Market Inefficiency, Insurance Mandate and Welfare: U.S. Health Care Reform 2010*

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February 5, 2014

Abstract

We quantify the effects of the Affordable Care Act using a stochastic general equilibrium overlapping generations model with endogenous health capital accumulation calibrated to match U.S. data on health spending and insurance take-up rates. The introduction of an insurance mandate and the expansion of Medicaid, that are at the core of the Affordable Care Act, increase the insurance coverage rate of workers from 76 to 90 percent while simultaneously causing a reduction in capital accumulation, labor supply and aggregate output. Individuals in poor health with low income experience welfare gains while high income individuals in good health experience welfare losses. The insurance mandate, enforced by penalties and subsidies, reduces the adverse selection problem in private health insurance markets and counteracts the crowding-out effect of the Medicaid expansion. In addition, an alternative design of the insurance mandate with more aggressive penalties can lead to universal insurance coverage at smaller efficiency and welfare losses.

JEL: H51, I18, I38, E21, E62

Keywords: Affordable Care Act 2010, insurance mandate, Medicaid, endogenous health capital, life-cycle health spending and financing, dynamic stochastic general equilibrium model, Grossman health capital

*This project was supported by the Agency for Healthcare Research and Quality (AHRQ, Grant No.: R03HS019796), the Australian Research Council (ARC, Grant No.: CE110001029), and funds from the Centers for Medicare & Medicaid Services, Office of the Actuary (CMS/OACT). The content is solely the responsibility of the authors and does not represent the official views of AHRQ, ARC, or CMS/OACT. We would like to thank Gianluca Violante, Dirk Kruger, Carlos Garriga, and Todd Caldis for their constructive comments. We also appreciate comments from participants of the CEF Conference, the Midwest Macroeconomics Meetings, the WEAI Conference, the Workshop on Macroeconomic Dynamics, and participants of research seminars at the Australian National University, the University of Melbourne, the Université du Québec à Montréal, and Colorado College.

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1 Introduction

Most industrialized countries have introduced large public health insurance programs in order to achieve almost universal health insurance coverage of its citizens. In the U.S., on the other hand, government run health insurance programs are limited to cover the retired population (Medicare) and the poor (Medicaid). Most working individuals receive private health insurance via their employers or buy private health insurance individually. This mixed health insurance system leaves over 45 million Americans uninsured (about 18 percent of the U.S. population in 2010). In addition, the U.S. health care system is the most expensive in the world with health care spending reaching 17.6 percent of GDP in 2010 (Keehan et al. (2011). The combination of low insurance coverage and high medical cost exposes many Americans to considerable financial risk. Moreover, the increase in the cost of delivering health care threatens the solvency of Medicare and Medicaid and puts pressure on the overall government budget. The fiscal situation is made worse by a demographic shift that increases the fraction of the older population.

In reaction to these challenges, a number of comprehensive health care reforms have been implemented in recent years. Of particular importance is the *Affordable Care Act* (ACA) passed in March 2010 or "Obamacare" as it is often called. The ACA has the following key features: (*i*) an insurance mandate that requires individuals to buy health insurance or pay a fine;[1] (*ii*) the introduction of insurance exchanges where individuals who are not covered by employer-based insurance programs can buy insurance at group-based premium rates with premium subsidies for those whose income is between 133 and 400 percent of the Federal Poverty Level (FPL); and (*iii*) the expansion of Medicaid to a new income eligibility threshold of 133 percent of the FPL.

The ACA was passed in an effort to increase the number of individuals with health insurance coverage, especially amongst low income groups. The ACA adopts a mixed approach that combines a private health insurance expansion by directly mandating health insurance via penalties and premium subsidies with the expansion of an existing public health insurance program (i.e. Medicaid). The former is designed to induce healthy, low health risk individuals to join the insurance pools. This expectedly decreases insurance premiums and further attract healthy individuals into private health insurance pools. The expansion of Medicaid, on the other hand, aims to make health insurance accessible to more low income individuals. The opinions about the results of the ACA are very divided. Critics maintain that the insurance mandate is unconstitutional and that the expansion of Medicaid can have detrimental effects on existing private health insurance markets. In addition, there are many unanswered questions as to whether the reform will actually lead to universal coverage or not, whether it is financially sustainable, what feature of the ACA is critically important, and what are the long-run effects on the macroeconomy and welfare.

The objective of our paper is to provide a quantitative analysis of these questions based on simulations of a stochastic dynamic general equilibrium model with endogenous health capital accumulation and insurance choice. Our model combines important features of two workhorse models from macroeconomics and health economics: an incomplete markets model with heterogeneous agents (Bewley

[1] Also, employers with more than 50 full-time employees need to provide health insurance to their employees or pay a fine.

(1986)) and a model of health capital accumulation (Grossman (1972a)). Our life-cycle approach is motivated by the life-cycle patterns of health expenditure and insurance take-up rates observed in U.S. medical expenditure data (Jung and Tran (2014)). In addition, we incorporate various sources of uncertainty including idiosyncratic labor productivity shocks, health shocks and shocks to the availability of employer provided group insurance to simulate the risk environment of a consumer of health care in the U.S. By construction, adverse selection and ex-post moral hazard effects are both present in our framework due to imperfect information and the explicit modeling of the insurance and health expenditure decisions.[2] More importantly, our model accounts for a wide range of institutional details of the U.S. health insurance system including public health insurance (Medicare and Medicaid), private employer provided group health insurance (GHI) and private, individually bought, health insurance (IHI).

We calibrate the model to U.S. data. The model consistently describes individual behavior over the life-cycle as observed in the Medical Expenditure Panel Survey (MEPS) and additional data from the Centers for Medicare and Medicaid Services (CMS) and the Panel Study of Income Dynamics (PSID). Our model reproduces the life-cycle patterns of health expenditure, the distribution of health expenditure, the life-cycle profiles of insurance take-up rates and the income distribution. In addition, our model is capable of reproducing fundamental macroeconomic aggregates of the U.S. economy.

We then apply the model to quantify the effects of the insurance mandate, the insurance exchange and the expansion of Medicaid on insurance take-up rates, medical spending, macro aggregates and welfare. Moreover, we explore alternative designs of the ACA reform by simulating counter factual tax and spending policies. Finally, we explore the sensitivity of the model dynamics to alternative calibration values of key preference parameters including risk aversion and the preference weights of medical and non-medical consumption. Our results can be summarized as follows:

First, we isolate the effects of the three key features of the ACA: (*i*) the insurance mandate enforced by penalties, (*ii*) the insurance exchange with premium subsidies and (*iii*) the Medicaid expansion.[3] We start from a pre-ACA benchmark equilibrium and then introduce hypothetical reforms with only one of the three key features introduced at a time. We find that the introduction of the insurance mandate enforced by penalties and the introduction of insurance exchanges with premium subsidies, both, extend private health insurance coverage while coverage via Medicaid decreases. The increase in insurance take-up rates depends on how aggressive penalties and subsidies are. The penalties effectively eliminates the adverse selection problem prevailing in private health insurance markets. The penalties from 5 percent of individual income can achieve almost universal coverage. Compared to the insurance exchange with premium subsidies, the insurance mandate is a more effective measure to extend insurance coverage. Even very generous subsidies cannot achieve take-up rates much higher

[2]Ex-ante moral hazard is absent in our framework since agents are not able to influence the probability distribution of health shocks. Ex-post moral hazard, on the other hand, describes the situation where the individual is assumed to have a choice among different treatment options once an illness has occurred. The insurer is not able to observe how ill the individual is and can therefore not condition the insurance contract on this information, so that a moral hazard issue arises. See Pauly (1968) and Zeckhauser (1970) for a formal model of ex-post moral hazard.

[3]Due to computational limitations we abstract from firm heterogeneity. As a consequence, we are not able to model the employer insurance mandate that requires firms with more than 50 full-time employees to provide health insurance. For that reason we only consider individual insurance mandate in this paper.

than 87 percent. The reason is that the insurance exchange with subsidies is limited to a relatively small group of individuals (i.e. individuals currently NOT on group health insurance and with incomes between 133 and 400 percent of FPL). In addition, we observe that the insurance mandate results in output increases while causing welfare losses in all experiments. This is due to individuals having to reduce their consumption levels in order to maintain their health insurance status. Conversely, the insurance exchange with premium subsidies is less successful in extending insurance coverage but results in an overall positive welfare outcome. The positive welfare effects stem from income redistribution via premium subsidies.

We then explore the crowding-out effects of expanding the Medicaid program on private insurance markets. Expanding public health insurance of the poor pulls low income individuals out of private health insurance markets. This leads to decreases in GHI take-up rates. If we extend the Medicaid eligibility threshold beyond the currently advocated level in the ACA, we find that even an expansion to 300 percent of the FPL would fall short of achieving universal coverage. Simultaneously, the fiscal distortion created by the Medicaid expansion causes output losses. The larger the expansion of Medicaid, the larger these losses become. The overall welfare outcome is ambiguous and depends on the magnitude of the Medicaid expansion. A moderate expansion of Medicaid results in positive welfare outcomes because the positive welfare effects created by income redistribution and improvements in risk sharing dominates the negative welfare effects associated with output losses.

Second, we quantify the overall long-run effects of the 2010 ACA reform when all its key features are combined. We find that the reform increases the fraction of insured workers from 76 percent to about 90 percent. This expansion is driven by expansions of the IHI market and Medicaid. We only detect small changes in the GHI market. These results indicate that the reform reduces adverse selection issues that are prevalent in private health insurance markets and which are partly responsible for the large number of uninsured individuals in pre-ACA markets. In most scenarios we find that the ACA reform triggers a decrease in labor supply and capital accumulation due to tax distortions and subsequent decreases in steady state output of up to 1.5 percent. In order to finance the reform the government has to either introduce a 0.5 percent payroll tax on high income earners above $200,000, a 3 percent capital income tax on high income earners, increase consumption taxes by about 1 percent, introduce a lump-sum tax of 0.36 percent of taxable income, or cut government spending by about 0.5 percent of GDP. These fiscal distortions subsequently lead to efficiency losses and lower GDP of up to 1.5 percent. Moreover, we find that the welfare effects vary significantly across agent types. In particular, high income workers in "good" health experience welfare losses while low income workers in "bad" health experience welfare gains. Overall, we observe a negative welfare outcome at the aggregate level. Specifically, welfare decreases by 0.23 percent in the new steady state after the ACA reform. This indicates that the welfare losses caused by the fiscal distortions dominate the welfare gains resulting from improvements in risk sharing and redistribution. Interestingly, if we keep all insurance premiums and factor prices unchanged (i.e. the partial equilibrium result), we find welfare gains of 1.1 percent. These opposite outcomes highlight the importance of accounting for general equilibrium price adjustments when conducting a comprehensive long-run assessment of a health care reform of such complexity.

Finally, we explore whether alternative designs of the ACA can further increase the insurance take-up rates. We find that more aggressive penalties can further reduce the adverse selection problem and mitigate the detrimental effects of the Medicaid expansion. Universal health insurance coverage with smaller decreases of aggregate output and welfare can be achieved with a penalty of 15 percent of taxable income. However, this design reduces the redistribution role of Medicaid and subsequently hurts low income households.

Related literature. Our paper is connected to a large literature in health economics that has discussed the effects of age, uncertainty and insurance on health capital accumulation and the demand for health care over the life-cycle (e.g. Grossman (2000)). Even though medical consumption accounts for a substantial part of consumption, standard models of consumption and savings focus on explaining the hump-shape of non-medical consumption over the life-cycle (e.g. see Carroll and Summers (1991), Deaton (1992), Hubbard, Skinner and Zeldes (1995), Gourinchas and Parker (2002), and Fernandez-Villaverde and Krueger (2007)) while neglecting medical consumption. It is documented that health risk and expenditure are an increasing function of age, and agents are not able to smooth their medical consumption over the life-cycle (e.g. see Deaton and Paxson (1998) and Jung and Tran (2014)). Only recently have there been studies developing consumption-savings models including medical and non-medical consumption (e.g. see Hall and Jones (2007), Forseca, Michaud, Galama and Kapteyn (2009), De Nardi, French and Jones (2010) and Scholz and Seshadri (2013)). These studies commonly construct a Grossman-type model of health investments and consumption in which health directly affects utility or longevity. Notice that these studies abstract from the dynamic interaction between health expenditure and financing. We advance this Grossman-type model to include more realistic sources of health care financing with various insurance options (Medicare, Medicaid, individual and group health insurance).

Our paper is also related to an emerging macro-health policy evaluation literature. Jeske and Kitao (2009) is one of the first efforts to conduct health policy reform using a large scale life-cycle model with a rich set of institutional details (e.g. distinction between employer provided group insurance and individually purchased health insurance, realistic taxes, etc.). Kashiwase (2009) examines a number of fiscal policies that achieve universal insurance coverage and finance the growing cost of health care. However, these models treat health in a highly stylized fashion as they assume exogenous health expenditure shocks. They ignore the micro-foundations of the health accumulation process and the utilization of health care services. These models, therefore, cannot account for health expenditure adjustments triggered by changes in the health insurance environment (ex-post moral hazard effects). There is a newly evolving health-macro literature that develops more realistic life-cycle (general equilibrium) models of the U.S. economy.[4] In particular, we extend previous studies and include the process of life-cycle health accumulation, health spending and financing into a dynamic general equilibrium framework. This extension is essential to capture the two-way relation between health spending and financing over age. More importantly, our model incorporates the ex-post moral hazard and adverse selection problems that affect health insurance take-up rates, health spending as well as

[4]See Suen (2006), Jung and Tran (2008), Jung and Tran (2009), Feng (2009), and Halliday, He and Zhang (2010).

macroeconomic aggregates and welfare.

Finally, our study contributes to the recent literature that attempts to evaluate the effects of the ACA. Brugenmann and Manovskii (2010) investigate the implications on firm decisions to offer health insurance. They use an infinite horizon model with exogenous health expenditure shocks and with institutional details of employer-provided health insurance markets. Closely related to our study is Pashchenko and Porapakkarm (2013). However, their model treats health spending as purely exogenous and therefore unaffected by the ACA. Instead, we include the micro-foundations of the health capital accumulation process that has been developed in the health economics literature, which allows us to derive the demand for medical services and the demand for health insurance from the household optimization problem together with life-cycle consumption, labor supply and savings. Moreover, we explicitly include the production side of the health care sector and therefore completely endogenize the supply of medical services and the determination of prices in the medical care sector. Hence, our work contributes to bridging the gap between health economics and macroeconomics.

The paper is structured as follows. Section 3 presents the model. In section 4 we present the calibration of the model. Section 5 contains the results of simulating the reform bill and discusses alternative policy experiments. Section 6 concludes. Appendix A contains details of MEPS data. Appendix B contains details of the ACA implementation in the model, and Appendix C contains calibration tables.

