiased wages profiles for two health (healthy vs. sick) and two education (no college vs. college) types.

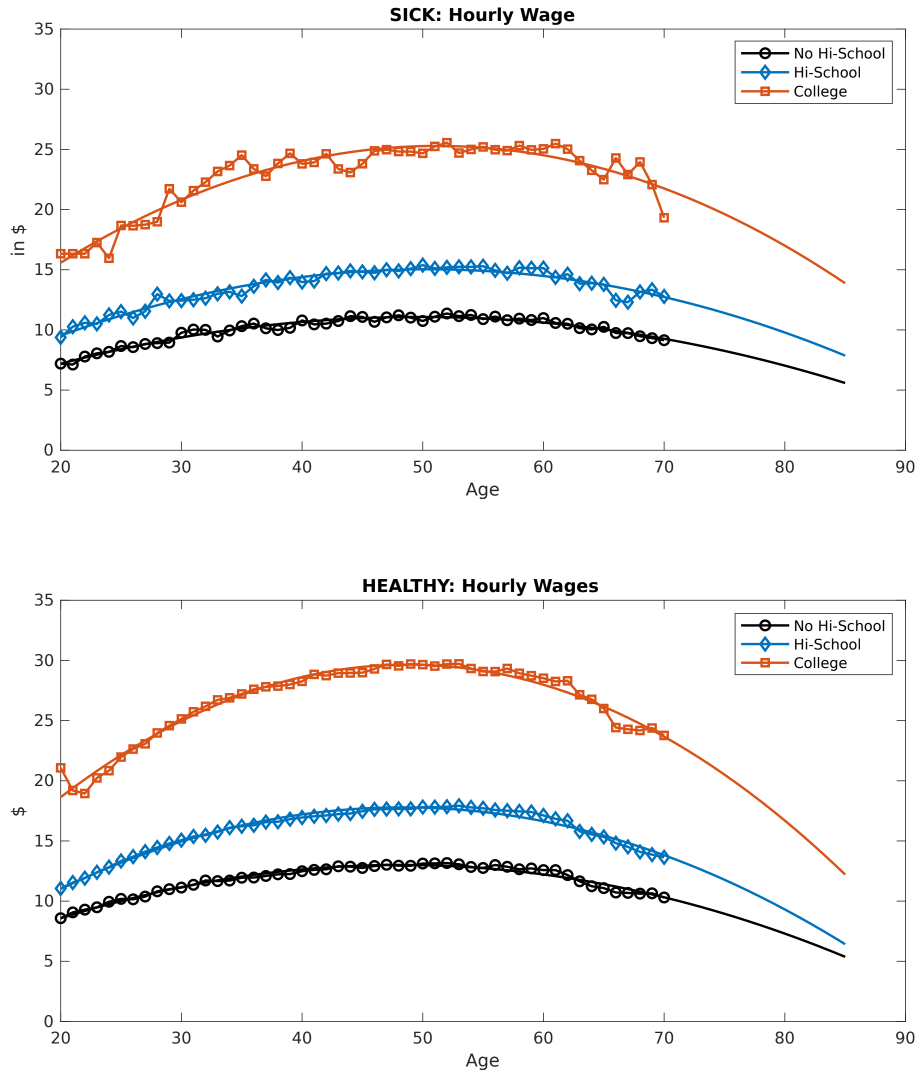

Figure C.3: **Selection bias adjusted wage profiles of heads of HIEUs**

Notes: Data source is MEPS 1999–2009, heads of HIEU, population weighted. This is used as wage efficiency input by health and education type into the model.

