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Abstract

This article investigates the impact on the U.S. economy of making health care more affordable. We compare health care cost reductions with the Patient Protection and Affordable Care Act (PPACA) using a rich life cycle general equilibrium model with heterogeneous agents. We found that all policies were able to reduce uninsured population, but the PPACA was the most effective: in the long run, less than 5% of Americans would remain uninsured. Cost reductions alleviated the government budget, while tax hikes were needed to finance the reform. Feasible cost reductions are less welfare improving than the PPACA.

Keywords: health care reform, affordable health care, health care costs, health insurance, general equilibrium, policy evaluation

JEL Codes: D91, E21, E62, H51, I13, I18, I38, E65

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1 Introduction

Health care costs in the U.S. are known to be high, especially when compared to other OECD countries. According to the OECD System of Health Accounts (SHA), in 2010, even controlling for income, population size, and cost of living, the U.S. spent 41.7% more on health care than would be predicted by the OECD trend. This amounts to $2,428 per year in excess for every American. At the same time, the share of uninsured population in the U.S. is also high: 13.1% in 2010, according to the Medical Expenditure Panel Survey (MEPS). Medical bills are the biggest cause of U.S. bankruptcies, and accounted for 62.1% of all bankruptcies in 2007 (Himmelstein et al. (2009)). Furthermore, between 2001 and 2007, the share of bankruptcies attributable to medical problems rose by 50%.

To address this issue, on March 23, 2010, President Barack Obama signed into law the Patient Protection and Affordable Care Act (PPACA). The primary objective of the bill is to increase health insurance coverage in the U.S. by making health insurance more affordable. To achieve this goal, among many features, the PPACA created a health insurance marketplace where Americans can purchase federally regulated and subsidized health insurance, expanded the Medicaid program, and introduced a mandate where Americans are required to be covered by some health insurance. However, this reform does not directly deal on trying to make health care goods and services more affordable. Instead of increasing public expenditures on health insurance, regulating the private insurance market, and forcing Americans to purchase insurance, the reform could have focused on policies that would reduce health care costs.

In addition, the PPACA is not capturing the important link between high health care costs and high share of uninsured population. After all, higher costs are reflected in higher insurance premiums, leading to a high share of individuals without insurance. By this reasoning, cost reductions could increase the share of covered population, and increasing the share of insured people without dealing with cost reductions may be a way of acting on the consequences of the problem, and not on the cause. Besides, cost reductions can have a potential positive welfare effect by alleviating the budget of individuals.

Therefore, important questions with respect to public policy can be raised. Which would further reduce the uninsured population, the PPACA or more affordable health care? In addition, which would be better in terms of the welfare of individuals? What is the long run impact of these policies on government budget? Which cost reduction would be equivalent to the PPACA regarding the welfare of individuals?

To answer these questions, we built a life cycle general equilibrium model with heterogeneous agents to compare the effects of the PPACA and of health care cost reductions on health insurance coverage, government budget, and welfare. This economy consists of a large number of heterogeneous agents, competitive production and health insurance sectors, and a government. Agents differ by age, education level, health status, asset holdings, medical expenditures, labor productivity, average lifetime earnings, employer-sponsored health insurance (EHI) offer, and health insurance coverage. There

are uncertainties regarding the age of death, health status, medical expenditures, labor productivity, and EHI offer status. Agents choose consumption, labor time, next period's asset holdings, and next period's health insurance coverage. Medical expenditures are costly relative to consumption. Five types of health insurance coverage are available: Medicare, Medicaid, employer-sponsored health insurance (EHI), individual health insurance (IHI), and no insurance. Premiums of private insurances are determined endogenously. Retirement is exogenous and the income tax is progressive and follows the current law for tax benefits on health insurance and medical expenditures.

The model is calibrated to the U.S. economy before the introduction of the PPACA, and is able to reproduce very closely the health insurance coverage and some key macroeconomic variables. In particular, the model reproduces the high share of uninsured population and the fact that most of the population purchases health insurance through the employer. We then simulated the model considering five changes introduced by the PPACA: premium tax credits, individual mandate, Medicaid expansion, individual health insurance regulation, and the increase in income threshold for claiming deduction of medical expenses in income tax. These changes were simulated individually, to capture the net effect of each one, and then together, to capture the effect of the reform as a whole.

Cost reductions were implemented through exogenous decreases in the relative price of medical expenses to consumption.[1] First, to carry out a realistic and politically feasible experiment, we implemented the estimated cost reductions calculated by Liu et al. (2014), which is a Rand Corporation project that identified fourteen ideas for relatively focused changes that would generate health care cost savings at the national level. Second, as a counterfactual benchmark to compare the U.S. with other OECD countries, we applied to the model the reduction in per capita health care expenditures required to bring the U.S. to the OECD trend in 2010. We call these experiments the "Rand Proposal" and "OECD Trend", respectively. Finally, to assess which cost reduction would be equivalent to the PPACA in terms of welfare, we implemented several reductions in a range limited by both reductions above.

We found that the PPACA as a whole is more effective than cost reductions in reducing uninsured population. It reduced uninsured population by 65.9%, while the Rand Proposal and the OECD Trend decreased it by only 1.4% and 19.7%, respectively. Mainly due to the Medicaid expansion, the PPACA increased public deficit and required an estimated increase of 5.1% in consumption tax rate to rebalance the government budget. In contrast, cost reductions alleviated the fiscal burden of public insurance, reducing public deficit and so tax collection. Regarding welfare effects, the PPACA and cost reductions are welfare improving. The OECD Trend is the most successful, demonstrating the importance of making health care more affordable. On average, we

[1] Attanasio et al. (2010) also adopted the strategy of exogenously changing the relative price of medical expenses to consumption in order to simulate, using a general equilibrium model, how the growth projections of health care costs affect alternative funding schemes for Medicare.

found that a cost reduction of 5% is enough to produce similar welfare effects as those generated by the PPACA.

Our work relates to the literature that uses quantitative models to perform *ex ante* policy evaluations regarding health care issues.[2] Jeske and Kitao (2009) and Huang and Huffman (2014) study tax subsidies for group health insurance. Attanasio et al. (2010) analyze alternative funding schemes for Medicare. Feng (2010) and Hsu and Lee (2013) investigate public provision for universal health insurance. Pashchenko and Porapakkarm (2013) and Jung and Tran (2016) study the PPACA. Hansen et al. (2014) evaluate the consequences of expanding the Medicare program. Janicki (2014) accesses the role of asset testing in public health insurance reform. Pashchenko and Porapakkarm (2015) evaluate the importance of reclassification risk in the health insurance market. Our contribution to this literature is that we compare the PPACA with health care cost reductions.