2 The U.S. health care system

2.1 Some stylized facts of the U.S. health care system

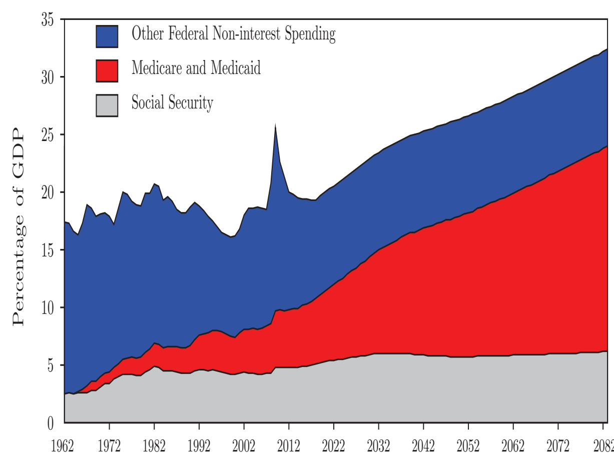

Figure 1: Public spending on health care

Health expenditures over time. Over the last two decades, medical expenditures have increased substantially while private insurance take-up rates have declined. The increase in health care costs threatens the solvency of public health insurance programs including Medicare and Medicaid and puts pressure on the overall government budget. As projected by the CBO in Figure 1, health care spending has become the second largest government spending program. The fiscal situation is getting worse due to a demographic shift that increases the fraction of the older population and subsequently the size of the Medicare and Medicaid programs. As seen in Figure 1, Medicare and Medicaid will soon become the largest government spending program.

Health expenditures and financing. We next briefly document the key life-cycle patterns of health spending and financing. We use data from the Medical Expenditure Panel Survey (MEPS) to construct life-cycle profiles of health expenditures and health care financing in Figure 2. In this figure we have averaged health expenditure by age group and financing source.[5]

We observe a pronounced increase of health expenditures as individuals get older. On average, individuals in their twenties spend about $\$1,500$ per year on health care whereas older individuals in their fifties spend about $\$4,000$ per year. Once individuals become older than fifty, their health expenditures start to increase significantly. The highest expenditures are incurred by the very old towards the end of their life and amount to approximately $\$12,000$ on average per year.

In addition, we break down health expenditures by funding source over the life-cycle. Private insurance reimbursements and out-of-pocket payments are the two major funding sources for medical spending. The fraction of health expenditure financed by private insurance and Medicaid decreases as an individual ages, whereas the fraction of health expenditures financed by out-of-pocket funds increases moderately. Around the retirement age of 65 there is a big shift in the magnitude of financing from private insurance toward public insurance including Medicare, Veteran's benefits, and other State run insurance.

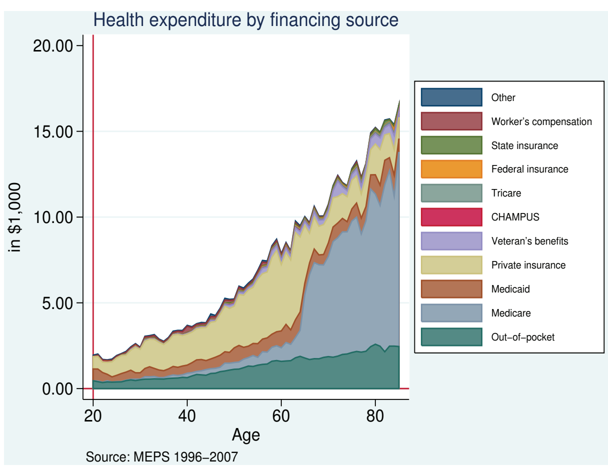

Figure 2: Health spending over the life-cycle: MEPS 1996-2007

Age profiles of insurance take-up rates. We present the insurance take-up rates over the life-cycle in Figure 3. As indicated in the first panel, the mixed health insurance system fails to provide full coverage. The employer-based group health insurance policies (GHI) cover only around 60 percent of the working population while the individual-based health insurance policies (IHI) cover less than 6 percent. The fraction of the uninsured is highest among young workers who are below 35 years old. This observation has often been attributed to the presence of adverse selection in the market for private health insurance. A large number of healthy and young individuals stay out of health

[5]Appendix A contains more details about MEPS data.

insurance markets, either by choice or by circumstance. The public health insurance program (i.e. Medicaid) picks up some low income workers, however, it covers less than 10 percent of the working age population. Consequently, this leaves about 25 percent of the working population without health insured which contributes to high insurance premiums and poor risk pooling.

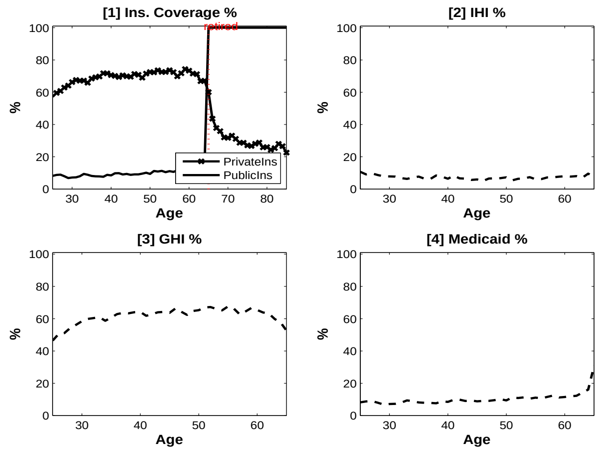

Figure 3: Insurance take-up rates over the life-cycle: MEPS 2000-2009

In summary, there are two problems prevailing in the U.S. health care system: first, a large fraction of the U.S. population does not have health insurance; second, the U.S. spends a much larger share of its national income on health care than any other OECD country. The ACA was implemented to address some of these problems, but its methods remain controversial. In the next section we discuss the main features of the ACA reform.

2.2 Key features of the ACA

The Affordable Care Act (hereafter, ACA), signed by President Obama in March 2010, represents the most significant reform to the U.S. health care system since the introduction of Medicare in 1965. There are many provisions in the ACA whose implementation will be phased in over several years, and some of the most significant changes will take effect in 2014. In particular, the most important features of the ACA are the following:

Insurance mandate with penalties. Starting in 2014 it is compulsory for workers to have health insurance. Workers who do not have health insurance face a tax penalty of up to 2.5 percent of their income. The implementation will be phased in over several years. The penalty is 1 percent of income or \$95 in 2014 and rises to 2 percent or \$325, whichever is higher, in 2015. These penalties are scheduled to be implemented fully by 2016. Cost-of-living adjustments will be made annually after 2016. If the least inexpensive policy available would cost more than 8 percent of one's monthly income, no penalties apply and hardship exemptions will be permitted for those who cannot afford the cost. Moreover, employers with more than 50 full-time employees will be required to provide health insurance. Employers who do not offer health insurance face a fine of $\$2,000$ per worker each year minus some allowances.

Insurance exchanges with premium subsidies. By 2014 state or federally run health insurance exchanges will be established in which all individuals who are either unemployed, self-employed and not currently covered by employer-sponsored health insurance can purchase insurance at subsidized premium rates. Premiums for individuals who purchase their insurance from the insurance exchanges will be based on the average health expenditure risks of those in the exchange pool. There are a series of statutory requirements for insurance companies that want to participate in an insurance exchange (i.e. no spending caps, no denial of coverage to children with pre-existing conditions, minimum coverage requirements, etc.). The reform also puts new restrictions on the price setting and screening procedures for health insurances traded on these markets. More importantly, workers who are not offered insurance from their employers and whose income is between 133 and 400 percent of the FPL are eligible to buy health insurance through insurance exchanges at subsidized rates according to Table 1.

Income in percent of FPL	**Premium subsidy rate**
100 – 150%	94%
150 – 200%	77%
200 – 250%	62%
250 – 300%	42%
300 – 350%	25%
350 – 400%	13%

Table 1: Income levels and insurance premium subsidies for an individual according to An Analysis of Health Insurance Premiums Under the Patient Protection and Affordable Care Act by the Congressional Budget Office, 2009.

Medicaid expansion. The ACA expands the Medicaid eligibility threshold uniformly to 133 percent of the FPL and removes the asset test. The asset test is an asset ceiling that an individual's asset holdings cannot exceed in order to be Medicaid eligible.[6] However, only about half the states participate in this expansion.

Financing. The reform bill is financed by increases in Medicare payroll taxes from 1.45 percent to 2.35 percent for individuals with incomes higher than $200,000 per year (or $250,000 for families). Various other sources are used to generate additional revenue in order to pay for the reform.[7] Other features of the reform include a $250 Medicare drug cost rebate to alleviate the problems caused by the "Donut Hole" in Medicare Part D and a provision that allows young adults to stay on their parents' health insurance up to age 26.[8] We next introduce the pre-ACA benchmark model.

[6]According to Kaiser (2013) the pre-ACA Medicaid eligibility thresholds vary greatly (i.e. 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 vary greatly with respect to the asset test.

[7]E.g. a 3.8 percent tax on unearned income for individuals with incomes higher than $200,000, a 40 percent excise tax on a portion of high-end insurance policies ("Cadillac plans"), fees collected from the insurance and pharmaceutical industry, funds from social security, Medicare and student loans, increased penalties on non-medical withdrawals from Health Savings Accounts, lower contribution limits to tax free Flexible Spending Accounts, a tanning tax of 10 percent, a new excise tax of 2.3 percent on medical equipment, and others.

[8]The "Donut Hole" refers to a coverage gap for prescription drugs in Medicare Part D. Individuals spending between $2,700 – $6,154 on prescription drugs pay fully out-of-pocket.

3 The model

3.1 Demographics

The economy is populated with overlapping generations of individuals who live to a maximum of J periods. Individuals work for J_1 periods and then retire for $J - J_1$ periods. In each period individuals of age j face an exogenous survival probability π_j. Deceased agents leave an accidental bequest that is taxed and redistributed equally to all working-age agents alive. The population grows exogenously at an annual net rate 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 $\mu_j = \frac{\pi_j}{(1+n)^{years}}\mu_{j-1}$ and $\tilde{\mu}_j = \frac{1-\pi_j}{(1+n)^{years}}\mu_{j-1}$, where $years$ denotes the number of years per model period.

3.2 Endowments and preferences

In each period individuals are endowed with one unit of time that can be used for work l or leisure. Individual utility is denoted by function $u(c, l, h, m)$ where $u : R^4_{++} \to R$ is C^2, increases in consumption c and health h, and decreases in labor l and health care services m as procuring the latter decreases available leisure.[9] Individuals are born with a specific skill type ϑ that cannot be changed over their life-cycle and that together with their health state h_j and an idiosyncratic labor productivity shock ϵ^l_j determines their age-specific labor efficiency unit $e\left(\vartheta, h_j, \epsilon^l_j\right)$. The transition probabilities for the idiosyncratic productivity shock ϵ^l_j follow an age-dependent Markov process with transition probability matrix Π^l. Let an element of this transition matrix be defined as the conditional probability $\Pr\left(\epsilon^l_{i,j+1}|\epsilon^l_{i,j}\right)$, where the probability of next period's labor productivity $\epsilon^l_{i,j+1}$ depends on today's productivity $\epsilon^l_{i,j}$.[10]

3.3 Health capital, insurance and expenditures

Health capital. Health capital depreciates due to aging at rate δ^h_j and idiosyncratic health shocks ϵ^h_j. Agents can buy medical services to improve their health capital as in Grossman (1972a). Health evolves endogenously over the lifetime of an agent according to

$$h_j = i\left(m_j, h_{j-1}, \delta^h, \epsilon^h_j\right), \tag{1}$$

where h_j denotes the current health capital, h_{j-1} denotes last period's health capital, and m_j is the amount of medical services bought in period j. The exogenous health shock ϵ^h_j follows a Markov process with age dependent transition probability matrix Π^h_j. Transition probabilities to next period's

[9] Our specification implicitly assumes a linear relationship between health capital and service flows derived from health capital which is similar to the assumption in the original Grossman model, see Grossman (1972a).

[10] We abstract from the link between health and survival probabilities. We are aware that this presents a limitation and that certain mortality effects cannot be captured (see Ehrlich and Chuma (1990) and Hall and Jones (2007)). However, given the complexity of the current model we opted to simplify this dimension to keep the computational structure more tractable.

health shock ϵ^h_{j+1} depend on the current health shock ϵ^h_j so that an element of transition matrix Π^h_j is defined as the conditional probability $\Pr\left(\epsilon^h_{j+1}|\epsilon^h_j\right)$.

Health insurance. We model private health insurance and public health insurance. In the private health insurance markets, we distinguish between two types of insurance policies, an individual health insurance plan (IHI) and a group health insurance plan (GHI). In order to be covered by insurance, agents have to buy insurance one period prior to the realization of their health shock. The insurance policy will become active in the following period and needs to be renewed each period.[11] IHI can be bought by any agent for an age and health dependent premium, $\text{prem}^{\text{IHI}}(j,h)$. GHI can only be bought for a premium, prem^{GHI}, by workers who are (randomly) matched with an employer that offers GHI which is indicated by random variable $\epsilon^{\text{GHI}} = 1$. The insurance premium, prem^{GHI}, is tax deductible and insurance companies are not allowed to screen workers by health or age. If a worker is not offered group insurance from the employer, i.e. $\epsilon^{\text{GHI}} = 0$, the worker can still buy IHI. In this case the insurance premium is not tax deductible and the insurance company screens the worker by age and health status. The probability of being offered group insurance is highly correlated with income, so that the Markov process that governs the group insurance offer probability will be a function of the permanent skill type ϑ of an agent. Let $\Pr\left(\epsilon^{\text{GHI}}_{j+1}|\epsilon^{\text{GHI}}_j,\vartheta\right)$ be the conditional probability that an agent has group insurance status $\epsilon^{\text{GHI}}_{j+1}$ at age $j+1$ given she had group insurance status ϵ^{GHI}_j at age j. We collect all conditional probabilities for group insurance status in the transition probability matrix $\Pi^{\text{GHI}}_{j,\vartheta}$ which has dimension 2×2 for each permanent skill type.

There are two public health insurance programs available, Medicaid for the poor and Medicare for retirees. To be eligible for Medicaid, individuals are required to pass an income and asset test. The health insurance state in_j can therefore take on the following values at age $j < J_1$:

$$in_j = \begin{cases} 0 & \text{if not insured,} \\ 1 & \text{if Individual health insurance (IHI),} \\ 2 & \text{if Group health insurance (GHI),} \\ 3 & \text{if Medicaid/Medicare.} \end{cases}$$

After retirement ($j > J_1$), all agents are covered by a public health insurance program i.e. a combination of Medicare and Medicaid for which they pay premium, prem^R.

Health expenditure. An agent's total health expenditure in any given period is $p_m^{in_j} \times m_j$, where the price of medical services $p_m^{in_j}$ depends on insurance state in_j.[12] The out of pocket health

[11] By construction, agents in their first period are thus not covered by any insurance.

[12] Note that we only model discretionary health expenditures so that income will have a strong effect on endogenous total medical expenses. Our setup assumes that given the same magnitude of health shocks ϵ^h_j, a richer individual will outspend a poor individual. This may be realistic in some circumstances, however, a large fraction of health expenditures in the U.S. is non-discretionary (e.g. health expenditures caused by catastrophic health events that require surgery etc.). In such cases a poor individual could still incur large health care costs. However, it is not unreasonable to assume that a rich person will outspend a poor person even under these circumstances.

expenditure of a working-age agent is given by

$$o(m_j) = \begin{cases} p_m^{in_j} \times m_j, & \text{if } in_j = 0, \\ \rho^{in_j}\left(p_m^{in_j} \times m_j\right), & \text{if } in_j > 0 \end{cases} \tag{2}$$

where $0 \leq \rho^{in_j} \leq 1$ are the insurance state specific coinsurance rates. The coinsurance rate denotes the fraction of the medical bill that the patient has to pay out-of-pocket.[13] A retired agents out-of-pocket expenditure is $o(m_j) = \rho^R\left(p_m^R \times m_j\right)$, where ρ^R is the coinsurance rate of Medicare and p_m^R is the price that a retiree pays for medical services.