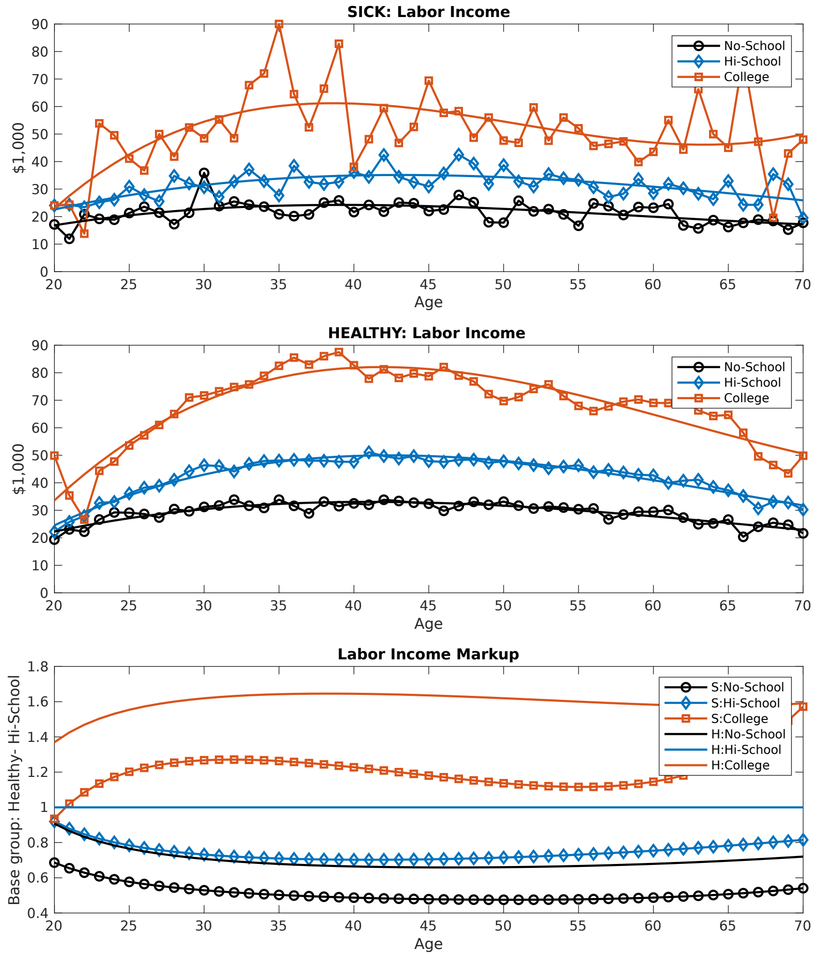

Figure C.4: **Cohort adjusted labor income profiles of heads of HIEUs**

Notes: Data source is MEPS 1999–2009, heads of HIEU, population weighted. This is a calibration target.

C.1.4 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. We drop 443 observations (out of

239,170) with health expenditure larger than USD 100,000 so that our estimates are not driven by outliers.