The remainder of the article is organized as follows. Section 2 presents some stylized facts about health care costs and health insurance coverage. Section 3 describes our model economy and Section 4 presents the changes introduced by the PPACA and discusses how they were implemented in the model. Section 5 explains the cost reduction experiments, and in the next section the model parameterization is discussed. Section 7 reports the performance of the model in replicating the data, and Section 8 describes the results of the policy analysis. Section 9 concludes.

2 Stylized Facts

Countries with higher incomes tend to spend more on health care. However, even taking this relationship into account, the U.S. spends far more on health care than might be predicted. On the left panel of Figure 1, we compare total health care expenditures within the OECD countries. The amount spent by the U.S. is far more than would be expected even adjusting for population size and relative wealth differences. In 2010, the U.S. spent 41.7% more than would be predicted by the OECD trend, which amounts to $2,428 per year in excess for every American.[3] The right panel of Figure 1 presents the evolution of U.S. health care expenditures as a fraction of GDP. This index has increased substantially, going from 5.68% in 1965 to 17% in 2009, a growth of 200%.

By decomposing the evolution of U.S. health care expenditures, we find that price is the main factor driving its growth. Figure 2 breaks down the evolution of health care expenditures among the growth of three factors: population, prices, and use and intensity. The left panel shows that price is the only factor able to explain the cumulative growth of total expenditures. The right panel shows that the annual growth rates of prices follow

[2] There is also a literature that uses quantitative models to study the role of health status, medical expenditures, and/or health insurance over individual decisions. See Palumbo (1999), French (2005), De Nardi et al. (2010), French and Jones (2011), Hsu (2013), Kopecky and Koreshkova (2014), Zhao (2015), and Capatina (2015).

[3] The same pattern can be observed if we drill down the data. In per capita terms, the excess for private sector expenditures is $2,965, for spending with private insurance is $2,423, and for spending with health care goods and services is $1,429.

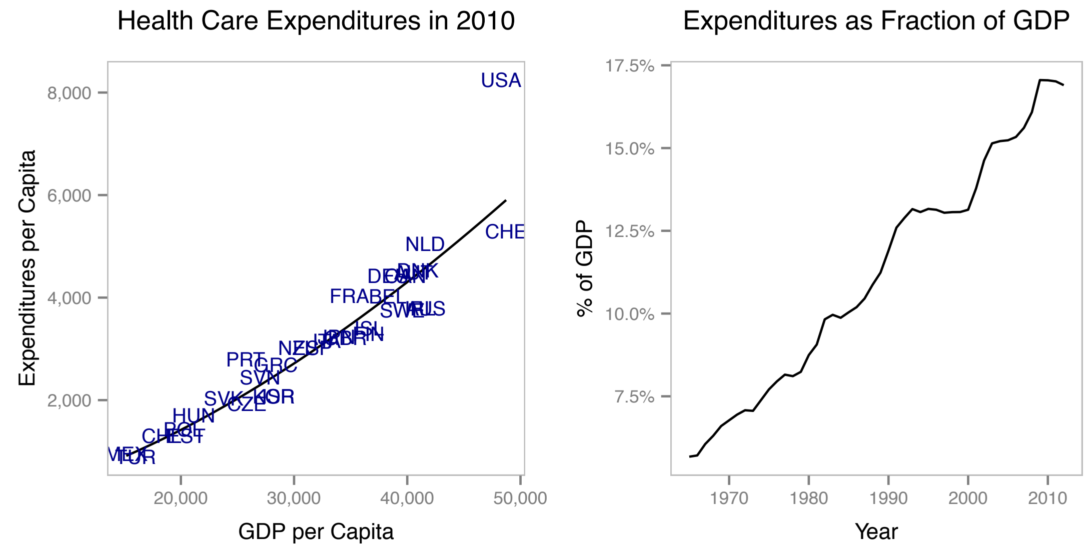

Figure 1: Facts about health care expenditures. Left: Health care expenditures and GDP per capita across OECD countries in 2010. Right: Evolution of U.S. health care expenditures as a fraction of GDP. Sources: OECD System of Health Accounts (SHA); Authors' analysis. Notes: Health care expenditures and GDP data are in 2010 dollars and adjusted for purchasing power parity.

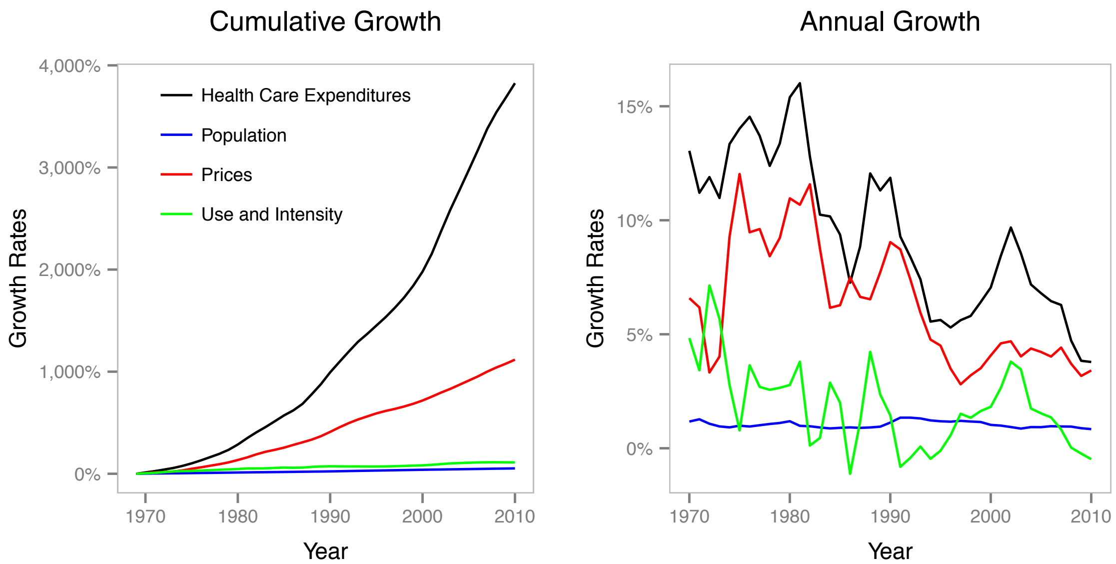

Figure 2: Decomposition of U.S. health care expenditures. Left: Cumulative growth rates. Right: Annual growth rates. Sources: National Health Expenditure Accounts (NHEA) and Council of Economic Advisers (2013); Authors' analysis. Notes: Health care expenditures are in nominal terms. Prices are represented by the CPI component for medical care. As a residual, the factor of use and intensity includes any errors in measuring total spending or prices.

closely the growth rates of total spending. From 1970 to 2010, the correlation between these two series is 0.82, while the correlations for the other factors are much lower: 0.58 for use and intensity and −0.02 for population. In a cross-country comparison, prices in the U.S. are also higher. Koechlin et al. (2010) found that, in 2007, prices for several hospital services in the U.S. are the highest among a selection of OECD countries.