3.4 Technology and firms

The economy consists of two separate production sectors that produce two types of final consumption goods. Sector one is populated by a continuum of identical firms that use physical capital K and effective labor services L to produce non-medical consumption goods c with a normalized price of one. Firms in the non-medical sector are perfectly competitive and solve the following maximization problem

$$\max_{\{K,\, L\}} \left\{F(K, L) - qK - wL\right\}, \tag{3}$$

taking the rental rate of capital q and the wage rate w as given. Capital depreciates at rate δ in each period. Sector two, the medical sector, is also populated by a continuum of identical firms that use capital K_m and labor L_m to produce medical services m at a price of p_m. Firms in the medical sector maximize

$$\max_{\{K_m,\, L_m\}} \left\{p_m F_m(K_m, L_m) - qK_m - wL_m\right\}. \tag{4}$$

The price p_m is a base price for medical services. The price paid by consumers is insurance state dependent so that $p_j^{in_j} = \left(1 + \nu^{in_j}\right) p_m$ where ν^{in_j} is an insurance state dependent markup factor that will generate a profit for medical care providers, denoted Profit^M. Profits are redistributed in equal amounts to all surviving agents.

3.5 Household problem

Workers. Agents with age $j \leq J_1$ are workers and thus exposed to labor shocks. The agent's state vector at age j is given by $x_j = \left(a_j, h_{j-1}, \vartheta, \epsilon_j^l, \epsilon_j^h, \epsilon_j^{GHI}, in_j\right)$, where a_j is the capital stock at the beginning of the period, h_{j-1} is the health state at the beginning of the period, ϑ is the skill type, ϵ_j^l is the positive labor productivity shock, ϵ_j^h is a negative health shock, ϵ_j^{GHI} indicates whether group insurance from the employer is available for purchase in this period, and in_j is the insurance state at the beginning of the period. Note that, $x_j \in D_W \equiv R_+ \times R_+ \times \{1, 4\} \times R_+ \times R_- \times \{0, 1\} \times \{0, 1, 2, 3\}$.

After realization of the state variables, agents simultaneously decide their consumption c_j, labor supply l_j, health service expenditures m_j, asset holdings for the next period a_{j+1}, and insurance state for the next period in_{j+1} to maximize their lifetime utility. The household optimization problem for

[13] For simplicity we include deductibles and copays into the coinsurance rate.

workers $j = \{1, ..., J_1\}$ can be formulated recursively as

$$V(x_j) = \max_{\{c_j, l_j, m_j, a_{j+1}, in_{j+1}\}} \left\{ u(c_j, h_j, l_j, m_j) + \beta \pi_j E\left[V(x_{j+1}) \mid \epsilon_j^l, \epsilon_j^h, \epsilon_j^{GHI} \right] \right\} s.t. \tag{5}$$

$$\begin{aligned}
& \left(1+\tau^C\right) c_j + (1+g)\, a_{j+1} + o(m_j) + 1_{\{in_{j+1}=1\}} \mathrm{prem}^{\mathrm{IHI}}(j,h) + 1_{\{in_{j+1}=2\}} \mathrm{prem}^{\mathrm{GHI}} \\
= \;& y_j + t_j^{\mathrm{SI}} - tax_j, \\
0 \;\leq\; & a_{j+1}, \; 0 \leq l_j \leq 1, \text{ and } (1),
\end{aligned}$$

where

$$\begin{aligned}
y_j &= e\left(\vartheta, h_j, \epsilon_j^l\right) \times l_j \times w + R\left(a_j + t^{\mathrm{Beq}}\right) + \mathrm{profits}^M + \mathrm{profits}^{\mathrm{Ins}}, \\
tax_j &= \tilde{\tau}(\tilde{y}_j) + tax_j^{SS} + tax_j^{\mathrm{Med}}, \\
\tilde{y}_j &= y_j - a_j - t^{\mathrm{Beq}} - 1_{[in_{j+1}=2]} \mathrm{prem}^{\mathrm{GHI}} - 0.5\left(tax_j^{SS} + tax_j^{\mathrm{Med}}\right), \\
tax_j^{SS} &= \tau^{\mathrm{SS}} \times \min\left(\bar{y}_{ss},\; e\left(\vartheta, h_j, \epsilon_j^l\right) \times l_j \times w - 1_{[in_{j+1}=2]} \mathrm{prem}^{\mathrm{GHI}}\right), \\
tax_j^{\mathrm{Med}} &= \tau^{\mathrm{Med}} \times \left(e\left(\vartheta, h_j, \epsilon_j^l\right) \times l_j \times w - 1_{[in_{j+1}=2]} \mathrm{prem}^{\mathrm{GHI}}\right), \\
t_j^{\mathrm{SI}} &= \max\left[0,\; \underline{c} + o(m_j) + tax_j - y_j\right].
\end{aligned} \tag{6}$$

Variable τ^C is the consumption tax rate, g is the exogenous growth rate of the economy, $o(m_j)$ is out-of-pocket medical spending, y_j is the sum of all income including labor, assets, bequests, and profits from medical providers ($\mathrm{profits}^M$) and insurance companies ($\mathrm{profits}^{\mathrm{Ins}}$). Variable w is the market wage rate, R is the gross interest rate, t_j^{Beq} denotes accidental bequests, tax_j is total taxes paid[14], and t_j^{SI} is social insurance (e.g. food stamp programs). Taxable income is denoted $\tilde{y}_j$ which is composed of wage income and interest income on assets, interest earned on accidental bequests, and profits from insurance companies and medical services providers minus the employee share of payroll taxes and the premium for health insurance. The payroll taxes are tax_j^{SS} for social security and tax_j^{Med} for Medicare. Both are paid on wage income below $\bar{y}_{ss}$ (i.e. \$106,800 in 2010).

Agents can only buy private individual or private group health insurance if they have sufficient funds. Agents become eligible for Medicaid if their income falls below the Medicaid eligibility threshold, $\tilde{y}_j \leq FPL_{\mathrm{Maid}}$, and if their asset holdings pass the asset test, $a_j \leq a_{Maid}$. In this case the insurance choice indicator switches to $in_{j+1} = 3$ and agents do not pay any more premiums for the

[14]If health insurance was provided by the employer, so that premiums would be partly paid for by the employer, then the tax function would change to

$$tax_j = \tilde{\tau}(\tilde{y}_j) + 0.5\left(\tau^{\mathrm{Soc}} + \tau^{\mathrm{Med}}\right)\left(\tilde{w}_j - 1_{\{in_j=2\}}(1-\psi)\, p\right),$$

where ψ is the fraction of the premium paid for by the employer. Jeske and Kitao (2009) use a similar formulation to model private vs. employer provided health insurance. We simplify this aspect of the model and assume that all group health insurance policies are offered via the employer but that the employee pays the entire premium, so that $\psi = 0$. The premium is therefore tax deductible in the employee (or household) budget constraint. We also allow for income tax deductibility of insurance premiums due to IRC provision 125 (Cafeteria Plans) that allows employers to set up tax free accounts for their employees in order to pay for qualified health expenses but also the employee share of health insurance premiums.

next period. In their last working period workers will not buy private insurance anymore because they become eligible for Medicare when retired. The social insurance program t_j^{SI} guarantees a minimum consumption level $\underline{c}$. If social insurance is paid out, then automatically $a_{j+1} = 0$ and insurance state $in_j = 3$ (Medicaid), so that social insurance cannot be used to finance savings and private health insurance.

Retirees. Old agents, $j > J_1$ are retired and receive pension payments. They do not face labor market shocks anymore. The only remaining idiosyncratic shock for retirees is the health shock ϵ_j^h. Retirees are also eligible for Medicare and do not buy any more private health insurance. The state vector of a retired agent therefore reduces to $x_j = \left(a_j, h_{j-1}, \epsilon_j^h\right) \in D_R \equiv R_+ \times R_+ \times R_-$ and the household problem can be formulated recursively as

$$V(x_j) = \max_{\{c_j, m_j, a_{j+1}\}} \left\{ u(c_j, h_j, m_j) + \beta \pi_j E\left[V(x_{j+1}) \mid \epsilon_j^h\right] \right\} \ s.t. \tag{7}$$

$$\begin{aligned} \left(1+\tau^C\right) c_j + (1+g) a_{j+1} + o(m_j) + \text{prem}^R &= y_j + t_j^{\text{SI}} - tax_j, \\ a_{j+1} &\geq 0, \end{aligned}$$

where

$$\begin{aligned} y_j &= t_j^{\text{SS}} + R\left(a_j + t^{\text{Beq}}\right) + \text{profits}^M + \text{profits}^{\text{Ins}}, \\ tax_j &= \tilde{\tau}\left(\tilde{y}_j^R\right), \\ \tilde{y}_j^R &= y_j - a_j - t_j^{\text{Beq}}, \\ t_j^{\text{SI}} &= \max\left[0, \underline{c} + o(m_j) + tax_j - y_j\right]. \end{aligned}$$

Variable t_j^{SS} denotes pension payments and prem^R is the insurance premium for Medicare Part B.

For each $x_j \in D_j$ let $\Lambda(x_j)$ denote the measure of age j agents with $x_j \in D_j$. Then expression $\mu_j \Lambda(x_j)$ becomes the population measure of age-j agents with state vector $x_j \in D_j$ that is used for aggregation.

3.6 Insurance sector

For simplicity we abstain from modeling insurance companies as profit maximizing firms and simply allow for a premium markup ω. Since insurance companies in the individual market screen customers by age and health, we impose separate clearing conditions for each age-health type (j, h), so that price, $\text{prem}^{\text{IHI}}(j,h)$ adjusts to balance

$$\begin{aligned} & \left(1+\omega_{j,h}^{\text{IHI}}\right)\sum_{j=2}^{J_1}\mu_j\int\left[1_{[in_j(x_{j,-h})=1]}\left(1-\rho^{\text{IHI}}\right)p_m^{\text{IHI}}m_{j,h}\left(x_{j,-h}\right)\right]d\Lambda\left(x_{j,-h}\right) \\ = & \; R\sum_{j=1}^{J_1-1}\mu_j\int\left(1_{[in_{j,h}(x_{j,-h})=1]}\text{prem}^{\text{IHI}}\left(j,h\right)\right)d\Lambda\left(x_{j,-h}\right), \end{aligned} \tag{8}$$

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

$$\begin{aligned} & \left(1+\omega^{\text{GHI}}\right)\sum_{j=2}^{J_1}\mu_j\int\left[1_{[in_j(x_j)=2]}\left(1-\rho^{\text{GHI}}\right)p_m^{\text{GHI}}m_j\left(x_j\right)\right]d\Lambda\left(x_j\right) \\ = & \; R\sum_{j=1}^{J_1-1}\mu_j\int\left(1_{[in_j(x_j)=2]}\text{prem}^{\text{GHI}}\right)d\Lambda\left(x_j\right), \end{aligned} \tag{9}$$

where $\omega_{j,h}^{\text{IHI}}$ and ω^{GHI} are markup factors that determine loading costs (fixed costs or profits), $1_{[in_j(x_j)=1]}$ is an indicator function equal to unity whenever agents bought the individual health insurance policy, $1_{[in_j(x_j)=2]}$ is an indicator function equal to unity whenever agents bought the group insurance policy, ρ^{IHI} and ρ^{GHI} are the coinsurance rates, and p_m^{IHI} and p_m^{GHI} are the prices for health care services for the two insurance types. The respective first line in the above expressions summarize aggregate payments made by insurance companies, whereas the second line in each equation aggregates 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.

The premium markups generate profits, denoted $\mathit{Profit}^{\text{Ins}}$, that are redistributed in equal amounts to all surviving agents. The difference between the two insurance contracts is that GHI can only charge one price, prem^{GHI}, and that GHI premiums are tax deductible in the household budget constraint.

Notice that ex-post moral hazard and adverse selection issues arise naturally in the model due to information asymmetry. Insurance companies cannot directly observe the idiosyncratic health shocks and have to reimburse agents based on the actual observed levels of health care spending. Adverse selection arises because insurance companies cannot observe the risk type of agents and therefore cannot price insurance premiums accordingly. They instead have to charge an average premium that clears the insurance companies' profit condition.[15]

3.7 Government

The government taxes consumption at rate τ^C and income (i.e. wages, interest income, interest on bequests, and profits for insurance companies and medical providers) at a progressive tax rate $\tilde{\tau}(\tilde{y}_j)$ which is a function of taxable income $\tilde{y}$ and finances a social insurance program T^{SI} (e.g. foodstamps),

[15]Individual insurance contracts do distinguish agents by age and health status but not by their health shock.

Medicare and Medicaid, as well as exogenous government consumption G. Government spending G is unproductive.

Since in the model health insurance for the old is a combination of Medicare and Medicaid, we make it part of the general budget constraint. The government uses a Medicare payroll tax on workers as well as Medicare plan B premiums to cover some of the cost of Medicare and Medicaid for retirees. The government budget is balanced in each period so that

$$\begin{aligned} & G+\sum_{j=1}^{J}\mu_j\int t_j^{\mathrm{SI}}\left(x_j\right)d\Lambda\left(x_j\right)+\sum_{j=2}^{J_1}\mu_j\int\left(1-\rho^{\mathrm{MAid}}\right)p_m^{\mathrm{MAid}}m_j\left(x_j\right)d\Lambda\left(x_j\right) \\ & +\sum_{j=J_1+1}^{J}\mu_j\int\left(1-\rho^{R}\right)p_m^{R}m_j\left(x_j\right)d\Lambda\left(x_j\right) \\ = & \sum_{j=1}^{J}\mu_j\int\left[\tau^{C}c\left(x_j\right)+tax_j\left(x_j\right)\right]d\Lambda\left(x_j\right)+\sum_{j=J_1+1}^{J}\mu_j\int\mathrm{prem}^{R}\left(x_j\right)d\Lambda\left(x_j\right) \\ & +\sum_{j=1}^{J_1}\mu_j\int\tau^{\mathrm{Med}}\left(e_j\left(x_j\right)\times l_j\left(x_j\right)\times w-1_{[in_{j+1}(x_j)=2]}\mathrm{prem}^{\mathrm{GHI}}\left(x_j\right)\right)d\Lambda\left(x_j\right), \end{aligned} \tag{10}$$

where ρ^{MAid} is the coinsurance rate of Medicaid, p_m^{MAid} is the price of medical services for individuals on Medicaid, ρ^R is the coinsurance rate for retired individuals on Medicare/Medicaid and p_m^R is the price for medical services for retirees. Indicator function $1_{\{in_{j+1}(x_j)=2\}}$ equals unity whenever the agent type x_j purchases GHI via their employer. In this case the insurance premium is tax deductible. In addition, the government runs a PAYG Social Security program which is self-financed via a payroll tax so that

$$\begin{aligned} & \sum_{j=J_1+1}^{J}\mu_j\int t_j^{\mathrm{SS}}\left(x_j\right)d\Lambda\left(x_j\right) \\ = & \sum_{j=1}^{J_1}\mu_j\int\tau^{\mathrm{SS}}\times\left(e_j\left(x_j\right)\times l_j\left(x_j\right)\times w-1_{[in_{j+1}(x_j)=2]}\mathrm{prem}^{\mathrm{GHI}}\right)d\Lambda\left(x_j\right). \end{aligned} \tag{11}$$

Accidental bequests are redistributed in a lump-sum fashion to working-age households

$$\sum_{j=1}^{J_1}\mu_j\int t_j^{\mathrm{Beq}}\left(x_j\right)d\Lambda\left(x_j\right)=\sum_{j=1}^{J}\int\tilde{\mu}_j a_j\left(x_j\right)d\Lambda\left(x_j\right), \tag{12}$$

where μ_j and $\tilde{\mu}_j$ denote the surviving and deceased number of agents at age j in time t, respectively.