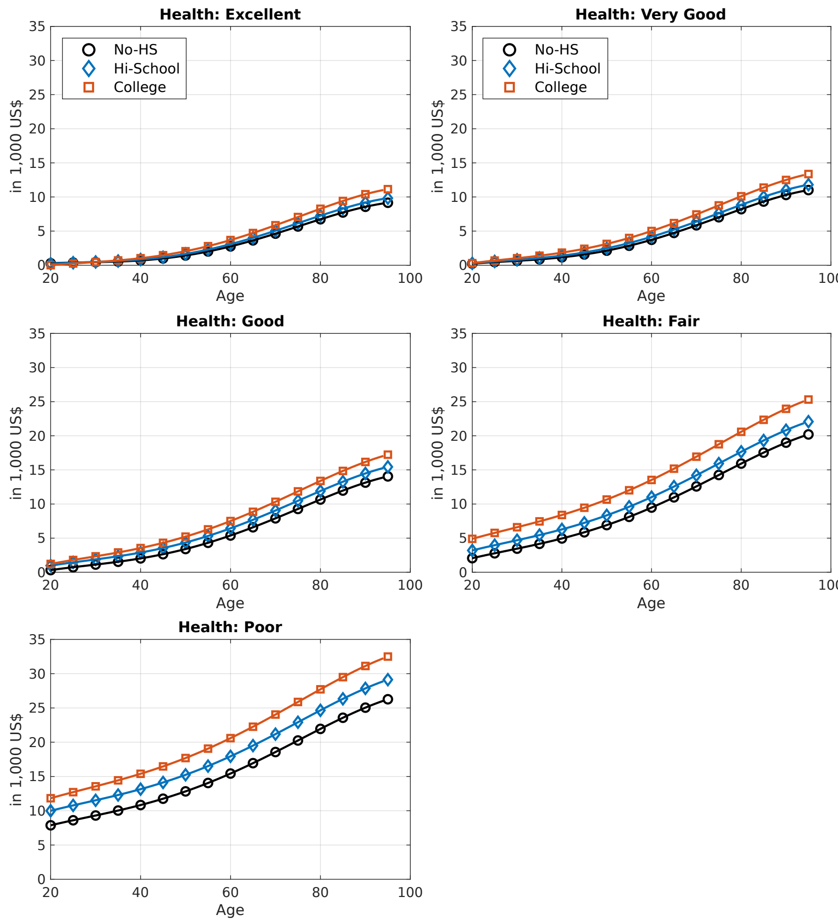

Figure C.5: **Average health spending by health state**

Notes: Data source is MEPS 1999–2009, heads of HIEU, population weighted. Cohort adjusted average health spending by self-reported health state and age in 2009 USD.