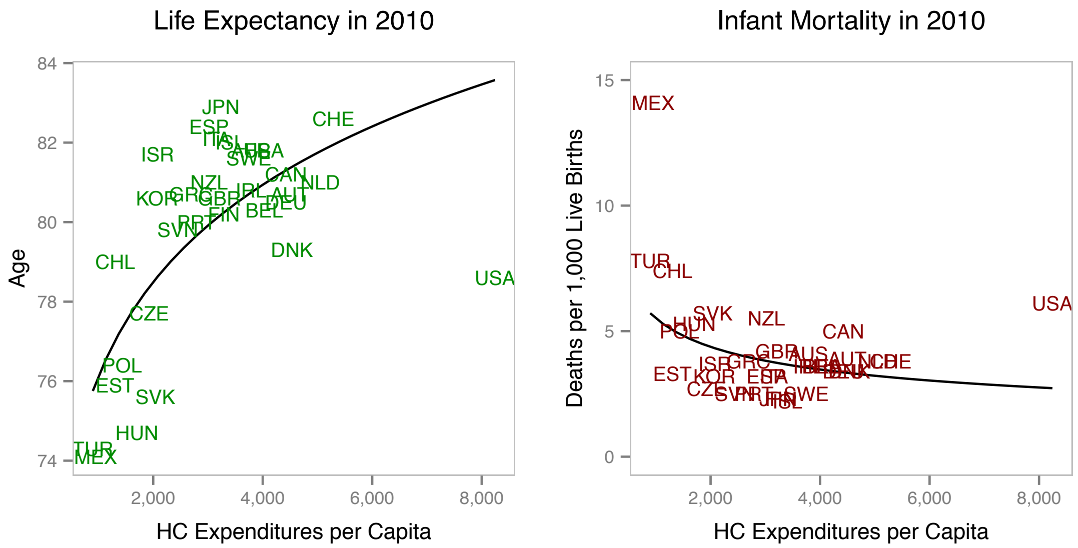

Figure 3: Facts about health outcomes. Left: Life expectancy and health care expenditures per capita across OECD countries in 2010. Right: Infant mortality and health care expenditures per capita across OECD countries in 2010. Sources: OECD System of Health Accounts (SHA); Authors' analysis. Notes: Health care expenditures data are in 2010 dollars and adjusted for purchasing power parity.

Squires and Anderson (2015) arrive at the same conclusion for hospital, physician, and pharmaceuticals prices across 13 high-income countries in 2013.

This excessive spending cannot be justified by better quality of health services. For instance, the World Health Organization (2000) placed the U.S. health system performance in the 37$^{\text{th}}$ position among 191 countries. In a series of reports from 2004 to 2014, the Commonwealth Fund compared the performance of health care systems among several developed countries regarding quality care, access, efficiency, equity, and healthy lives.[4] In every year, the U.S. held the last position in the overall ranking. Looking only at the U.S., McGlynn et al. (2003) identified serious deficits in adherence to recommended processes for basic care, and concluded that adults receive only half of the recommended processes involved in care.

In Figure 3, we look at two popular measures of a population's health among OECD countries: life expectancy and infant mortality. For both measures, in 2010, the U.S. result is worse than what would be expected after adjusting for population size and total health care expenditures. Life expectancy in the U.S. is below the first quartile of the distribution of countries, and Americans live about 5 years less than would be predicted by the OECD trend. Infant mortality in the U.S. is above the third quartile of the distribution of countries, and exhibits about 3.4 more deaths per 1,000 live births than would be predicted by the OECD trend.

In a scenario where medical expenditures are excessive, health insurance becomes essential. In Figure 4, we present the evolution of health insurance coverage in the U.S. in

[4] The reports are Davis et al. (2004), Davis et al. (2006), Davis et al. (2007), Davis et al. (2010), and Davis et al. (2014).