3.8 Recursive equilibrium

Given transition probability matrices $\left\{\Pi_j^l,\Pi_{j,\vartheta}^{\mathrm{GHI}}\right\}_{j=1}^{J_1}$ and $\left\{\Pi_j^h\right\}_{j=1}^{J}$, survival probabilities $\{\pi_j\}_{j=1}^{J}$ and exogenous government policies $\left\{tax\left(x_j\right),\tau^C,\mathrm{prem}^R,\tau^{SS},\tau^{\mathrm{Med}}\right\}_{j=1}^{J}$, a competitive equilibrium is a collection of sequences of distributions $\{\mu_j,\Lambda_j\left(x_j\right)\}_{j=1}^{J}$ of individual household decisions

$\{c_j(x_j), l_j(x_j), a_{j+1}(x_j), m_j(x_j), in_{j+1}(x_j)\}_{j=1}^J$, aggregate stocks of physical capital and effective labor services $\{K, L, K_m, L_m\}$, factor prices $\{w, q, R, p_m\}$, markups $\{\omega^{\text{IHI}}, \omega^{\text{GHI}}, \nu^{in}\}$ and insurance premiums $\{\text{prem}^{\text{GHI}}, \text{prem}^{\text{IHI}}(j,h)\}_{j=1}^J$ such that

(a) $\{c_j(x_j), l_l(x_j), a_{j+1}(x_j), m_j(x_j), in_{j+1}(x_j)\}_{j=1}^J$ solves the consumer problems (5) and (7),

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

$$\begin{aligned} w &= F_L(K,L) = p_m F_{m,L}(K_m, L_m), \\ q &= F_K(K,L) = p_m F_{m,K}(K_m, L_m), \\ R &= q + 1 - \delta, \end{aligned}$$

(c) markets clear

$$\begin{aligned} K + K_m &= \sum_{j=1}^{J} \mu_j \int (a(x_j))\, d\Lambda(x_j) + \sum_{j=1j}^{J} \int \tilde{\mu}_j a_j(x_j)\, d\Lambda(x_j) \\ &+ \sum_{j=1}^{J_1} \mu_j \int \left(1_{[in_{j+1}=2]}(x_j) \times \text{prem}^{\text{IHI}}(j,h) + 1_{[in_{j+1}=3]}(x_j) \times \text{prem}^{\text{GHI}} \right) d\Lambda(x_j), \\ L + L_m &= \sum_{j=1}^{J_1} \mu_j \int e_j(x_j) l_j(x_j)\, d\Lambda(x_j), \end{aligned}$$

(d) the aggregate resource constraint holds[16]

$$\begin{aligned} & G + (1+g) S + \sum_{j=1}^{J} \mu_j \int \left(c(x_j) + p_m^{in_j(x_j)} m(x_j) \right) d\Lambda(x_j) + \text{Profit}^{\text{Ins}} \\ = \;& Y + p_m Y_m + (1-\delta) K + \text{Profit}^{\text{M}}, \end{aligned}$$

(e) the government programs clear so that (11), (10), and (12) hold,

(f) the budget conditions of the insurance companies (8) and (9) 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 distribution.

[16] Profits from medical providers, Profit^M, are already included in the marked up prices $p_m^{ins_j(x_j)}$ for medical services on the left hand side.

4 Parameterization, estimation and calibration

We next parameterize the model and use a standard numeric algorithm to solve the model.[17] For the calibration we distinguish between two sets of parameters that we refer to as *external* and *internal* parameters. *External* parameters are estimated independently from our model and either based on our own estimates using data from MEPS, CMS, or estimates provided by other studies. We summarize these external parameters in Appendix B, Table 13. *Internal* parameters are calibrated so that model-generated data match a given set of targets from U.S. data. These parameters are presented in Appendix B, Table 14. Model generated data moments and target moments from U.S. data are juxtaposed in Appendix B, Table 15.

4.1 Demographics

One period is defined as 5 years. We model households from age 20 to age 95 which results in $J = 15$ periods. The annual conditional survival probabilities are taken from U.S. life-tables in 2010 and adjusted for period length.[18] The population growth rate for the U.S. was 1.2 percent on average from 1950 to 1997 according to the Council of Economic Advisors (1998). In the model the total population over the age of 65 is 17.7 percent which is very close to the 17.4 percent in the census.

4.2 Endowments and preferences

Preferences. We choose a Cobb-Douglas type utility function of the form

$$u(c,l,h,m) = \frac{\left(\left(c^{\eta} \times \left(\frac{1-l-1_{[l>0]}\bar{l}_j}{(1+m)^{\eta_m}}\right)^{1-\eta}\right)^{\kappa} \times h^{1-\kappa}\right)^{1-\sigma}}{1-\sigma},$$

where c is consumption, l is labor supply, $\bar{l}_j$ is the age dependent fixed cost of working as in French (2005), m is the amount of medical services, $0 < \eta_m < 1$ is a curvature parameter that determines the reduction in leisure due to the procurement of medical services, η is the intensity parameter of consumption relative to leisure, κ is the intensity parameter of health services relative to consumption and leisure, and σ is the inverse of the intertemporal rate of substitution (or relative risk aversion parameter). This functional form ensures that marginal utility of consumption declines as health deteriorates which has been pointed out in empirical work by Finkelstein, Luttmer and Notowidigdo (2008).

Fixed cost of working is set in order to match labor hours per age group. Parameter σ is set to 3.5 and the time preference parameter β is set to 1.025 to match the capital output ratio and the interest rate. It is understood that in a general equilibrium model every parameter affects the equilibrium value of all endogenous variables to some extent. Here we associate parameters with those equilibrium variables that are the most directly affected (quantitatively). The intensity parameter η is 0.43 to

[17] We first guess a price vector, then backward solve the household problem using these prices, then aggregate the economy and solve for a new price vector using firm first order conditions. We then update the price vector and repeat all the steps until the price vector converges. The algorithm is implemented on a multi-core server in parallel Fortran.

[18] CMS projections.

match the aggregate labor supply and κ is 0.89 to match the ratio between final goods consumption and medical consumption. In conjunction with the health productivity parameters ϕ_j and ξ from expression (14) these preference weights also ensure that the model matches total health spending and the health insurance take-up rate for each age group.

Labor productivity. The effective quality of labor supplied by workers is

$$e = e_j\left(\vartheta, h_j, \epsilon^l\right) = \left(\overline{wage}_{j,\vartheta}\right)^{\chi} \times \left(\exp\left(\frac{h_j - \overline{h}_{j,\vartheta}}{\overline{h}_{j,\vartheta}}\right)\right)^{1-\chi} \times \epsilon^l \text{ for } \; j = \{1, ..., J_1\}, \tag{13}$$

and has three components. First, we model the work efficiencies of four permanent skill types ϑ that are predetermined and evolve over age to capture the "hump" shape of life-cycle earnings. We estimate these labor efficiency profiles using average hourly wage estimates $\overline{wage}_{j,\vartheta}$ per permanent skill group ϑ and age j from MEPS data. The four permanent skill types are defined as average individual wages per wage quartile.

Second, the quality of labor can be influenced by health. Since $\overline{wage}_{j,\vartheta}$ already reflects the productivity for average health capital among the (j, ϑ) types, the idiosyncratic health effect is measured as percent deviation from the average health capital $\overline{h}_{j,\vartheta}$ per skill and age group. In order to avoid negative numbers we use the exponent function. Parameter $\chi = 0.85$ measures the relative weight of the average productivity vs. the individual health effect.

The third component is an idiosyncratic labor productivity shock ϵ^l and is based on Storesletten, Telmer and Yaron (2004). We specify $\log\left(\epsilon^l_{t+1}\right) = \omega_t + \epsilon_t$ and $\epsilon_t = \gamma \times \omega_t + v_t$, where $\epsilon_t \sim N\left(0, \sigma^2_\epsilon\right)$ is the transitory component and ω is the persistent component of the labor shock ϵ^l. The error term in the second equation follows a normal distribution, $v_t \sim N\left(0, \sigma^2_v\right)$. Storesletten et al. (2004) estimate $\gamma = 0.935$, $\sigma^2_\epsilon = 0.01$ and $\sigma^2_v = 0.061$. We then discretize the labor shocks into a five state Markov process following Tauchen (1986) so that the magnitude of the labor shocks are $\epsilon^l \in \{4.41;\ 3.51;\ 2.88;\ 2.37;\ 1.89\}$.

4.3 Health capital

The law of motion of health capital consists of three components:

$$h_j = i\left(m_j, h_{j-1}, \delta^h_j, \epsilon^h_j\right) = \overbrace{\phi_j m^{\xi}_j}^{\text{Investment}} + \overbrace{\left(1 - \delta^h_j\right) h_{j-1}}^{\text{Trend}} + \overbrace{\epsilon^h_j}^{\text{Disturbance}}. \tag{14}$$

The first component is a health production function that uses health services m as inputs to produce new quantities of health capital. Agents can use health services to reinvest into their health capital. The second component measures the natural health deterioration over time. Depreciation rate δ^h_j is the per period health depreciation of an individual of age j. Finally, the third component represents a random and age dependent health shock. This law of motion for health is widely used in the Grossman health capital literature. The first two components are used in the original deterministic analysis of Grossman (1972a). The third component can be thought of as a random depreciation rate as discussed in Grossman (2000). Calibrating the law of motion for health is non-trivial for two reasons. First, there is no consensus on how to measure health capital. Second, to the best of our knowledge, suitable estimates for health production processes within macro modeling frameworks do not exist.

MEPS contains two possible sources of information on health status that could serve as a measure of health capital: self-reported health status and the health index Short-Form 12 Version 2 ($SF-12v2$).[19] Many previous studies use the former as a proxy for health capital and health shocks (e.g. De Nardi, French and Jones (2010) use self-reported health status reported in AHEAD data from the Health and Retirement Study). However this measure is very subjective and not directly comparable between two individuals with different age (i.e. the definition of "excellent" health may mean something entirely different for a 20 or 60 year old individual, respectively). The $SF-12v2$ is a more objective measure of health. This index is widely used in the health economics literature to assess health improvements after medical treatments in hospitals. For this reason, we use the $SF-12v2$ as measure for health capital in our model.

A metric space for health capital. In order to construct a health capital grid in the model we first choose a maximum health capital level $h_m^{max} = 3.5$. All other health shock and health production parameters are then calibrated off this value. The lower bound of the health grid $h_m^{\min}$ is treated as an internal parameter whose magnitude will influence the model outcome. It therefore has to be calibrated and is chosen in conjunction with the health production parameters ϕ_j and ξ. We allow for 15 health states on this grid.

Health depreciation rates. We next approximate the natural rate of health depreciation δ_j^h per age group. We calculate the average health capital $\bar{h}_j$ per age group of individuals with group insurance and zero health spending in any given year. We then postulate that such individuals did not incur a negative health shock in this period as they could easily afford to buy medical services m to replenish their health due to their insurance status. This means that for those individuals the smoothing and shock component in expression (14) disappears as $\epsilon_j^h = 0$ and $m_j = 0$. The average law of motion of health capital then reduces to $\bar{h}_j = \overbrace{\left(1 - \delta_j^H\right) \bar{h}_{j-1}}^{\text{Trend}}$, from which we can recover the age dependent natural rate of health depreciation δ_j^h. The depreciation rates are increasing in age and fall between 0.6 and 2.13 percent per period. Note that these values are rather small because they do not contain the negative health shocks that are modeled separately.

Health shocks. For each age cohort j we separate individuals into four risk groups: group 1, whose health capital levels fall into the 25^{th} percentile of age j individuals, group 2 whose health capital levels fall between the 25^{th} and the 50^{th} percentile, group 3 falls between the 50^{th} and the 75^{th} percentile, and group 4 whose health capital is in the top quartile. We then assume that group 4 experiences no health shock, so that this group's average health capital defines the maximum health capital $\bar{h}_{j,d}^{max}$ (where subscript d indicates that this variable is calculated from MEPS data). Group 3 experiences a "small" health shock, group 2 experiences a "moderate" health

[19] The $SF-12v2$ includes twelve health measures of physical and mental health. There are two versions of this index available, one for physical health and the other for mental health. Both measures use the same health measures to construct the index but the physical health index puts more weight on variables measuring physical health components (compare Ware, Kosinski and Keller (1996) for further details about this health index). For this study we use the physical health index.

shock, and group 1 suffers from a "large" health shock. The averages of health capital per age group are denoted $\left\{\bar{h}_{j,d}^{\max} > \bar{h}_{j,d}^{3} > \bar{h}_{j,d}^{2} > \bar{h}_{j,d}^{1}\right\}$. We next express the shock magnitudes as percentage deviations from the maximum health state in the data, so that the shock vector is: $\epsilon_j^{h\%} = \left\{0, \frac{\bar{h}_{j,d}^{3}-\bar{h}_{j,d}^{\max}}{h_{j,d}^{\max}}, \frac{\bar{h}_{j,d}^{2}-\bar{h}_{j,d}^{\max}}{h_{j,d}^{\max}}, \frac{\bar{h}_{j,d}^{1}-\bar{h}_{j,d}^{\max}}{h_{j,d}^{\max}}\right\}$. This vector is then multiplied with the maximum health capital level in the model $h_m^{\max}$ to calculate the shock levels in the model. The transition probability matrix of health shocks Π^h is calculated by counting how many individuals move across risk groups between two consecutive years in MEPS data. We smooth the transition probabilities and adjust for period length.

The health production technology. Grossman (1972b) and Stratmann (1999) estimate positive effects of medical services on measures of health outcomes. However, we are not aware of any precise estimates for parameters ϕ_j and ξ in expression (1). A recent empirical contribution by Galama, Hullegie, Meijer and Outcault (2012) finds weak evidence for decreasing returns to scale which would imply that $\xi < 0$. In our paper we allow ϕ_j to be age-dependent and calibrate ξ and ϕ_j together to match aggregate health expenditures and the medical expenditure profile over age.

4.4 Technology and firms

We impose a standard Cobb-Douglas production technology that uses physical capital and labor as inputs to produce a final consumption good according to $F(K, L) = AK^{\alpha}L^{1-\alpha}$. The medical sector uses $F_m(K_m, L_m) = A_m K_m^{\alpha_m} L_m^{1-\alpha_m}$. We set the capital share of production α to 0.33 and the annual capital depreciation rate at $\delta = 0.1$, which are both standard values in the calibration literature (e.g. Kydland and Prescott (1982)). The capital share in production in the health care sector is set lower at $\alpha_m = 0.26$ (based on Donahoe (2000) and our own calculations).

4.5 Insurance sector

Group insurance offer. MEPS data contain information about whether agents have received a group health insurance offer from their employer i.e. offer shock $\epsilon^{GHI} = \{0, 1\}$ where 0 indicates no offer and 1 indicates a group insurance offer. MEPS contains variables OFFER31X, OFFER42X, and OFFER53X that indicate whether an individual was offered health insurance by her employer in a specific year.[20] We assume that an individual was offered group health insurance when either one of the three variables indicates so. Since the probability of a GHI offer will be highly correlated with income, we also condition on the skill type ϑ of an individual when constructing the transition matrix $\Pi_{j,\vartheta}^{h}$ with elements $\Pr\left(\epsilon_{j+1}^{\mathrm{GHI}} | \epsilon_j^{\mathrm{GHI}}, \vartheta\right)$. That is, for each skill type we count the fraction of individuals with a GHI offer in year j, that is still offered group insurance in $j+1$. We smooth the transition probabilities and adjust for the five-year period length.