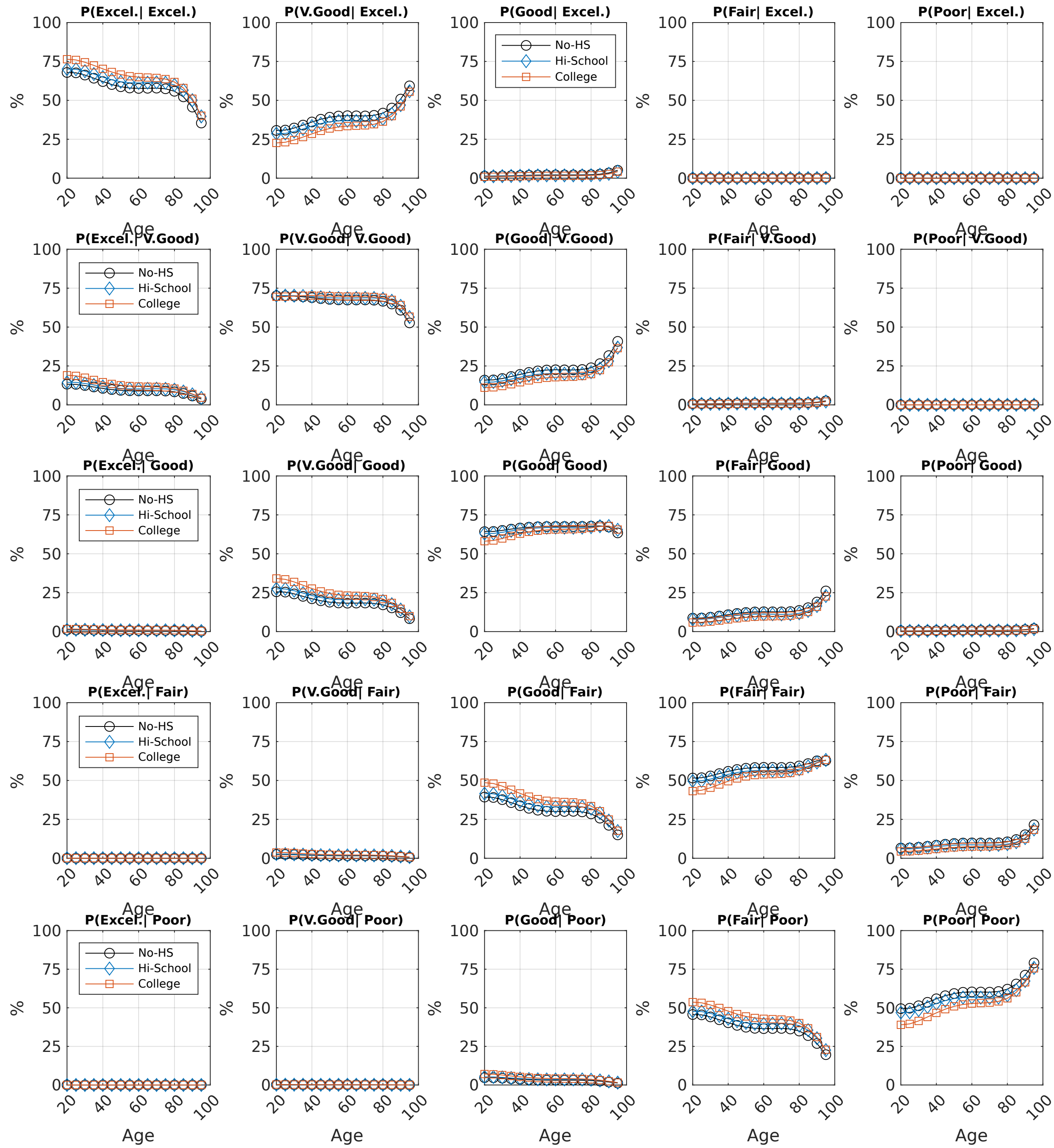

Figure C.6: **Conditional health status transition probabilities**

Notes: Data source is MEPS 1999–2009, heads of HIEU, population weighted.

C.1.5 Group Health Insurance (GHI) offer status

MEPS asks detailed questions about the type and length of health insurance coverage. If health insurance is offered through the current main job (OFFER31X, OFFER42X, OFFER 53X) an individual can opt into buying employer sponsored (group) health insurance. The offer variable is automatically set to one (and skipped in the survey) if the individual reports having health insurance via their employer. We set the indicator variable GROUP-OFFER equal to one if the individual reports having received a health insurance offer from their employer in either one of the three interview rounds.

In addition, a second variable asks whether an individual has had public (PUBJAx–PUBDEx) or private health insurance (PRIJAx–PRIDEx) for each month. In addition, if it is private health insurance, the survey asks whether the insurance is from an employer or union (PEGJAx–PEGDEx). We define an individual as having employer provided group insurance (GHI) in a given year if she is covered for at least 8 months with employer provided insurance, she is otherwise classified as having individual private health insurance (IHI).

We estimate an order logit model in order to determine the GHI offer probability for each age-education group where we distinguish between individuals with less than high school, high school, or college level education. The predicted probabilities of receiving a GHI offer from an employer are shown in Figure C.7.

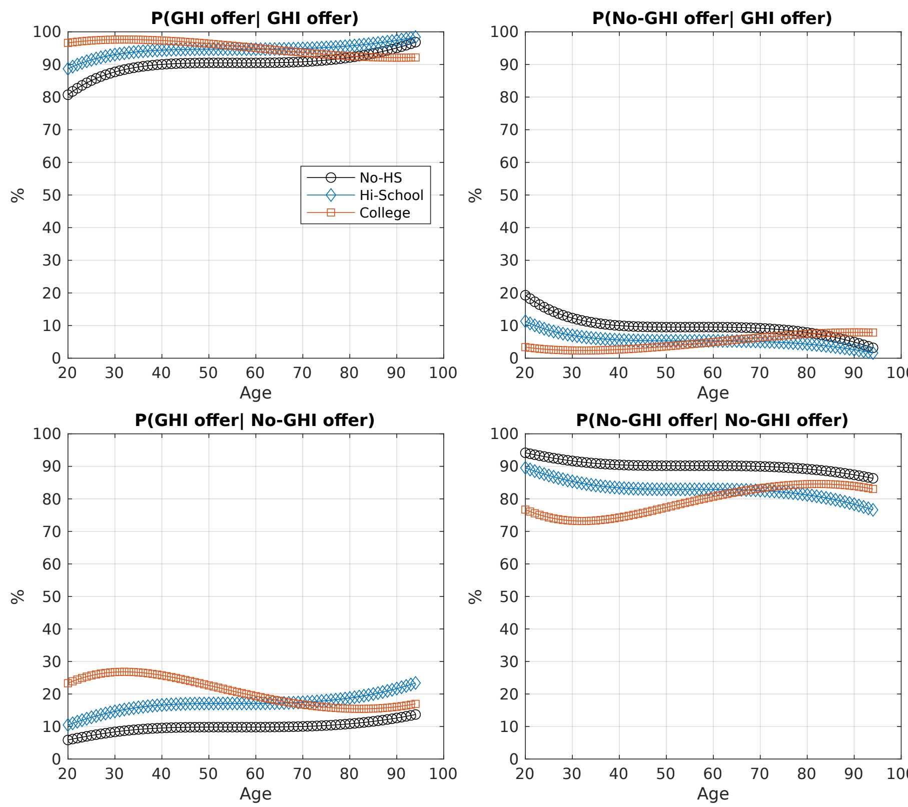

Figure C.7: **Conditional GHI offer status transition probabilities**

Notes: Data source is MEPS 1999–20009, heads of HIEU, population weighted. Using spline interpolation to get annual frequencies.