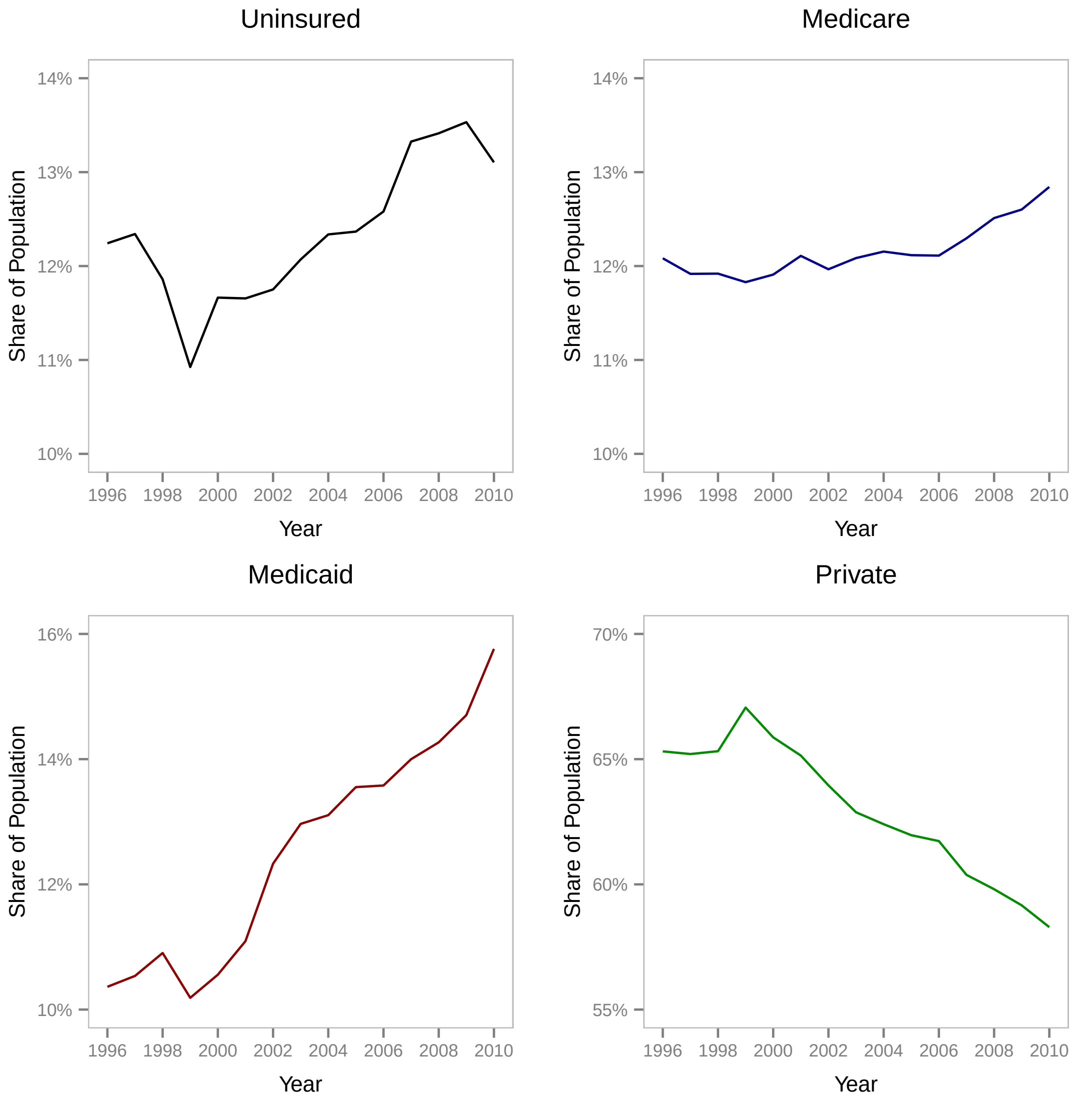

Figure 4: Evolution of health insurance coverage in the U.S. over time. Sources: Medical Expenditure Panel Survey (MEPS); Authors' analysis.

a pre-PPACA period. From 1999 to 2010, there was a reallocation of the population with private insurance to public insurance or no insurance. The share of uninsured increased 2.2 percentage points, reaching 13.1% by the end of the period. The share with public insurance also rose, with the Medicare and Medicaid increasing 1.0 and 5.6 percentage points, reaching 12.8% and 15.8% in 2010, respectively. On the other hand, the share with private health insurance decreased 8.8 percentage points, reaching 58.3% in 2010. This reallocation is expected in an environment with increasing health care costs. Higher costs are reflected in private insurance premiums, making private insurance unaffordable, forcing people to rely on public insurance or to become uninsured.

3 Model Economy

We built a life cycle general equilibrium model in the tradition of İmrohoroğlu et al. (1995) and Huggett (1996). We extended these models to consider features of health status, medical expenditures, and health insurance. The benchmark economy consists of a large number of heterogeneous agents, a competitive production sector, a competitive health insurance sector, and a government with a commitment technology. Time is discrete and one model period is a year. All shocks are independent among agents and, as a consequence, there is no uncertainty over the aggregate variables even though there is uncertainty at the individual level.

3.1 Agents

The economy is populated by a large number of heterogeneous agents with age $j \in \{1, \ldots, R, \ldots, J\}$, where R is the mandatory retirement age and J is the maximum survival age. The population grows exogenously at a constant rate η. Besides age, agents also differ by education level e, health status h, asset holdings a, medical expenditures m, labor productivity z, average lifetime earnings x, employer-sponsored health insurance (EHI) offer ι, and health insurance coverage i. In each life period, they choose consumption c and next period's asset holdings a'. In addition, workers also choose labor time l and next period's health insurance coverage i'. Retirees receive a Social Security benefit and are covered by Medicare.

Agents face seven sources of individual uncertainty. When entering the economy, they receive an education level $e \in \{e^L, e^H\}$ drawn from the distribution $\Lambda(e)$, where e^L means low education and e^H means high education. The education level is retained throughout life. They also receive an initial endowment of assets drawn from the distribution $\Omega(a)$.[5] After this first draw, the evolution of asset holdings is endogenous. In each period of life, health status $h \in \{h^B, h^G\}$ evolves according to a first-order Markov process, where h^B means bad health and h^G means good health. Conditional on being at age j, with education level e, and current health status h, the probability of having next period's health status h' is given by $\Phi_{j,e}(h, h')$. Survivorship is also uncertain in each period of life. Conditional on being alive at age j, with education level e, and current health status h, the probability of surviving to age $(j + 1)$ is given by $\Pi_{j,e,h}$.[6] The demographics of this economy implies that the share of agents of type (j, e, h), denoted by $\mu_{j,e,h}$, can be recursively defined as

$$\mu_{j+1,e,h'} = \frac{\Pi_{j,e,h}\Phi_{j,e}(h, h')}{1 + \eta}\mu_{j,e,h}.$$

Medical expenditures $m \in \mathcal{M}_{j,h}$ are also uncertain throughout life, and its possible values depend on age and health status. Current expenses are known, but next period's

[5] For other articles that also considered an initial distribution of assets in a life cycle model, see Hendricks (2007), Kaplan and Violante (2010), and Hintermaier and Koeniger (2011).

[6] Since all agents enter alive in the economy with age $j = 1$, we must assume that $\Pi_{0,e,h} = 1$ for all (e, h). Besides, agents die with certainty at the end of age J, which means that $\Pi_{J,e,h} = 0$ for all (e, h).

expenses are uncertain and drawn from the distribution $\Psi_{j,h}(\cdot)$, which depends on age and health status. Therefore, conditional on being at age j, with education level e, and current health status h, the probability of incurring in next period's medical expenditures m', with next period's health status h', is given by $\Phi_{j,e}(h, h')\Psi_{j+1,h'}(m')$. The relative price of medical expenditures to consumption is denoted by π, implying that the final value paid by agents is πm. Labor productivity $z \in \mathcal{Z}$ and EHI offer status $\iota \in \{0, 1\}$ jointly evolve over time according to a first-order Markov process, where $\iota = 0$ means that the agent did not receive the offer and $\iota = 1$ means that the agent received the offer. Conditional on being at age j, with education level e, and current productivity-offer pair (z, ι), the probability of having next period's productivity-offer pair (z', ι') is given by $\Gamma_{j,e}(z, \iota, z', \iota')$.