Insurance premiums and coinsurance rates. Insurance companies in the individual markets screen their customers and price discriminate according to age and health status. The insurance premium, $\mathrm{prem}^{\mathrm{IHI}}(j, h)$, adjusts to balance expression (8). Age and health dependent markup profits

[20]The numbers 31, 42, and 53 refer to the interview round within the year (individuals are interviewed five times in two years).

$\omega_{j,h}^{\text{IHI}}$ are calibrated to match the take-up rate over age of IHI. Similarly, prem^{GHI} adjusts to balance expression (9) and the markup profit ω^{GHI} is calibrated to match the insurance take-up rate of GHI.[21] We define the coinsurance rate as the fraction of out-of-pocket health expenditures over total health expenditures, so that our coinsurance rates include deductibles and copayments. We use MEPS data to estimate coinsurance rates ρ^{IHI} and ρ^{GHI} for individual and group insurance respectively.

Price of medical services. The base price of medical services p_m is endogenous. Shatto and Clemens (2011) report that the reimbursement rates of Medicare and Medicaid are close to 70 percent of the price that private health insurances pay for comparable health care services. Furthermore, various studies have found that uninsured individuals pay over 50 percent higher prices for prescription drugs as well as hospital services than insured individuals (see *Playing Fair, State Action to Lower Prescription Drug Prices* (2000), Anderson (2007), Gruber and Rodriguez (2007)). According to Brown (2006) the national average is a markup of around 60 percent. Large group insurance companies are able to operate at lower average fixed costs and will also be able to negotiate lower prices for health care services (see Phelps (2003)). Based on this information and assuming that Medicaid reimbursement levels result in zero provider profits, we pick the following markup factors for p_m :

$$\left[p_m^{\text{noIns}}, p_m^{\text{IHI}}, p_m^{\text{GHI}}, p_m^{\text{Maid}}, p_m^{\text{Mcare}}\right] = (1 + [0.70, 0.25, 0.10, 0.0, -0.10]) \times p_m.$$

4.6 Government

Pensions. In the model, social security transfers are defined as a function of skill type and average labor income. Let $\bar{L}(\vartheta)$ and $w \times \bar{L}(\vartheta)$ denote the average effective human capital and the average wage income per skill type. Let $t^{\text{Soc}}(\vartheta) = \Psi(\vartheta) \times w \times \bar{L}(\vartheta)$ be pension payments, where $\Psi(\vartheta)$ is a scaling vector that determines the total size of pension payments by skill type. Total pension payments amount to 4.1 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 in the model.

Public health insurance for the old. We use data from CMS (Keehan, Sisko, Truffer, Poisal, Cuckler, Madison, Lizonitz and Smith (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 4.16 percent of GDP of public health insurance reimbursements for the old. Since MEPS only accounts for about 65-70 percent of health care spending in the national accounts (see Sing, Banthing, Selden, Cowan and Keehan (2006) and Bernard, Cowan, Selden, Cai, Catling and Heffler (2012)) we target a size of 3.0 percent of GDP. Given a coinsurance rate of $\rho^R = 0.20$, the size of the combined Medicare/Medicaid program in the model is 3.1 percent of GDP. We fix the premium for Medicare as 2.11 percent of per-capita GDP as in Jeske and Kitao (2009).

Medicaid. 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

[21] In the GHI we allow for lower premiums for the two youngest age cohorts in order to match the relatively high take-up rates despite the very low probability of adverse health shocks. Without this "minor" discrimination, GHI premiums would be too high and not enough young low risk types would buy into it to match the take-up rate in the data.

eligibility levels that exceed 100 percent of the FPL. In addition, state regulations vary greatly with respect to the asset test of Medicaid. Second, many individuals who are eligible for Medicaid are either unaware or unwilling to enrol because of social stigma and access costs (Remler and Glied (2001) and Aizer (2003)). We do not account for these effects in our model as all agents are fully informed and rational. For the reasons, using the FPL directly would grossly overstate the Medicaid population.

According to MEPS data, 9.2 percent of working age individuals are on some form of public health insurance. In order to match the fraction of the working age population covered by Medicaid we keep the Medicaid eligibility level to 70 percent of the FPL ($FPL_{\text{Maid}} = 0.7\times\text{FPL}$), that is the state average level, and calibrate the asset test level, $\bar{a}_{Maid}$.

All model experiments that expand the Medicaid program are therefore percentage expansions based on the model threshold, FPL_{Maid}. The size of Medicaid for workers is about 1.46 percent of GDP according to national accounts data but Medicaid spending in MEPS only accounts for about 0.95 to 1.02 percent of GDP according to Keehan et al. (2011), Sing et al. (2006) and Bernard et al. (2012). Again, based on MEPS data we set the age dependent coinsurance rate for Medicaid to ρ_j^{Maid} which results in a Medicaid size for workers of 0.5 percent of GDP in the model.

Taxes. We use the formula from Gouveia and Strauss (1994) to calculate the progressive federal income tax as

$$\tilde{\tau}\left(\tilde{y}\right) = a_0 \left[\tilde{y} - \left(\tilde{y}^{-a_1} + a_2\right)^{-1/a_1}\right],$$

where $\tilde{y}$ is taxable income. The parameter estimates for this tax polynomial are $a_0 = 0.258$, $a_1 = 0.768$ and $a_2 = 0.031$.

The Medicare tax τ^{Mcare} is set to 2.9 percent. Medicare payroll taxes are 2×1.45 percent on all earnings split in employer and employee contributions (see *Social Security Update 2007* (2007)). The social security system is self-financed via a payroll tax of $\tau^{SS} = 9.4$ percent. The Old-Age and Survivors Insurance Security tax rate of 10.6 percent that has been used by Jeske and Kitao (2009) in a similar calibration. Both payroll taxes are collected on labor income up to a maximum of \$97.500.

Finally, the consumption tax rate is set to 5.0 percent (Mendoza, Razin and Tesar (1994) report 5.67 percent). The model results in total tax revenue of 21.8% of GDP and residual (unproductive) government consumption of 12 percent.

4.7 Benchmark model performance

In order to provide a convincing simulation environment the model has to be able to reproduce the stylized facts in the data before the implementation of the ACA in 2010. This section presents how well the model matches the life-cycle profiles of health expenditures, insurance take-up rates, labor supply, as well as aspects of the US income distribution and important macro-aggregates from data. Figures 4 and 5 and Tables 2 and 15 summarize the model output.

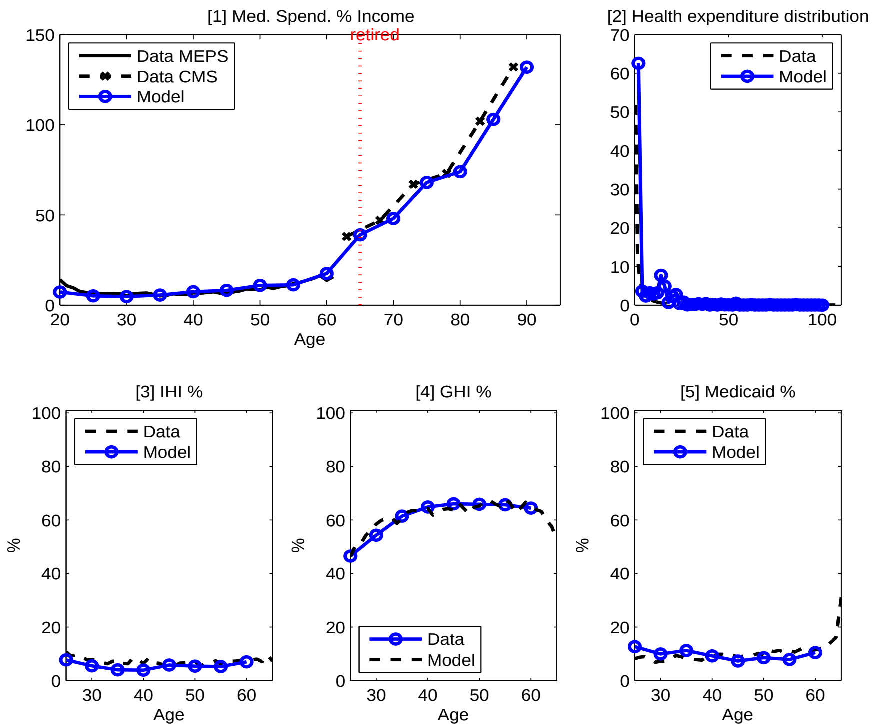

Figure 4: Health expenditure and insurance take-up rate: Model vs. data

Medical expenditures. Panel 1 of Figure 4 compares health expenditure profiles as fraction of income with MEPS data for heads of households. Our model generates total medical expenditures of 17.7 percent of gross household income which matches data provided by CMS.[22] In addition, our model reproduces the distribution of health expenditures as seen in panel 2 of Figure 4.

Insurance take-up ratio. Panels 3, 4 and 5 of Figure 4 plot the life-cycle profiles of insurance take-up rates for individual health insurance (IHI), group health insurance (GHI) and Medicaid of the working age population. Young agents with low income are less likely to buy private health insurance compared to middle aged agents at the peak of their life-cycle earnings ability. Young individuals face lower health risk and are less willing to buy private health insurance than older individuals who are both, more willing (i.e. they face higher expected negative health shocks) and more able to buy health insurance. The model slightly overstates the take-up rate of Medicaid among young agents.

Income distribution. Table 2 and Figure 5 provide a summary of the income distribution compared to data from MEPS. Our benchmark model matches the lower and upper tails of the

[22] Personal communication with OACT/CMS.

income distribution with around 14.8 percent of individuals having income below the FPL vs. 16.4 percent in MEPS.

Quantiles	**MEPS data** (in $1,000)	**Model** (in $1,000)
10%	11.02	8.12
20%	18.17	15.86
30%	24.88	23.39
40%	31.14	31.05
50%	37.98	38.00
60%	45.75	48.05
80%	68.82	78.21
100%	391.18	323.52

Table 2: Select quantiles of the income distribution

Assets and labor supply. The model reproduces the hump-shaped patterns of life-cycle asset holdings from the PSID and the life-cycle pattern of labor supply from MEPS. However, the model does not match the peak age of asset holdings in the data. Our model slightly overstates the hours worked of the youngest cohort.

Aggregates. The benchmark model reproduces many important macroeconomic aggregates in the U.S. data. Table 15 compares model moments with first moments from MEPS, CMS, and National Income data.

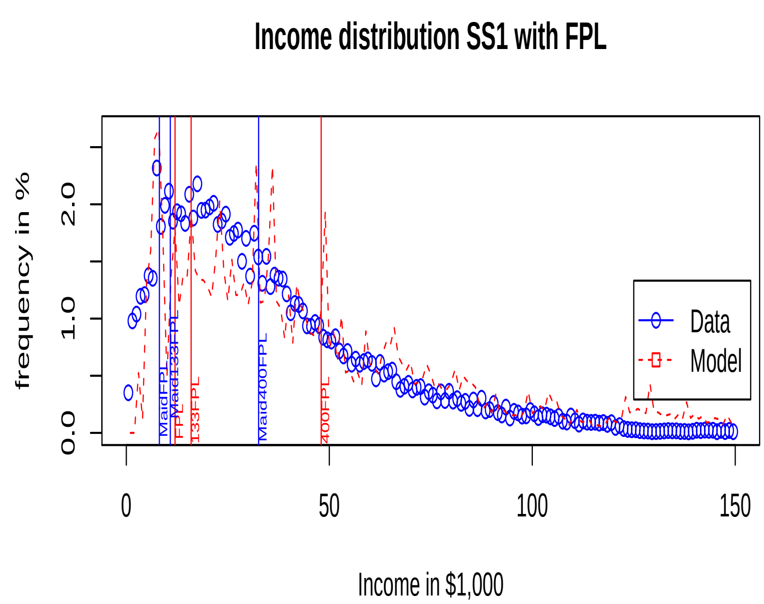

Figure 5: Income distribution: Model vs. MEPS data 1999-2009

5 Quantitative results

In this section we apply the model to quantify the effects of the ACA on insurance take-up rates, medical spending, macro aggregates and welfare. The ACA introduces the following three key policies: (i) an insurance mandate enforced by penalties, (ii) an insurance exchange with premium subsidies and (iii) a Medicaid expansion. We provide the details of the model implementation of the reform in Appendix B.

We first isolate the quantitative importance of each policy component. In section 5.1, we start from the benchmark pre-ACA equilibrium and then introduce each policy separately and then solve for a new long-run equilibrium (i.e. steady state) with this reform component in place. In addition, in all reforms, we hold the share of government spending as a percent of GDP constant.[23] In section 5.2 we quantify the overall effect of the ACA when all three policy components are allowed to interact. We then explore alternative (counterfactual) designs of the ACA and provide sensitivity analysis of our results in section 5.3.

5.1 Isolating the effects of the ACA

5.1.1 Insurance mandate with penalty

According to the ACA, workers who do not have health insurance by February 2014 face a tax penalty of up to 2.5 percent of their income. This insurance mandate enforced by penalties is probably the most controversial policy of the ACA. In order to understand the role of the penalty we consider an experiment in which only the penalty will be introduced while all other features of the ACA are ineffective. We then compare the pre-ACA benchmark equilibrium to equilibria (i.e. steady states) where the mandate is enforced by penalties of 2.5, 5, 10, and 15 percent of gross income in Table 3.

	Benchmark	**Penalty in % of individual income**			
		(a) 2.5%	(b) 5%	(c) 10%	(d) 15%
Workers insured (%):	76.23	98.72	99.33	99.73	99.84
+ IHI (%)	5.55	23.78	24.43	25.19	25.69
+ GHI (%)	61.05	66.92	67.41	68.10	68.85
+ Medicaid (%)	9.62	8.03	7.49	6.44	5.31
IHI average premium	100.00	102.22	101.64	101.16	101.20
GHI premium	100.00	66.30	65.58	64.90	64.35
Med. spending	100.00	95.53	95.47	95.46	95.50
Med. spending/GDP(%)	17.66	17.24	17.21	17.17	17.14
GDP	100.00	100.55	100.74	101.04	101.33
Welfare change (%Δ)	0.00	-0.09	-0.16	-0.26	-0.33

Table 3: The effects of the insurance mandate with penalties

The mandate is expected to induce more of the young and healthy individuals to participate in the private health insurance markets. Intuitively, the penalties are an implicit income tax for the

[23]Alternatively, we could fix government spending at the level of the benchmark pre-ACA steady state. However, we believe it is more realistic to assume that if an economy shrinks in the long-run, its level of government spending will also decrease. The same argument can be made for a growing economy.

uninsured who face a higher marginal income tax rate in case they do not buy health insurance. Penalties thereby alter the trade-off between the costs and benefits of health insurance. Working age individuals, especially the young and healthy, now face higher financial cost of not participating in the health insurance markets. Young workers, with their low income and low risk of getting sick, tend to be very sensitive to changes in the insurance premium. Having more healthy workers participating in the health insurance markets improves risk-sharing and drives down premiums, especially in GHI markets since those markets where already not allowed to screen pre-ACA. This in return makes private health insurance more affordable for low income agents and mitigates the negative effects of adverse selection.