C.1.6 Coinsurance rates

We define the coinsurance rate as the fraction of out-of-pocket health expenditures over total health expenditures. The coinsurance rates in our model therefore include copayments and other direct out-of-pocket payments. We use MEPS data from 1999–2000 and calculate the average coinsurance rate of heads of HIEU (population weighted) by age for all four insurance types represented in the model. Consequently we set the coinsurance rates for the different types of insurance plans to $\gamma^{\text{IHI}} = 0.45$, $\gamma^{\text{GHI}} = 0.31$, $\gamma^{\text{MAid}} = 0.11$, and $\gamma^{\text{MCare}} = 0.30$ respectively, as shown in Figure C.8.

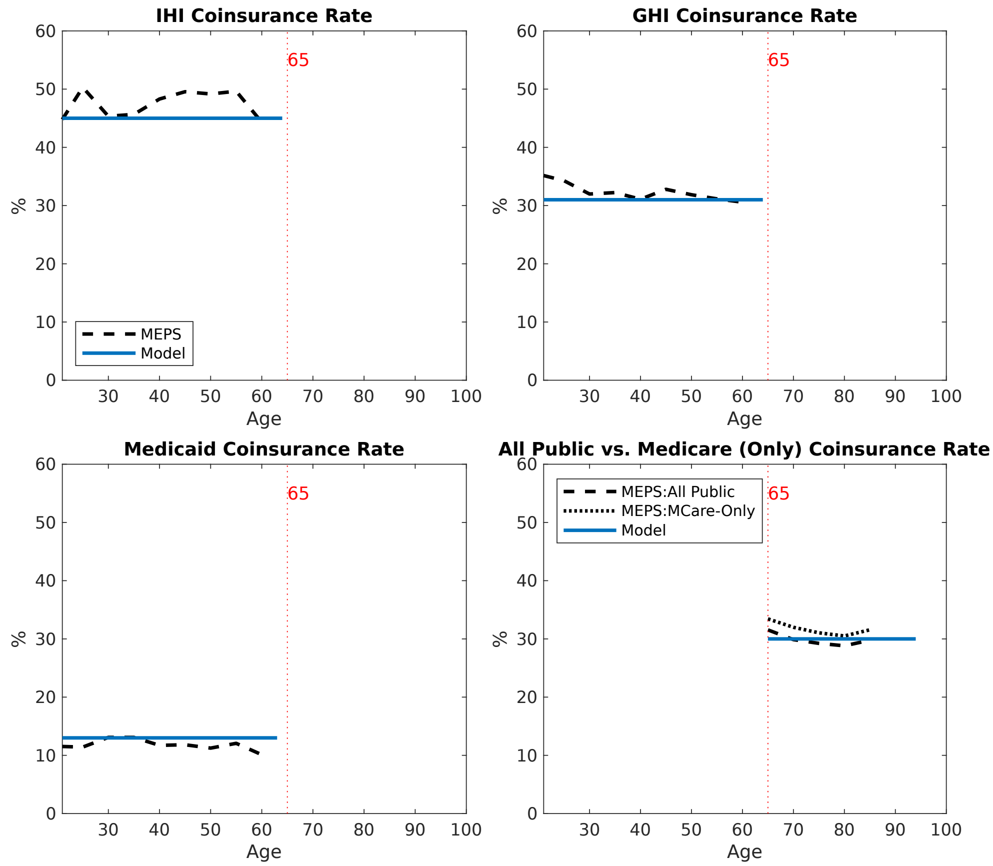

Figure C.8: **Coinsurance rates**

Notes: These are not calibration targets. Data sources: is MEPS 1999–2009, heads of HIEU, population weighted.