Asset holdings $a \in \mathcal{A}$ are composed by a one-period riskless asset that pays a rate of return r. Total resources used to acquire these assets are exogenously divided between the productive sector, in the form of capital, and the government, in the form of public debt. Borrowing is not allowed, so that the choice of next period's asset holdings is such that $a' \geq 0$. All assets left by the deceased are collected by the government and distributed to the live agents as a lump-sum bequest transfer B. Agents are endowed with ℓ units of time. Workers can split this endowment among leisure and labor $l \in \left\{0, l^P, l^F\right\}$, where l^P is the time needed for a part-time job, l^F is the time needed for a full-time job, and $0 < l^P < l^F < \ell$. They receive a wage rate $\widetilde{w}$ measured in efficiency units, so that the labor income of a worker that supplies l to the labor market is given by $y = \widetilde{w}zl$.

Agents enjoy utility over consumption, leisure, and health status, and maximize the discounted expected utility throughout life. The intertemporal discount factor is given by β. The effect of health status on utility is modeled as a fixed time cost.[7] In addition, there is a cost of work treated as a loss of leisure. The period utility function is given by

$$u(c, l, h) = \frac{\left[c^{\gamma}\left(\ell - l - \phi_1 \mathbf{1}_{\{l>0\}} - \phi_2 \mathbf{1}_{\{h=h^B\}}\right)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma},$$

where γ is the share of consumption in utility, σ is the risk aversion parameter, ϕ_1 is the time cost of work, ϕ_2 is the time cost associated with bad health status, and $\mathbf{1}_{\{\cdot\}}$ is an indicator function that maps to one if its argument is true. The term in parentheses represents leisure time.

3.2 Health Insurance

Agents can protect themselves against medical expenditures shocks by acquiring a health insurance $i \in \left\{i^0, i^{MC}, i^{MA}, i^E, i^I\right\}$, where i^0 is no coverage, i^{MC} is Medicare, i^{MA} is Medicaid, i^E is employer-sponsored health insurance (EHI), and i^I is individual health

[7] An alternative way of modeling the effect of health on preferences is by lowering the utility received from consumption when health is bad, as in De Nardi et al. (2006). Another way is by lowering the share of consumption in the utility function when health is bad, as in Ferreira and dos Santos (2013).

insurance (IHI). Medicare and Medicaid are provided by the government, while EHI and IHI are provided by health insurance firms. Health insurance is a one-period contract where the insured commits to pay a premium today and the insurer commits to cover a fraction of medical expenditures in the next period. Thus, the type of insurance coverage that an agent has today was subscribed the period before, and the premium that an agent pays today is for the next period's coverage. The coinsurance rate of a particular coverage is denoted by $q(i,m)$, which depends on current health insurance type and realized medical expenditures. The premium paid for an insurance coverage is denoted by $p(i',j,h)$, which depends on the choice of next period's coverage, age, and current health status. Naturally, we assume that $q\left(i^0,m\right)=0$ for all m and $p\left(i^0,j,h\right)=0$ for all (j,h). For ease of notation, we denote net medical expenditures paid by

$$\widetilde{m}=[1-q(i,m)]\,\pi m.$$

The government provides health insurance for the elderly through Medicare. Once reaching the retirement age R, agents are automatically enrolled in this program, meaning that agents aged $(R-1)$ and older cannot choose any other type of health insurance. A fixed premium is charged, so that $p\left(i^{MC},j,h\right)=p^{MC}$ for all (j,h). Moreover, the government incurs in administrative costs φ per unit of medical expenditures covered by this program. Non retired agents can obtain insurance coverage from Medicaid for free, so that $p\left(i^{MA},j,h\right)=0$ for all (j,h). There are two pathways to qualify for this program. First, agents are eligible if labor income plus asset income is less than or equal the threshold y^{MA}. Second, agents can become eligible through the Medically Needy program. This happens if labor income plus asset income, minus net medical expenditures, is less than or equal to the threshold y^{MN}, and if assets are less than or equal to the limit a^{MN}. Thus, the eligibility criteria for Medicaid can be represented by

$$\mathbf{1}^{MA}=\begin{cases}1 & \text{if} \quad y+ra\leq y^{MA},\\ 1 & \text{if} \quad y+ra-\widetilde{m}\leq y^{MN} \quad \text{and} \quad a\leq a^{MN},\\ 0 & \text{otherwise.}\end{cases}$$

We assume that there is a representative and competitive health insurance firm operating each type of private health insurance contract. Premiums are priced as the expected present value of insured medical expenses. These firms can observe all variables that drive future medical expenditures of insured agents. Revenues collected from premiums today are invested in the asset market and used in the following period to cover possible realized expenditures. They incur in administrative costs κ per unit of medical expenditures covered. There is also a fixed cost $\varkappa$ for providing IHI. This fixed cost captures the difference in overhead costs between IHI and EHI.[8]

[8] An alternative setup would be to assume different administrative costs and no fixed cost. Pashchenko and Porapakkarm (2013) tested both approaches and obtained a better match of the life-cycle profile of individual health insurance rates using the fixed cost.

Non retired agents may receive an exogenous offer of an EHI contract, which can only be accepted if they choose to work. The eligibility criteria for an EHI coverage is represented by

$$\mathbf{1}^E = \begin{cases} 1 & \text{if} \quad \iota = 1 \quad \text{and} \quad l > 0, \\ 0 & \text{otherwise.} \end{cases}$$

As required by law, screening is not allowed when pricing the EHI contract, which means that all participants of the employer-based poll are charged the same fixed premium. Moreover, an employer offering EHI must pay a fraction ω of the premium. Thus, the premium that agents pay for this type of coverage is given by $p\left(i^E, j, h\right) = (1-\omega)p^E$ for all (j, h). IHI coverage is always available for non retired agents. Screening is allowed for this type of health insurance, which means that there is a contract for each type of age-health pair. Thus, the premium charged for this coverage is given by $p\left(i^I, j, h\right) = p^I\left(j, h\right)$.

As seen above, the set of possible coverages available for non retired agents is not static, and may change according to the options that an agent is eligible to choose. Since Medicaid is free, we assume that Medicaid-eligible agents cannot stay uninsured. Therefore, the set of choices for next period's health insurance must satisfy

$$i' \in \begin{cases} \left\{i^0, i^I\right\} & \text{if} \quad \mathbf{1}^{MA} = 0 \quad \text{and} \quad \mathbf{1}^E = 0, \\ \left\{i^0, i^E, i^I\right\} & \text{if} \quad \mathbf{1}^{MA} = 0 \quad \text{and} \quad \mathbf{1}^E = 1, \\ \left\{i^{MA}, i^I\right\} & \text{if} \quad \mathbf{1}^{MA} = 1 \quad \text{and} \quad \mathbf{1}^E = 0, \\ \left\{i^{MA}, i^E, i^I\right\} & \text{if} \quad \mathbf{1}^{MA} = 1 \quad \text{and} \quad \mathbf{1}^E = 1. \end{cases} \tag{1}$$

3.3 Production Sector

We assume that there are two representative firms which act competitively and produce a single consumption good. Both firms maximize profits using capital and labor as inputs. Their production functions are the same and take the form of a Cobb-Douglas specification, given by $F(K, L) = AK^{\alpha}L^{1-\alpha}$, where K and L are aggregate capital and labor inputs, A is total factor productivity, and α is the share of capital in the output. Capital depreciates at a rate δ each period. The difference between the two firms lies in the fact that one offers EHI to its workers and the other not. The firm that offers the insurance must pay a fraction of the premiums for the agents who have accepted the offer. This cost is passed on to all its employees through a wage rate reduction. In specifying this reduction, we follow Jeske and Kitao (2009) and assume that this firm subtract the amount χ from the wage rate of all its workers. This amount is just enough to cover the firm's total premium cost.