Our quantitative result confirms that the insurance mandate enforced by penalties extends the overall insurance coverage to almost universal coverage. Most of the increase in coverage is driven by the expansion of the private health insurance markets, while the coverage of Medicaid declines slightly. More specifically, considering a 2.5 percent penalty, which is the benchmark level in the ACA (e.g. see column (a) 2.5% in Table 3), we find that the fraction of insured workers increases to 98.7 percent (from 76.2 percent in the benchmark economy). The largest share of this expansion is due to more young individuals picking up IHI which jumps to 23.8 percent from 5.5 percent in the benchmark. In addition, more low risk types join the GHI policies so that premiums in GHI markets drop significantly. The GHI market expands modestly by 5.9 percent. The expansion of the private health insurance markets draws individuals out of Medicaid and causes a small decline in Medicaid coverage by 1.5 percent. More aggressive penalty rates of 5, 10 and 15 percent lead to even higher private insurance take-up rates while the Medicaid take-up decreases further (columns (b) to (d) in Table 3). Almost universal coverage can be reached with a penalty of about 5 percent. Penalties higher than that only modestly increase the take-up rate but tend to generate larger losses of welfare. This result indicates that the introduction of penalties greatly reduces the severity of adverse selection in private health insurance markets. We also do observe overall welfare losses that are stronger among low skill types.

5.1.2 Insurance exchanges with premium subsidies

According to the ACA, workers who are not offered insurance from their employers and whose income is between 133 and 400 percent of the FPL are eligible to buy health insurance at insurance exchanges at subsidized rates as described in Table 1. This feature of the ACA is designed to make health insurance more affordable for low income workers who currently do not have access to GHI from their employer. In order to isolate the role of the insurance exchanges with premium subsidies, we again compare the pre-ACA steady state (compare the Benchmark column in Table 4) to a steady state with insurance exchanges for IHI and premium subsidies set at ACA levels (compare column (a) in Table 4). We then calculate a steady state with 20 percent larger premium subsidies relative to the standard subsidies (see column 120% in Table 4), followed by even more aggressive increases of 35 and 50 percent. Note that all other features of the ACA are not effective, including penalties and the Medicaid expansion.

Subsidies at ACA levels alone increase the coverage rates of IHI and GHI insurance from 5.6 to

	Benchmark	IHI Subsidies relative to ACA (%)			
		(a) 100%	(b) 120%	(c) 135%	(d) 150%
Workers insured (%):	76.23	85.13	86.36	86.76	87.02
+ IHI (%)	5.55	14.40	15.79	16.41	16.67
+ GHI (%)	61.05	63.99	65.02	65.25	65.36
+ Medicaid (%)	9.62	6.74	5.56	5.10	4.98
IHI average premium	100.00	99.14	101.30	102.40	102.81
GHI premium	100.00	88.07	83.16	81.64	80.93
Med. spending	100.00	98.57	98.46	98.41	98.36
Med. spending/GDP (%)	17.66	17.64	17.69	17.72	17.73
ACA payroll tax (%)	0.0	0.32	0.53	0.67	0.73
GDP	100.00	99.78	99.59	99.44	99.37
Welfare change (%Δ)	0.00	0.24	0.30	0.32	0.32

Table 4: The effects of insurance exchanges with premium subsidies

14.4 percent and from 61 to 64 percent, respectively while decreasing the fraction of workers covered by Medicaid from 8.2 to 6.7 percent. As the subsidies get larger, the coverage via Medicaid drops further while the coverage via IHI expands further. However, these increases in coverage are relatively small. The subsidies have only a small indirect effect on the GHI insurance market and the coverage of the GHI insurance market stays roughly constant once subsidy rates increase beyond 120 percent of ACA rates (compare columns (b)-(d) in Table 4).

Premium subsidies by themselves result in much smaller insurance take-up rates than in the previously analyzed equilibria with penalties. This result is in line with empirical evidence reported in Gruber and Washington (2005) who also find that subsidies have a very small effect on insurance take-up, but tend to induce people to buy more expensive health insurances. In addition, since the subsidies do result in negative income effects due to tax distortions in our general equilibrium setting, Medicaid coverage drops for a significant share of low income households. Since these low income households do not benefit from the subsidies (which only become effective for income levels above 133 percent of the FPL_{Maid}), they stay out of insurance. Some of the high risk types that previously bought GHI are now better off buying into IHI with the help of subsidies. This will lower premiums in the GHI markets, so that we can observe a slight expansion of said insurance types. In terms of welfare we observe small welfare gains, as the additional payroll tax of up to 0.73 percent is only paid by a very small fraction of high income workers and wealth is redistributed to a relatively larger group of low income workers.

5.1.3 Medicaid expansion

The ACA expands the Medicaid eligibility threshold uniformly to individuals with income below 133 percent of the FPL. The primary goal of the Medicaid expansion is to cover individuals whose income is below the subsidy thresholds to prevent a coverage gap and subsequently penalties for individuals in the low income segment. The expansion of Medicaid can potentially crowd-out some segments of the private health insurance markets as it provides an alternative insurance option for low income individuals. On the other hand, the expansion can have positive effects on private health insurance markets that can result in lower the premiums if bad income shocks and large negative health shocks are strongly correlated. In this case private health insurance markets can retain the low risk types (i.e. cream-skimming) while Medicaid draws in the costly high risk types. This will lower premiums in private insurance markets which in turn attracts additional low risk types. The final effect of expanding Medicaid depends on how these two forces play out.

In order to isolate the effects of the Medicaid expansion, we consider an experiment in which we implement the expansion of the Medicaid program to 133 percent of the FPL_{Maid} while ignoring all other elements of the ACA. We then compare alternative expansion levels to 150, 200, and 300 percent of the FPL_{Maid} and report the results of these experiments in Table 5.

	Benchmark	**Medicaid extension (% of FPL_{Maid})**			
		(a) 133	(b) 150	(c) 200	(d) 300
Workers insured (%):	76.23	79.81	81.36	84.75	87.16
+ IHI (%)	5.55	6.21	6.61	6.43	5.72
+ GHI (%)	61.05	58.51	56.89	54.05	49.90
+ Medicaid (%)	9.62	15.09	17.86	24.26	31.54
IHI average premium	100.00	98.38	96.71	92.33	88.07
GHI premium	100.00	98.87	98.08	97.64	98.38
Med. spending	100.00	99.17	98.74	97.71	96.71
Med. spending/GDP(%)	17.66	17.74	17.77	17.91	18.07
ACA payroll tax (%)	0.0	0.25	0.40	0.83	1.35
GDP	100.00	98.93	98.39	96.77	94.94
Welfare change (%Δ)	0.00	0.14	0.23	−0.04	−0.49

Table 5: The effects of the medicaid expansion

Expanding Medicaid eligibility to individuals with income below 133 percent of the FPL_{Maid}, we find that Medicaid take-up increases by 5.4 percent (from 9.6 percent to 15.1 percent, column (a) in Table 5). The fraction of workers insured by IHI increases slightly by about 0.75 percent while the fraction of workers on GHI declines by 2.5 percent. This result indicates that the crowding-out effect dominates the cream-skimming effect in the GHI market but not in the IHI market.

Overall, private health insurance markets, IHI and GHI, lose a combined market share of about 1.75 percent. The net effect of newly insured workers is therefore only a 3.5 percent increase so that the overall coverage increases to 79.8 percent. When allowing Medicaid to expand to 150 percent of the FPL_{Maid}, the insurance take-up rate of workers increases to up to 81.4 percent despite further losses in market share for GHI. As Medicaid expands further to 300 percent of the FPL_{Maid}, the insurance take-up rate increases further to 87 percent.

Medical spending in levels decreases slightly but since output also drops due to tax distortions, health spending as a fraction of income increases only by about 0.2 percent. The Medicaid expansion causes a tax distortion and has implications for output and welfare. Specifically, the Medicaid expansion to 133 percent of the FPL_{Maid} comes at a cost of a new payroll tax of 0.25 percent on high income earners. The realized loss in output is about 1 percent of GDP, which potentially lowers welfare. On the other hand, Medicaid is a means-tested social insurance program that targets low income individuals. The expansion subsequently improves risk sharing and results in redistributional effects which is welfare improving for the relatively large group of low income earners. Overall, we find that positive welfare effects dominate negative income effects when Medicaid expands to 133 percent of the FPL_{Maid}, so that there is a small but positive welfare effect. As the Medicaid program expands to 150 percent of the FPL_{Maid}, the overall welfare outcome is still positive compared to the pre-ACA benchmark. However, as the Medicaid program extends further, the tax distortion caused by the new 1.35 percent payroll tax becomes more severe and the overall welfare effect eventually turns negative.

5.2 The overall effects of the ACA

We next evaluate the general equilibrium effects of the entire ACA reform with (*i*) penalties for the uninsured; (*ii*) subsidies to buy IHI for income holders between 133 and 400 percent of the FPL_{Maid}; (*iii*) an expansion of the eligibility threshold for Medicaid to 133 percent of the FPL_{Maid} and no more asset test for Medicaid; and (*iv*) no more screening by age and health in IHI markets. We again compare pre-ACA steady state (Benchmark) outcomes to the steady states calculated under two different reform settings: (*a*) a partial equilibrium setting in which all prices are kept unchanged at the initial steady state levels and (*b*) a general equilibrium setting in which all prices adjust in order to satisfy market clearing conditions. The results of this exercise are summarized in Table 6.

	Benchmark	**The ACA Reform**	
		(a) Partial eqm.	(b) General eqm.
Workers insured (%):	76.23	99.00	90.41
+ IHI (%)	5.55	23.85	12.38
+ GHI (%)	61.05	57.64	60.38
+ Medicaid (%)	9.62	17.51	17.64
Medical services (M)	100.00	100.06	100.04
Med. spending ($p_m \times M$)	100.00	95.04	96.31
Med. spending/GDP(%)	17.66	–	17.61
IHI average premium	100.00	100.00	140.20
GHI premium	100.00	100.00	80.48
ACA payroll tax (%)	0.00	0.60	0.50
GDP	100.00	–	98.51
Capital (K_c)	100.00	99.12	98.61
Capital (K_m)	100.00	101.22	100.24
Weekly hours worked	29.17	27.65	28.08
Health (H)	100.00	100.10	100.01
Consumption (C)	100.00	98.33	97.85
Welfare change (%Δ)	0.00	1.11	−0.23

Table 6: Partial and general equilibrium effects of the ACA

Health insurance take-up ratios. Comparing the partial equilibrium outcome of column (a) in Table 6 to the benchmark, we observe that the reform increases the fraction of workers with health insurance significantly. This expansion is driven by the increase in the number of workers insured by IHI (up 18 percent) and by the increase in number of workers insured by Medicaid (up 8 percent). Meanwhile, the GHI market loses market share (down 3.4 percent) as it competes with subsidized IHI markets and Medicaid. Since the expansion in the private IHI market and Medicaid dominates the reduction in GHI numbers, the reform reaches almost universal coverage (99 percent of workers). Note that in this reform setting, prices are not free to adjust to clear markets. We can interpret these as pure demand side or "first round" partial-equilibrium effects that can either be amplified or diminished by price substitution and income effects that are provided by the general equilibrium analysis that now follows.

General equilibrium results are presented in column (b) of Table 6. If all prices are free to adjust in order to clear all markets, the ACA leads to a 13 percent increase of health insurance coverage of the working age population (first row of column (b)). This increase is driven by the expansion of Medicaid from 9.6 to 17.6 percent which is very similar to the partial equilibrium outcome. Since the average premium of IHI increases by 40 percent in the long-run due to the subsidies and the discontinuation of price discrimination by age and health (IHI are only allowed to charge one premium to all its clients, just like GHI), the increase in coverage via IHI is more modest than before. IHI coverage increases from 5.5 percent to 12.4 percent. The competition for GHI contracts is therefore weaker so that the take-up rates in the GHI market drop by less than 1 percent.

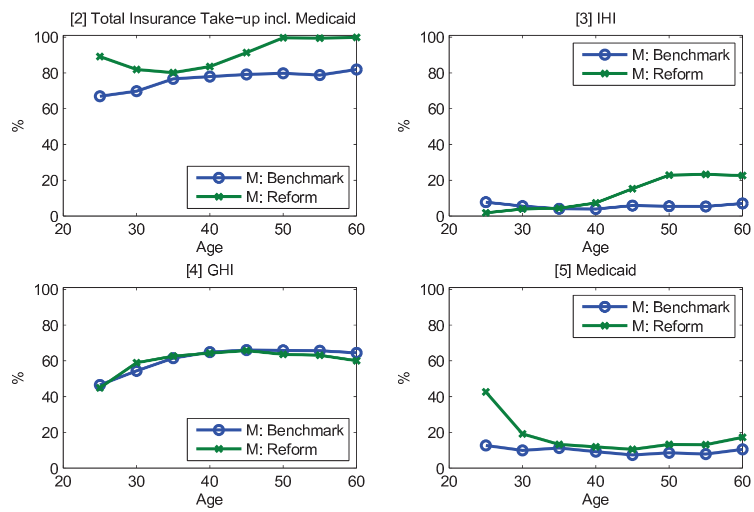

Figure 6: Insurance take-up rate: Benchmark vs. the ACA

Figure 6 presents the change in the take up-rates of the different insurance types over the life-cycle. The ACA induces or allows workers who are 50 and older to participate in the IHI markets; meanwhile, the Medicaid expansion significantly increases the insurance take-up rate of young workers below 30. The ACA has very small effects on the GHI market.

Health spending. Despite the increase in health insurance coverage we do observe a drop in the level of health expenditures. In a general equilibrium model, this result is driven by two forces: (i) a negative income effect and (ii) a move of a group of individuals that pays a high price for medical services (i.e. the uninsured) into a program that pays the lowest price for medical services (i.e. Medicaid). Medicaid patients, as a group, pay a lower price than the uninsured for medical services. An extreme example of this gap in the price tag of the two groups would be a comparison of the relatively low Medicaid reimbursement levels and the chargemaster prices billed to uninsured individuals in emergency room situations. Since after the implementation of the ACA, a large group of uninsured individuals moves into Medicaid, the overall spending level decreases by 3.69 percent despite the slight increase in the traded quantity of medical services of 0.04 percent (compare row five of Table 6).

One assumption in our model is of course that providers cannot refuse to treat Medicare or Medicaid patients, so that these "cost savings" are always fully realized in the model but may potentially be unattainable in the real world where providers might try to renegotiate Medicare/Medicaid reimbursement levels. Since the economy shrinks, the drop in medical spending levels barely factors in when comparing medical spending as a fraction of GDP. If the low prices that Medicaid pays can be maintained and if providers do not refuse to treat Medicaid patients, then the shifting of uninsured individuals into Medicaid is an effective cost containment tool.

Aggregate variables. In the model, the government imposes a new flat payroll tax on individuals with incomes higher than $200,000 per year to finance the ACA. The general equilibrium result shows that this new tax has to be about 0.5 percent in the long-run in order to be able to finance the expansion of Medicaid and as well as the subsidies (see row 9 of column (b) in Table 6). The new Medicaid arrangement, together with the new tax, distorts individuals' incentives to save and work. Capital accumulation in the non-medical sector decreases while capital accumulation in the medical sector decreases. Overall weekly hours worked decrease from 29.17 hours to 28.08 hours, a decrease of 3.7 percent. This seems to be consistent with a recent CBO study that attributes a loss of 2.3 million jobs to the ACA (CBO, 2014, p. 127). These distortions subsequently lead to efficiency losses and lower GDP by about 1.5 percent.