C.2 Panel study of income dynamics (PSID)

C.2.1 Summary statistics

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. Summary statistics of the unweighted sample are presented in Table C.2.2 and a histogram of the age distribution is presented in Figure C.9.[48]

C.2.2 Asset profiles

We use household level data and information of the head of the household to assign age and educational status to the wealth data. We drop observations with wealth above 1 million USD and labor income above USD 400,000 and use PSID sample weights to calculate averages by age group. For our wealth measure we use variable S[wave]17 which is the sum of seven asset types including home equity but net of debt.

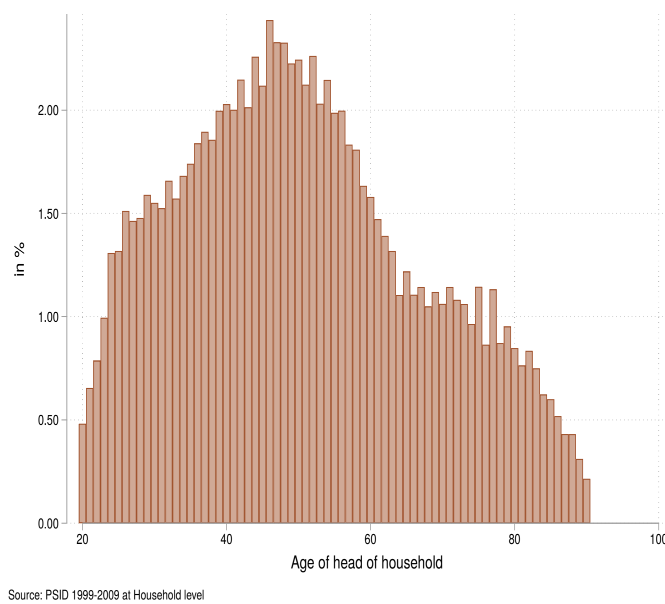

Figure C.9: **Age Distribution in PSID 1999–2009**

Notes: Data source is PSID 1999–2009, heads of household, population weighted.

[48]All dollar values are denominated in 2009 dollars using the OECD CPI for the US for all monetary measures. This measure is available here: OECD (2018), Inflation (CPI) (indicator). doi: 10.1787/eee82e6e-en (Accessed on 29 June 2018) at https://data.oecd.org/price/inflation-cpi.htm

Table C.2: **PSID - Summary Statistics**

	(1) 1999-2009 mean/sd	(2) 1999-2009: HH-Heads mean/sd
Calendar year	2004.136	2004.136
	(3.402)	(3.402)
Age of head of household	46.082	46.082
	(15.869)	(15.869)
Female	0.288	0.288
	(0.453)	(0.453)
Married	0.521	0.521
	(0.500)	(0.500)
Number of Years of Education	12.753	12.753
	(2.547)	(2.547)
Individual labor earnings in $1,000	39.787	39.787
	(48.595)	(48.595)
Labor income HH in $1,000	55.308	55.308
	(60.689)	(60.689)
Pre-government HH income in $1,000	60.702	60.702
	(61.731)	(61.731)
Wealth without equity HH in $1,000	89.483	89.483
	(155.488)	(155.488)
Wealth with equity HH in $1,000	102.776	102.776
	(177.396)	(177.396)
No high school degree	0.186	0.186
	(0.389)	(0.389)
High school degree	0.367	0.367
	(0.482)	(0.482)
College	0.198	0.198
	(0.399)	(0.399)
Insured	0.917	0.917
	(0.277)	(0.277)
d_H_excellent	0.216	0.216
	(0.411)	(0.411)
d_H_very_good	0.328	0.328
	(0.469)	(0.469)
d_H_good	0.293	0.293
	(0.455)	(0.455)
d_H_fair	0.117	0.117
	(0.322)	(0.322)
d_H_poor	0.041	0.041
	(0.199)	(0.199)
Observations	36823	36823

Notes: Unweighted summary statistics of heads of households based on PSID 1999–2009.