Indexing by 0 the firm that does not offer EHI and by 1 the firm that offers EHI, we can write the problems of both firms as

$$\max_{K_0, L_0} F(K_0, L_0) - (r_0 + \delta)K_0 - w_0 L_0$$

and

$$\max_{K_1,L_1} F(K_1, L_1) - (r_1 + \delta)K_1 - (w_1 + \chi)L_1.$$

Assuming that capital is freely allocated between both firms, by no arbitrage we have that $r_0 = r_1 \equiv r$. From the first order conditions for capital, this implies that the capital-labor ratio of both firms are equal, that is, $K_0/L_0 = K_1/L_1$. Therefore, from the first order conditions for labor, we must have that $w_1 = w_0 - \chi \equiv w - \chi$. Thus, from the agents' point of view, we can summarize the wage rate received by a worker as being

$$\widetilde{w} = \begin{cases} w & \text{if} \quad \iota = 0, \\ w - \chi & \text{if} \quad \iota = 1. \end{cases}$$

3.4 Government

The government taxes agents in order to finance its public programs: Medicare, Medicaid, Social Security, and Social Insurance. In addition to taxes, its revenue is also composed by Medicare premiums and issuance of a one-period riskless debt D, which by no arbitrage must carry the same return in equilibrium as claims to capital. These revenues finance Medicare and Medicaid coverages, Social Security benefits, Social Insurance transfers, government expenditures G, and the servicing and repayment of the debt.

All agents are charged income tax according to a progressive function $\tau^Y\left(y^T\right)$, which is levied on taxable income y^T. Taxable income is based on labor and asset income. According to the current law for tax benefits, the amount of EHI premium can be deducted from taxable income in the calculation of income tax. Moreover, agents can also deduct net medical expenditures paid that exceed a fraction ξ of labor income plus asset income.[9] Therefore, taxable income can be formalized by

$$y^T = \max\left\{y + ra - (1-\omega)p^E \mathbf{1}_{\{i'=i^E\}} - \max\left\{\widetilde{m} - \xi(y+ra),\, 0\right\},\, 0\right\}.$$

The progressive income tax function follows the rules of the Internal Revenue Service (IRS), and can be recursively defined as

$$\tau^Y\left(y^T\right) = \tau^Y\left(y_n\right) + \tau_{n+1}\left(y^T - y_n\right) \quad \text{if} \quad y_n < y^T \leq y_{n+1},$$

where $\{\tau_n\}$ are the marginal income tax rates, $\{y_n\}$ are the income brackets, and $n \in \{0, \ldots, 6\}$. It also must satisfy $\tau^Y(0) = 0$.[10]

[9] See Mulvey (2012) for references on the current law for tax benefits on health insurance and medical expenses.

[10] To the best of our knowledge, every article in the quantitative macroeconomic literature that considers a progressive income taxation uses the function estimated by Gouveia and Strauss (1994). This function calculates the effective income tax taking into account tax deductions. However, we have already modeled two tax deductions that are important to our analysis: EHI premium and medical expenditures. To avoid double counting these deductions, and possibly biasing our results, we prefer to adopt the official functional form defined by the IRS. By doing so, we were able to replicate very closely the per capita income taxes collected by the government.

Agents also pay a consumption tax τ^C, which is proportional and levied directly on consumption. Workers must pay a Social Security tax τ^{SS}, which is proportional and levied on the minimum between labor income and the Social Security wage base y^{SS}. They also have to pay a Medicare tax τ^{MC}, which is proportional and levied on labor income. The EHI premium is also tax deductible in calculating taxes from Social Security and Medicare. We can formalize the Social Security and Medicare taxes, respectively, by

$$T^{SS} = \tau^{SS} \min \left\{ \max \left\{ y - (1-\omega)\, p^E \mathbf{1}_{\{i'=i^E\}},\, 0 \right\},\, y^{SS} \right\}$$

and

$$T^{MC} = \tau^{MC} \max \left\{ y - (1-\omega)\, p^E \mathbf{1}_{\{i'=i^E\}},\, 0 \right\}.$$

For ease of notation, we define total taxes paid, excluding consumption tax, by

$$T = \tau^Y \left(y^T \right) + T^{SS} + T^{MC}.$$

The government pays Social Security benefits to agents that reach the retirement age R. This benefit depends on average lifetime earnings $x \in \mathcal{X}$, which is calculated by taking into account individual earnings up to age $(R-1)$.[11] It can be recursively defined as

$$x' = \begin{cases} \dfrac{x(j-1) + \min\left\{y,\, y^{SS}\right\}}{j} & \text{if} \quad j < R, \\ x & \text{if} \quad j \geq R. \end{cases}$$

The benefit function $b(x)$ corresponds to the *Primary Insurance Amount* (PIA).[12] It is calculated as a piecewise linear function, which in accordance with the rules of the U.S. Social Security system is given by

$$b(x) = \begin{cases} \theta_1 x & \text{if} \quad x \leq x_1, \\ \theta_1 x_1 + \theta_2 (x - x_1) & \text{if} \quad x_1 < x \leq x_2, \\ \theta_1 x_1 + \theta_2 (x_2 - x_1) + \theta_3 (x - x_2) & \text{if} \quad x_2 < x \leq y^{SS}, \end{cases}$$

where $\{x_1, x_2\}$ are the bend points of the function and the parameters $\{\theta_1, \theta_2, \theta_3\}$ satisfy $0 \leq \theta_3 < \theta_2 < \theta_1$.

The government also commits to a Social Insurance transfer that works as a means-tested program that guarantees a minimum level of consumption $\underline{c}$ to every agent by supplementing income with a lump-sum transfer T^{SI}.[13] We follow Hubbard et al. (1995)

[11] According to the Social Security legislation, the average lifetime earnings should be calculated by taking into account the 35 highest individual earnings up to the *Earliest Retirement Age*. For simplicity, we consider the whole history of earnings, since it is hard to identify the 35 highest earnings when solving the model.