Welfare. The ACA improves risk sharing across agents and redistributes income from low to high health risk types as well as from high to low skill types, all of which can result in welfare gains. To understand how the welfare effects vary across agent types, we compute compensating consumption by health and permanent income type. For every agent type we calculate what fixed percentage of consumption, as a fraction of pre-reform life-time consumption, has to be added or subtracted in each period to make agents indifferent between the pre-ACA steady state and the new steady state after the ACA reform. This welfare measure allows us to investigate the size of welfare gains/losses for different agent types. Table 7 reports the welfare results by health capital and skill type.

As expected, we find that the welfare effects vary significantly across health capital and skill types. High skill workers in "good" health (see the top right corner of Table 7) experience welfare losses, while low skill workers in "bad" health (see the bottom left corner of Table 7) experience welfare gains in the new steady state. The welfare gain for the lowest skill type can be large at up to 14 percent of life-time consumption.

At the aggregate level, however, we observe negative welfare outcomes. Specifically, welfare decreases of 0.23 percent in the new steady state after the ACA reform (see the last row of column (b) in Table 6). This indicates that the welfare losses caused by the fiscal distortions dominate the welfare gains resulting from better risk sharing and redistribution. In addition, some of the welfare losses can be attributed to the penalties that disproportionally hurt low income groups and counter the positive

Health capital	Skill 1 (low)	Skill 2	Skill 3	Skill 4 (high)
h = 15 (healthy)	1.40	-1.03	-2.60	-2.30
h = 14	1.16	-1.33	-2.68	-2.35
h = 13	0.37	-1.44	-2.77	-2.40
h = 12	0.12	-1.56	-2.83	-2.45
h = 11	0.07	-1.54	-2.89	-2.48
h = 10	0.14	-1.26	-2.65	-2.36
h = 9	0.38	-0.55	-2.14	-2.29
h = 8	0.77	0.55	-1.72	-2.09
h = 7	1.06	1.46	-1.42	-1.70
h = 6	2.22	2.40	-0.92	-1.31
h = 5	3.96	3.69	-0.20	-0.98
h = 4	5.71	5.28	0.68	-0.58
h = 3	7.58	7.31	1.73	0.01
h = 2	10.37	9.11	2.38	0.38
h = 1 (sick)	14.14	12.89	4.86	1.06

Table 7: Welfare gains/losses in percent of life-time consumption by health capital and permanent skill type. Positive numbers are welfare gains, negative numbers are welfare losses.

welfare effects of subsidies and the Medicaid expansion that target the very same type of individual (compare Table 3 and the negative welfare results in the last row).

More importantly, we identify substantial differences between partial equilibrium and general equilibrium welfare outcomes. When we keep market prices unchanged, i.e. the partial equilibrium setting, we find that the ACA results in significant welfare gains of 1.1 percent in the last row of column (a) in Table 6. This emphasizes the importance of accounting for general equilibrium price adjustments when conducting a comprehensive long-run assessment of a reform of such complexity.

5.3 Extensions and sensitivity analysis

5.3.1 The role of screening IHI markets and asset tests of Medicaid

The ACA prevents insurers in the IHI markets from price discrimination by age and health state. In addition, the reform completely removes the asset test for Medicaid eligibility. We therefore analyze how these two elements, implemented in isolation, affect market outcomes in columns [2] and [3] of Table 8.

	[1] Benchmark	[2] IHI screening off	[3] Medicaid asset test off
Workers insured (%):	76.23	65.22	77.36
+ IHI (%)	5.55	0.00	5.87
+ GHI (%)	61.05	56.12	59.80
+ Medicaid (%)	9.62	9.10	11.70
Med. spend.	100.00	101.93	99.69
Med. spend./GDP(%)	17.66	17.84	17.67
GDP	100.00	99.96	99.80
Welfare (%Δ)	0.00	-0.09	0.05

Table 8: The effects of no-screening in IHI markets and the removal of the asset test for Medicaid

Removing the ability to screen by age and health in the IHI market without introducing measures to support IHI markets completely destroys this market (see column [2] in Table 8). An adverse selection spiral can be observed. Low risk types leave the IHI market which is now forced to charge an average premium of the entire risk pool. This in turn increases the premium in the IHI market and leads to a further exodus of low income types. Premiums eventually rise high enough until the entire IHI market collapses and no single agent buys IHI anymore. The GHI market, which is also not allowed to screen, is partly protected by tax deductibility of insurance premiums which keeps the market viable.

We next simulate a scenario where the asset test in Medicaid is abolished (see column [3] in Table 8). The Medicaid eligibility is therefore simply based on the income test of the benchmark economy (i.e. income less than $FPL_{\text{Maid}} = 0.7 \times FPL$ qualifies for Medicaid). As expected, the share of Medicaid increases by about 2 percent as low income but high asset households now qualify for Medicaid. The slight expansion of Medicaid crowds out GHI slightly but barely affects IHI. A negative income effect can be observed as output drops due to tax distortions caused by the slightly larger Medicaid program. Since the distortions are small, the redistributive function of the Medicaid expansion dominates the efficiency losses in terms of welfare, so that overall we can observe a positive welfare effect.

5.3.2 Alternative reform scenarios

In this section we change the intensity of one of the three core components of the ACA while leaving all remaining policies of the ACA active in order to analyze how sensitive the long-run results are to the specific levels of policy variables set by the ACA. We summarize the main results of these alternative reforms in Table 9.

Aggressive penalties. When the ACA was originally under discussion, one of the selling points of the ACA to insurance companies was the introduction of a penalty for individuals who refuse to join an insurance pool. Since the ACA prevents insurance companies in IHI markets from price discrimination by health and age, the mandate, so it was argued, is required to circumvent adverse selection spirals in IHI markets.[24] We next run several alternative ACA scenarios where we increase the magnitude of the penalty while leaving subsidies and the size of the Medicaid expansion at their respective ACA levels and report the results in columns [3-a] and [3-b] of Table 9.

	[1] Bench.	**[2] ACA**	**[3] Penalty**		**[4] Subsidy**		**[5] Medicaid**	
			(a) 5%	(b) 15%	(a) 120%	(b) 150%	(a) 150%	(b) 300%
Workers insured (%):	76.23	90.41	95.81	100.0	92.68	93.72	89.85	87.58
+ IHI (%)	5.55	12.38	18.07	24.99	16.16	18.03	9.92	0.00
+ GHI (%)	61.05	60.38	62.35	65.47	61.13	61.52	58.21	44.29
+ Medicaid (%)	9.62	17.64	15.39	9.55	15.39	14.17	21.72	43.29
Med. spend.	100.00	96.31	95.43	95.36	96.09	96.04	96.17	95.90
Med. spend./GDP(%)	17.66	17.61	17.47	17.32	17.62	17.67	17.65	18.17
Payroll tax τ^V (%)	–	0.5	0.43	0.31	0.75	0.99	0.58	1.4
GDP	100.00	98.51	98.83	99.87	98.48	98.29	98.02	94.79
Welfare change (%Δ)	0.00	−0.23	−0.23	−0.16	−0.11	−0.09	−0.30	−0.53

Table 9: The effects of alternative ACA provisions

More aggressive penalties increase the insurance coverage of individuals via IHI and GHI. As the penalty rate increases from the ACA level of 2.5 percent to 5 percent of income, the fraction of

[24]We have already discussed this case in column [2] of Table 8.

individuals covered by private health insurance increases to 95.8 percent (see column [3-a]); meanwhile, the fraction of workers covered by Medicaid decreases compared to the coverage under "standard" ACA with a benchmark penalty of 2.5 percent. If the government increases the penalty rate further to 15 percent, private health insurance markets expand even further, while the size of Medicaid keeps declining. A 15 percent penalty is sufficient to achieve universal insurance coverage. Interestingly, the underlying mechanism behind this result is different from the mechanisms described in the previous section. Unlike the benchmark ACA reform where a large share of the insurance coverage expansion is driven by Medicaid, the universal coverage result in column [3-b] is mainly driven by the expansion of private health insurance coverage rather than that of public health insurance. In fact, the Medicaid coverage rate is virtually unchanged under this design. This outcome implies that the insurance mandate can counteract the adverse effects of Medicaid on the private health insurance markets. However, this also weakens income redistribution via Medicaid, which consequently hurts low income households.

Higher subsidies. In order to investigate the interaction between the subsidy and the other features of the ACA, we implement subsidy rates that exceed the ACA rates by 20 percent and 50 percent and report the long-run results of this reform in columns [4-a] and [4-b] of Table 9. The fraction of individuals covered by IHI increases to almost 18 percent with subsidies that exceed current ACA levels by 50 percent. The GHI market share stays fairly constant. Conversely, the fraction of Medicaid declines, compared to the benchmark ACA reform in column [2] of Table 9. Overall, if subsidies are increased by 50 percent the insurance take-up rate increases to 93.7 percent at the cost of a payroll tax of 1 percent for individuals earning more than US \$200,000 and lower output. Due to the stronger redistribution of income the welfare losses are slightly smaller than in the benchmark ACA reform. The marginal effect of IHI subsidies on IHI take-up rates equals almost zero once subsidy levels are raised above 35 percent of current ACA regulation. Overall, since subsidies only affect a small portion of the working population, they alone are insufficient in achieving universal coverage.

Further Medicaid expansion. The ACA expands the Medicaid eligibility threshold uniformly to individuals whose income is below 133 percent of the FPL. To quantify the effects of a further expansion of Medicaid, we consider two alternative Medicaid extension scenarios and increase the eligibility threshold in the model to 150 and 300 percent of the FPL_{Maid} respectively (compare columns [5-a] and [5-b] in Table 9). This expansion of public health insurance crowds out private health insurance markets and amplifies fiscal distortions caused by additional taxes. A seen in column [5-b], the crowding-out of private health insurance markets can be substantial if Medicaid is allowed to grow beyond ACA expansion levels. An increase of the eligibility threshold from 100 to 300 percent of the FPL causes reductions in the fraction of insured workers in IHI and GHI plans by up to 5.6 and 17 percent, respectively. Agents who were covered by private health insurance before, now move into Medicaid. As a direct consequence, the take-up rate of Medicaid grows to 43 percent. Since this expansion of Medicaid dominates the take-up losses in the private health insurance markets, the overall insurance take-up increases to 87.6 percent. The additional 1.4 percent tax on high income earners leads to large distortions and a drop in output of over 5 percent. In addition, once Medicaid expands beyond 150 percent, it starts to crucially cut into IHI markets which subsequently collapse due to adverse selection spirals (note that IHI markets are not allowed to price discriminate any longer under ACA).

Thus, it is clear that Medicaid is not an effective policy instrument to achieve universal coverage. Neither are subsidies. It appears that only the insurance mandate with aggressive penalties can achieve full coverage while keeping output losses small. However, low income groups would suffer significant welfare losses from such a policy.

5.3.3 Alternative financing instruments

In the benchmark ACA reform described earlier a flat income tax on high income earners is the tax financing instrument. In this section we investigate alternative ways to finance the reform. More specifically, the financing options considered are: (*i*) a tax neutral reduction of exogenous government consumption C_G, (*ii*) a consumption tax τ^C, and (*iii*) a lump-sum tax τ^{Lump} on all households. We summarize the results Table 10.

	[1] Benchmark	**[2] ACA**	**[3] ACA financed by**		
		τ^V	(a) C^G	(b) τ^C	(c) τ^{Lump}
Workers:	76.23	90.41	90.68	90.35	90.53
+ IHI (%)	5.55	12.38	12.74	12.39	13.01
+ GHI (%)	61.05	60.38	60.55	60.42	61.55
+ Medicaid (%)	9.62	17.64	17.39	17.54	15.97
Med. Spending	100.00	96.31	96.29	96.35	96.34
Output (GDP)	100.00	98.51	98.74	98.70	99.15
Welfare change (%Δ)	0.00	−0.23	0.41	−0.21	−0.36
Taxes financing the ACA:					
Payroll tax τ^V (%)	0.00	0.50	–	–	–
Gov't consumption C^G (%)	11.51	–	11.03	–	–
Consumption tax τ^C (%)	5.00	–	–	5.94	–
Lump-sum tax τ^{Lump} (%)	0.00	–	–	–	0.36

Table 10: Health care reforms with alternative taxes

In our first alternative policy experiment we assume the government adjusts its own, unproductive, consumption to finance the reform (see column(a) in Table 10). In this case the government keeps tax rates unchanged and simply adjusts the level of government consumption to finance the extra spending caused by Medicaid and IHI subsidies. This is a tax neutral reform since all tax rates remain unchanged. Note that government consumption is not productive in our model. When we let government consumption adjust we can eliminate any distortionary effects caused by new or higher taxes. This experiment allows for a rough estimate of the pure fiscal cost of the reform absent any of the tax distortions. Second, this experiment reveals how an insurance mandate with fines and premium subsidies affects the individuals' optimal portfolio choice independent of distortionary effects triggered by changes in the tax system. Our simulation results indicate that the cost of the reform is about 0.5 percent of GDP. Increases in government spending for the insurance premium subsidy program and the expansion of Medicaid is relatively small and very close to the results of the earlier benchmark reform. Similarly, this reform results in efficiency losses but overall positive welfare effects. This shows how detrimental distortionary taxes are for welfare.

Next, we assume that the government increases the consumption tax rate to finance the premium subsidies and the expansion of the Medicaid program (see column (b) of Table 10). This reform leads to very similar outcomes compared to the benchmark ACA reform in column [1] where a payroll tax on the rich finances the reform. As before, the reform triggers an increase in the number of individuals buying health insurance contracts. However, we find a smaller decrease in the capital accumulation rate, which leads to a smaller decrease of steady state output of 1.3 percent as the tax distortion triggered by the consumption tax is less severe than the tax distortion triggered by the payroll tax on high income earners. Consumption taxes increase from 5.0 percent to 5.9 percent in the new steady state. In response to the increase in the consumption tax rate agents consume less of the final consumption good and direct their spending towards the consumption of medical services and savings. Overall, we find that this reform results in slightly smaller efficiency and welfare losses than the benchmark ACA reform.

Finally the government can use a lump-sum tax of about 0.36 percent of taxable income on all households to finance the reform. We find similar effects on insurance take-up rates. Compared to the other financing instruments, the output loss is the smallest while the welfare loss is the largest. This is due to the regressive feature of a lump-sum tax.

5.3.4 Sensitivity analysis of preference parameters

We finally explore the sensitivity of the model dynamics to alternative calibration values of key preference parameters including risk aversion and the preference weights on medical and non-medical consumption. For each change in a preference parameter we re-calibrate the pre-ACA steady state (Benchmark) and let labor cost, health productivity, IHI insurance markup profits as well as the FPL_{Maid} level adjust to match labor supply and insurance take-up rates as these are the most affected by changes in preferences. We then simulate the ACA reform again and compare the reform outcome across calibration specifications in Table 11.

Our results are stable with respect to changes in preference parameters. The changes in insurance take-up rates triggered by the ACA fall within 0.5 percent across alternative parameter specifications. Changes in GDP and aggregate consumption are even smaller at about 0.1 percent. We therefore conclude that our simulation results are robust with respect to alternative calibration values of preference parameters.