[12] This is the benefit that individuals are entitled to at the *Full Retirement Age*. Its value is neither reduced for early retirement nor increased for delayed retirement.

[13] The Social Insurance program summarizes succinctly various U.S. transfer programs, such as food stamps, Temporary Assistance for Needy Families (TANF), Supplemental Security Income (SSI), and

and assume that this transfer occurs if $\underline{c}$ is greater than total resources minus necessary expenditures. Total resources are defined as the sum of labor income (or Social Security benefit), total assets, and bequest transfer. Necessary expenditures are defined as the sum of taxes and net medical expenditures paid. If the agent is insured by Medicare, we consider the Medicare premium as a necessary expenditure. Therefore, we can formalize the Social Insurance transfer by

$$T^{SI} = \begin{cases} \max\left\{\left(1+\tau^C\right)\underline{c} + T + \widetilde{m} - y - (1+r)a - B,\, 0\right\} & \text{if} \quad j \leq R-2, \\ \max\left\{\left(1+\tau^C\right)\underline{c} + T + \widetilde{m} + p^{MC} - y - (1+r)a - B,\, 0\right\} & \text{if} \quad j = R-1, \\ \max\left\{\left(1+\tau^C\right)\underline{c} + T + \widetilde{m} + p^{MC} - b\left(x\right) - (1+r)a - B,\, 0\right\} & \text{if} \quad R \leq j < J, \\ \max\left\{\left(1+\tau^C\right)\underline{c} + T + \widetilde{m} - b\left(x\right) - (1+r)a - B,\, 0\right\} & \text{if} \quad j = J. \end{cases}$$

3.5 Agents' Problem

There are two groups of heterogeneous agents: workers and retirees. Workers are those aged $(R-1)$ and younger, while retirees are those aged R and older. The state vector of a worker is given by $(j, e, h, a, m, z, x, \iota, i)$, and its value function is given by V^W. Similarly, the state vector of a retiree is given by (j, e, h, a, m, x), and its value function is given by V^R. The problem of agents must be solved separately for specific age groups.

For $j \in \{1, \dots, R-2\}$, agents are workers in the current period and will remain workers in the next period. They choose consumption, labor supply, next period's asset holdings, and next period's health insurance coverage. Their problem can be recursively defined as

$$V^W\left(j, e, h, a, m, z, x, \iota, i\right) = \max_{(c,l,a',i')} \left\{u(c,l,h) + \beta\Pi_{j,e,h} E V^W\left(j+1, e, h', a', m', z', x', \iota', i'\right)\right\}$$

subject to

$$\left(1+\tau^C\right)c + a' + \widetilde{m} + p\left(i', j, h\right) + T = y + (1+r)a + T^{SI} + B,$$

$$c \geq 0, \quad l \in \left\{0, l^P, l^F\right\}, \quad a' \geq 0,$$

with i' satisfying equation (1). For $j = (R-1)$, there are two differences in relation to the above problem. First, because these agents will be retirees in the next period, they take into account the expected value function of retirees in the next period rather than the expected value function of workers. Second, as they will automatically have Medicare in the next period, they pay the fixed Medicare premium and no longer choose next period's health insurance coverage.

For $j \in \{R, \dots, J-1\}$, agents are retirees in the current period and will remain retirees in the next period, no longer choosing labor supply. They choose consumption and next period's asset holdings, and receive Social Security benefit in the current period.

Aid to Families with Dependent Children (AFDC).

Their problem can be recursively defined as

$$V^{R}(j,e,h,a,m,x)=\max_{(c,a')}\left\{u(c,0,h)+\beta\Pi_{j,e,h}EV^{R}\left(j+1,e,h',a',m',x'\right)\right\}$$

subject to

$$\left(1+\tau^{C}\right)c+a'+\widetilde{m}+p^{MC}+T=b\left(x\right)+(1+r)a+T^{SI}+B,$$

$$c\geq 0,\quad a'\geq 0.$$

For $j=J$, there are two differences in relation to the above problem. First, because these agents will be dead next period, they no longer take into account the expected value function of retirees in the next period. Second, because they will no longer use the Medicare coverage next period, they do not pay the fixed Medicare premium.

We present the formal equilibrium definition in the online appendix that accompanies this article.

4 Health Care Reform

In this section we describe the changes implemented by the PPACA and show how they were implemented in the model. An important concept created by the reform is affordable health insurance. This concept is important to determine who will receive premium tax credits and who will be exempt from paying penalties for being uninsured. If an agent is not eligible to choose an EHI coverage, then the IHI contract will be considered affordable if its premium costs less than or equal to a fraction d^I of the agent's labor income plus asset income. On the other hand, if an agent is eligible to choose an EHI coverage, then the EHI contract will be considered affordable if the part of the premium that should be paid by the agent costs less than or equal to a fraction d^E of the agent's labor income plus asset income. The affordable health insurance criteria can be formalized as

$$\mathbf{1}^{A}=\begin{cases}1 & \text{if}\quad \mathbf{1}^{E}=0\quad\text{and}\quad p^{I}\left(j,h\right)\leq d^{I}\left(y+ra\right),\\ 1 & \text{if}\quad \mathbf{1}^{E}=1\quad\text{and}\quad (1-\omega)p^{E}\leq d^{E}\left(y+ra\right),\\ 0 & \text{otherwise.}\end{cases}$$

Agents who can not afford health insurance are eligible to receive a premium tax credit to buy health insurance in the individual market. The tax credit structure ensures that agents within a certain income category do not spend more than a certain fraction of their income on health insurance. The income categories are based on a range of the Federal Poverty Level (FPL), which we denote by f. Furthermore, the size of the tax credit is decreasing in the share of income, which means that the less an agent earns the

lower the premium will cost. The premium tax credit can be formalized as

$$T^P = p^I (j,h) - \varepsilon_n (y + ra) \quad \text{if} \quad \mathbf{1}^A = 0 \quad \text{and} \quad i' = i^I \quad \text{and} \quad g_n f \leq (y + ra) < g_{n+1} f,$$

and equals zero otherwise, where $\{\varepsilon_n\}$ are the fractions of income spent on insurance, $\{g_n\}$ are the fractions of the FPL that determine the income categories, and $n \in \{1, \ldots, 7\}$. In order to reflect the premium tax credit in the model, we need to add the credit as a source of funds in the budget of the agents, and also add the aggregate credit as an expense in the government budget.