6 Conclusion

Confronted with an ever increasing number of uninsured Americans and health expenditures exceeding 17 percent of GDP, President Obama signed the *Affordable Care Act* in early 2010. The long run effects of the reform are unknown and controversial. In addition, many of the macroeconomic aspects of the reform are largely unexplored. In this paper we develop a realistic overlapping generation, general-equilibrium model with endogenous health capital and evaluate the long-run macroeconomic effects of the ACA. The general equilibrium approach that we propose is novel and necessary to capture the

	ACA-Benchmark	The ACA with different parameter values					
	$\sigma = 3.0$ $\eta = 0.43$ $\kappa = 0.75$	$\sigma = 2.5$	$\sigma = 3.5$	$\eta = 0.38$	$\eta = 0.48$	$\kappa = 0.7$	$\kappa = 0.8$
Workers insured (%):	90.41	90.47	91.06	90.59	90.74	90.74	90.95
+ IHI (%)	12.38	12.25	13.15	13.00	12.93	12.93	13.32
+ GHI (%)	60.38	59.98	60.60	60.91	61.13	61.13	61.37
+ Medicaid (%)	17.64	18.23	17.30	16.68	16.69	16.69	16.27
Med. Spending	96.31	96.67	96.69	96.40	96.61	98.86	96.49
Med. Spending/GDP(%)	17.61	17.60	17.57	17.48	17.69	17.69	17.59
IHI base premium	140.20	153.18	138.17	147.99	149.43	150.60	145.47
GHI base premium	80.48	84.40	81.40	80.91	82.21	81.38	80.88
Payroll tax (τ^V)	0.50	0.54	0.49	0.51	0.50	0.50	0.50
GDP	98.51	98.52	96.62	98.66	98.55	99.61	98.65
Capital (K_c)	98.61	98.60	98.77	98.75	98.68	97.70	98.78
Health (H)	100.01	100.01	100.01	100.01	100.01	99.97	100
Consumption (C)	97.85	97.88	97.96	98.02	97.87	99.70	97.98
Welfare change ($\%\Delta$)	-0.23	-0.26	-0.12	-0.23	-0.24	-0.23	-0.22

Table 11: The long-run effects of the ACA with different values for preference parameters. Note: For each change in a preference parameter we need to re-calibrate the pre-ACA steady state before we can run the ACA reform again and solve for the post-ACA steady state.

dynamics between health accumulation, health spending, health insurance, and the remaining optimal portfolio decisions of U.S. households.

Our results indicate that the reform reduces adverse selection problems that are prevalent in private health insurance markets and are partly responsible for high insurance premiums and the large number of uninsured individuals. The reform increases the fraction of insured workers to about 90 percent. In order to finance the reform the government has to either introduce a 0.5 percent payroll tax on individuals with incomes above $\$200,000$, increase the consumption tax rate by about 1 percent, introduce a lump-sum tax of 0.36 percent of taxable income, or cut government spending by about 0.5 percent of GDP. In most scenarios the reform triggers a small increase in the aggregate health stock, a decrease in labor supply and capital stock due to tax distortions, and decreases in steady state output of up to 1.5 percent.

We also find that penalties imposed on individuals who decide to not buy health insurance introduce welfare losses but are most effective in increasing the insurance take-up rates. Subsidies that help low income workers buy IHI are less successful in achieving high coverage rates, but are welfare improving due to income redistribution effects. The expansion of Medicaid crowds out private health insurance markets but leads to smaller welfare losses than reforms without a Medicaid expansion.

Our quantitative analysis is informative for academics and also useful for policymakers as it merges aspects of health economics, macro economics, and public finance to shed light on the likely effects of an important comprehensive health care reform bill. Our paper contributes to a rapidly growing literature that uses standard macroeconomic models to examine issues pertaining to health care spending. This paper further bridges the gap between macroeconomics and health economics. Our model can be extended to address a wide range of other health related issues including long-term care and long-term care insurance, health-related behavior such as smoking or exercising, as well as obesity related topics. We leave these extensions for future work.

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7 Appendix A: MEPS and PSID data

MEPS. We primarily use data from the Medical Expenditure Panel Survey (MEPS) from the years 1999 to 2009 for our estimation. 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). We do abstract from family size effects and concentrate on adults aged 20 to 91 who are the head of the household. We remove individuals with income smaller than \$500. If we only keep individuals with observations in two consecutive years, we are left with $131,121$ head-of-household/year observations. We calculate population weighted health expenditure profiles, as well as Markov transition probability matrices for income shocks, health shocks, and employer matching shocks. Summary statistics are presented in Table 12. All dollar values are denominated in 2009 dollars using the Personal Consumption Expenditures (PCE - chain price) index for monetary measures. All distributional statistics for income are calculated for working age individuals between age $20-65$ as the eligibility thresholds for Medicaid and subsidies in the ACA reform are most relevant to these cohorts. The details of our calibration results are presented in Appendix B.

PSID. We use eight waves of the Panel Study of Income Dynamics (PSID) in combination with the wealth surveys of 1984, 1989, 1994, 1999, 2001, 2003 and 2005 to calculate the initial asset distribution of agents in period one. We use variable Sx16, which is the sum of all asset value types net of debt value and home equity (x refers to wave) and drop values above \$$800,000$. All values are converted to 2009 dollars using the Personal Consumption Expenditures index.

8 Appendix B: Calibration tables

Variable	Mean	St.err.	Obs.
Age	47.53	0.14	131,121
Female	44.6%	0.002	131,121
Person total income	\$39,976	\$271	131,121
Hourly wage	\$20.0	\$0.12	85,149
Health expenditure	\$4,203	\$54.85	131,121
Health capital ($4.56 - 74.38$)	49.48	0.07	112,672$^{(*)}$
No insurance	21.1%	0.003	91,538$^{(**)}$
Workers on individual health insurance(IHI)	7.2%	0.001	91,538
Workers on group health insurance (GHI)	62.17%	0.004	91,538
Workers with GHI offer	63.07%	0.003	91,538
Workers on Medicaid/Public	9.60%	0.002	91,538
Coinsurance IHI	0.50	*N/A*	4,646$^{(***)}$
Coinsurance GHI	0.32	0.002	42,186
Coinsurance Medicaid	0.17	*N/A*	10,855
Coinsurance Medicare	0.31	*N/A*	28,381

Table 12: Summary statistics MEPS 1999-2009. (*) Individuals in the first wave 1999 do not report health capital states. (**) The insurance take-up statistics are calculated from the subgroup of 25-65 year old individuals. (***) Coinsurance rates are only calculated for individuals with positive health expenditures and some form of health insurance.

Parameters:		**Explanation/Source:**
- Periods working	$J_1 = 9$	
- Periods retired	$J_2 = 6$	
- Population growth rate	$n = 1.2\%$	CMS 2010
- Years modeled	$years = 75$	from age 20 to 95
- Total factor productivity	$A = 1$	Normalization
- Capital share in production	$\alpha = 0.33$	Kydland and Prescott (1982)
- Capital in medical services production	$\alpha_m = 0.26$	Donahoe (2000)
- Capital depreciation	$\delta = 10\%$	Kydland and Prescott (1982)
- Health depreciation	$\delta_{h,j}= [0.6\% - 2.13\%]$	MEPS 1999/2009
- Survival probabilities	π_j	CMS 2010
- Health Shocks	see technical appendix	MEPS 1999/2009
- Health transition prob.	see technical appendix	MEPS 1999/2009
- Productivity shocks	see text section 4	MEPS 1999/2009
- Productivity transition prob.	see technical appendix	MEPS 1999/2009
- Group insurance transition prob.	see technical appendix	MEPS 1999/2009
- Price for medical care for uninsured	$\nu^{\text{noIns}} = 0.7$	MEPS 1999/2009
- M price markup for IHI insured	$\nu^{\text{IHI}} = 0.25$	Shatto and Clemens (2011)
- M price markup for GHI insured	$\nu^{\text{GHI}} = 0.1$	Shatto and Clemens (2011)
- M price markup for Medicaid	$\nu^{\text{Maid}} = 0.0$	Shatto and Clemens (2011)
- M price markup for Medicare	$\nu^{\text{Mcare}} = -0.1$	Shatto and Clemens (2011)
- Coinsurance rate	$\rho = 0.20$	MEPS 1999/2009
- Medicare premiums/GDP	2.11%	Jeske and Kitao (2010)
- Public coinsurance rate	$\rho^{Mcare} = \rho^{Maid} = 0.20$	Center for Medicare and Medicaid Services (2005)

Table 13: External parameters

Parameters:		**Explanation/Source:**	**Nr.M.**
- Relative risk aversion	$\sigma = 3.0$	to match $\frac{K}{Y}$ and R	1
- Preference on consumption vs. leisure:	$\eta = 0.43$	to match labor supply and $\frac{p \times M}{Y}$	1
- Disutility of health spending:	$\eta_m = 1.5$	to match health capital profile	1
- Preference on c and l vs. health	$\kappa = 0.89$	to match labor supply and $\frac{p \times M}{Y}$	1
- Discount factor	$\beta = 1.0$	to match $\frac{K}{Y}$ and R	1
- Health production productivity	$\phi_j \in [0.7 - 0.99]$	to match spending profile	14
- TFP in medical production	$A_m = 0.4$	to match $\frac{p \times M}{Y}$	1
- Production parameter of health	$\xi = 0.175$	to match $\frac{p \times M}{Y}$	1
- effective labor services production	$\chi = 0.26$	to match labor supply	1
- Health productivity	$\theta = 1$	used for sensitivity analysis	1
- Pension replacement rate	$\Psi = 40\%$	to match τ^{soc}	1
- Residual Government spending	$\Delta_C = 12.0\%$	to match size of tax revenue	1
- Minimum health state	$h_{\min} = 0.01$	to match health spending	1
-Total number of internal parameters:			26

Table 14: Internal parameters used to match a set of target moments in the data.

Moments	Model	Data	Source	Nr.M.
- Medical expenses HH income	17.6%	17.07%	CMS communication	1
- Workers IHI	5.6%	7.2%	MEPS 1999/2009	1
- Workers GHI	61.1%	62.2%	MEPS 1999/2009	1
- Workers Medicaid	9.6%	9.2%	MEPS 1999/2009	1
- Capital output ratio: K/Y	2.7	$2.6-3$	NIPA	1
- Interest rate: R	4.2%	4%	NIPA	1
- Size of Social Security/Y	5.9%	5%	OMB 2008	1
- Size of Medicare/Y	3.1%	$2.5-3.1\%$	U.S. Department of Health 2007	1
- Payroll tax Social Security: τ^{Soc}	9.4%	$10-12\%$	IRS	1
- Consumption tax: τ^{C}	5.0%	5.7%	Mendoza et al. (1994)	1
- Payroll tax Medicare: τ^{Med}	2.9%	$1.5-2.9\%$	Social Security Update 2007	1
- Medical spend. profile		see figure 4		15
Total number of moments				26

Table 15: Model vs. data

9 Appendix C: ACA model implementation

Household problem. Including penalties for not having health insurance as well as subsidies for individuals buying IHI whose income falls within the eligibility thresholds. Suppressing state vector x_j in order to not clutter the notation, the household budget constraint changes to

$$\left(1+\tau^{C}\right)c_j+(1+g)\,a_{j+1}+o^{W}\left(m_j\right)+1_{\{in_{j+1}=1\}}\text{prem}^{\text{IHI}}+1_{\{in_{j+1}=2\}}\text{prem}^{\text{GHI}}$$

$$= \quad y_j+t_j^{\text{SI}}-tax_j-1_{\{in_{j+1}=0\}}penalty_j+1_{\{in_{j+1}=1\}}subsidy_j-tax_j^{\text{ACA}},$$

where

$$subsidy_j \quad = \quad \begin{cases} 0.94\ \text{prem}^{\text{IHI}}\left(j,h\right) \text{ if } 1.33\ FPL_{Maid} \leq \tilde{y}_j < 1.5\ FPL_{Maid}, \\ 0.77\ \text{prem}^{\text{IHI}}\left(j,h\right) \text{ if } 1.5\ FPL_{Maid} \leq \tilde{y}_j < 2.0\ FPL_{Maid}, \\ 0.62\ \text{prem}^{\text{IHI}}\left(j,h\right) \text{ if } 2.0\ FPL_{Maid} \leq \tilde{y}_j < 2.5\ FPL_{Maid}, \\ 0.42\ \text{prem}^{\text{IHI}}\left(j,h\right) \text{ if } 2.5\ FPL_{Maid} \leq \tilde{y}_j < 3.0\ FPL_{Maid}, \\ 0.25\ \text{prem}^{\text{IHI}}\left(j,h\right) \text{ if } 3.0\ FPL_{Maid} \leq \tilde{y}_j < 3.5\ FPL_{Maid}, \\ 0.13\ \text{prem}^{\text{IHI}}\left(j,h\right) \text{ if } 3.5\ FPL_{Maid} \leq \tilde{y}_j < 4.0\ FPL_{Maid}, \text{ and} \end{cases} \tag{15}$$

$$penalty_j \quad = \quad 0.025 \times \tilde{y}_j.$$

Variable $\tilde{y}_j$ is individual gross income as defined in expression (6). In the model we use a flat payroll tax on individuals with incomes higher than \$200,000 in order to finance the ACA. The additional tax term is defined as:

$$tax_j^{\text{ACA}} = \tau^{V} \times \tilde{y}_j \text{ if } \tilde{y}_j \geq \$200,000.$$

Insurance companies. The ACA prevents IHI companies from screening by age or health, so that only an average premium, prem^{IHI}, can be charged. The price setting mechanism in GHI and IHI markets is now identical except for the fact that GHI premiums are still tax deductible while IHI premiums are not. The new zero profit condition for IHI can be written as

$$\begin{aligned} & (1+\omega) \times \sum_{j=2}^{J_1} \mu_j \int \left[1_{\{in_j(x_j)=1\}} \left(1-\rho^{\text{IHI}}\right) p_m^{\text{IHI}} m_j\left(x_j\right) \right] d\Lambda\left(x_j\right) \\ = \quad & R \sum_{j=1}^{J_1-1} \mu_j \int \left(1_{\{in_j(x_j)=1\}} \text{prem}^{\text{IHI}} \right) d\Lambda\left(x_j\right). \end{aligned}$$

The new government budget constraint is

$$\begin{aligned} & G + \sum_{j=1}^{J} \mu_j \int t_j^{\text{SI}}\left(x_j\right) d\Lambda\left(x_j\right) + \sum_{j=2}^{J_1} \mu_j \int \left(1-\rho^{\text{MAid}}\right) p_m^{\text{MAid}} m_j\left(x_j\right) d\Lambda\left(x_j\right) \\ & + \sum_{j=J_1+1}^{J} \mu_j \int \left(1-\rho^{R}\right) \left(p_m^{R} m_j\left(x_j\right)\right) d\Lambda\left(x_j\right) + \sum_{j=1}^{J_1-1} \mu_j \int 1_{\{in_{j+1}(x_j)=1\}} subsidy\left(x_j\right) d\Lambda\left(x_j\right) \\ = \quad & \sum_{j=1}^{J} \mu_j \int \left[\tau^C c\left(x_j\right) + tax_j\left(x_j\right)\right] d\Lambda\left(x_j\right) + \sum_{j=J_1+1}^{J} \mu_j \int \text{prem}^R d\Lambda\left(x_j\right) \\ & + \sum_{j=1}^{J_1} \mu_j \int \tau^{\text{Med}} \left(e\left(h_{j-1}\left(x_j\right), \epsilon_j^l\right) l_j\left(x_j\right) w - 1_{\{in_{j+1}(x_j)=2\}} \text{prem}^{\text{GHI}} \right) d\Lambda\left(x_j\right) \\ & + \sum_{j=1}^{J_1} \mu_j \int tax_j^{\text{ACA}}\left(x_j\right) d\Lambda\left(x_j\right) + \sum_{j=1}^{J_1-1} \mu_j \int 1_{\{in_{j+1}(x_j)=0\}} penalty\left(x_j\right) d\Lambda\left(x_j\right), \end{aligned}$$