The reform creates an individual mandate where uninsured agents must pay a penalty to the government unless they are qualified for an exemption. The penalty is equal to the maximum between the value υ and a fraction ν of taxable income. Additionally, the maximum value of the penalty is equal to ρ. Uninsured individuals are exempt from the penalty if they cannot afford a health insurance coverage. The penalty can be formalized as

$$T^M = \begin{cases} \min\left\{\max\left\{\upsilon, \nu y^T\right\}, \rho\right\} & \text{if} \quad \mathbf{1}^A = 1 \quad \text{and} \quad i' = i^0, \\ 0 & \text{otherwise.} \end{cases}$$

In order to reflect the individual mandate in the model, we need to add the penalty as an expense in the budget of agents, and also add the aggregated penalty as a revenue in the government budget.

Medicaid eligibility is expanded to all non retired agents with income below a fraction ζ of the FPL. There are no changes in the Medically Needy Program. In order to reflect the Medicaid expansion in the model, we just need to change the value of the parameter y^{MA} to ζf. The reform imposes a severe regulation on the IHI market. This regulation limits the ability of insurers to do the screening when pricing IHI contracts. Health insurance firms can no longer condition IHI premiums on health status. The only factor that can affect these premiums is age. Thus, the regulated IHI premiums are given by $p\left(i^I, j, h\right) = p^R(j)$ for all h. This regulation is reflected in the model by adjusting the equilibrium expression of IHI premiums. The reform also increases the income threshold for claiming deduction for medical expenditures, making it much more difficult to qualify for deductions. To reflect this in the model, we just need to change the value of the parameter ξ to the new threshold.

5 Cost Reductions

Cost reductions were implemented through exogenous decreases in the relative price of medical expenses to consumption, a strategy similar to Attanasio et al. (2010). This choice is a compromise between evidence and model complexity, and can be justified as follows. As shown in Section 2, prices seem to be the main driver of medical expenses'

growth over time.[14] Furthermore, we modeled medical expenses as exogenous shocks, abstracting from the fact that individuals have some degree of control over their medical expenses, creating no room for endogenous health care prices. We did so because medical expenses to a significant extent represent exogenous shocks. Preventive medicine, the portion that people really choose, have a low rate of use.[15] Besides, costs are not the only or main reason for this low usage.[16] Our goal here is to quantify the effects of more affordable health care using the relief in the budgets of individuals and government as the main mechanism.

The "Rand Proposal", detailed in Liu et al. (2014), is a Rand Corporation project that identified fourteen ideas for relatively focused changes that would generate health care cost savings. As argued by the authors, these ideas are quite feasible to implement and are only moderately politically sensitive.[17] Savings were estimated at the national level in 2012 dollars. Considering the national health expenditures of 2012 reported by the Centers for Medicare & Medicaid Services (CMS), this amounts to an annual cost reduction of 0.64%. The proposal was reflected in the model by applying this reduction to the relative price of medical expenditures π.

In the "OECD Trend" experiment, we applied to the model the same percentage reduction in per capita health care expenditures required to bring the U.S. to the OECD trend in 2010, as shown on the left panel of Figure 1. The trend was calculated as a power fit with the GDP per capita as the independent variable and the health care expenditures per capita as the dependent variable. Data is from the OECD System of Health Accounts (SHA), and all values are in 2010 dollars and adjusted for purchasing power parity. Given the U.S. GDP per capita, the U.S. health care expenditures per capita predicted by the trend should be 29.5% lower. We applied this reduction to the relative price of medical expenditures π. We do not know which public policies would be able to generate such a reduction, and we believe that policies capable of that must be difficult to be approved and implemented. However, this reduction makes the U.S. comparable in terms of per capita health care spending with the OECD countries, and serves as a benchmark.

Finally, we performed some cost reductions in a range limited by both reductions above. The main goal of this analysis is to assess which cost reduction would be equivalent

[14] In a similar analysis, Keehan et al. (2008) and Moses et al. (2013) also found that prices account for the majority of total health care cost increase. Aaron and Ginsburg (2009) also argue that much of the excess of U.S. spending is attributable to the fact that the unit prices of various services are higher in the United States than elsewhere.

[15] Using MEPS data, and controlling for income quintiles, Tables 1 and 12 of Ozkan (2014) show that the average number of years since respondents' last usage of some forms of preventive care is high. For additional references, see Partnership for Prevention (2007), Maciosek et al. (2010), and America's Health Rankings (2016).

[16] According to Partnership for Prevention (2007), other important factors are the failure of providers to manage their patients regarding preventive medicine, limited investment in developing a prevention-oriented health care workforce, limited training for doctors and other health care providers in delivering preventive care, and lack of information from the public about what preventive services are recommended.

[17] See Tables 1 and 2 of Liu et al. (2014) for the description and savings estimate of each idea, respectively. See Table 3 for the political and operational feasibility rating of each idea.

to the PPACA in terms of welfare of individuals. The percentage reductions that were evaluated are 5%, 10%, 15%, 20%, and 25%.

6 Model Parametrization

We parameterized the model using several different data sources. Three sources of micro data were used: the Medical Expenditure Panel Survey (MEPS), the Health and Retirement Study (HRS), and the Survey of Consumer Finances (SCF). Our main source of macro data is the Council of Economic Advisers (2013). Other sources of data were used and will be appropriately cited.

6.1 Education Level

High education level e^H corresponds to at least a college degree, and low education level e^L corresponds to at most an incomplete college. To calculate the probabilities of education level, we used the data from Barro and Lee (2012). We used data for the years 1990, 1995, 2000, 2005, and 2010, and considered the age groups of individuals aged 20 and over. For each year-age pair, this data set provides the estimated population and the share of population that completed the tertiary education. All data were pooled in order to calculate the average across years and age groups. Using the estimated population as weights, we calculated the weighted average of the share of the population that completed the tertiary education. We assigned this value to $\Lambda\left(e^H\right)$. The final values obtained are $\Lambda\left(e^H\right) = 28.28\%$ and $\Lambda\left(e^L\right) = 71.72\%$.

6.2 Health Status

We used the MEPS database to estimate the transition probabilities of health status. To establish the health status of each individual, we used a perceived health status measure. During a year, individuals are interviewed three times and report their health status on a scale from 1 to 5, where 1 means "excellent" and 5 means "poor".[18] We then calculated the average of the three responses. If this average was greater than 3, we assigned a bad health (h^B) to the individual in that year. Otherwise, we assigned a good health (h^G).

We used data of the two-year panels from 1996–1997 up to 2009–2010. For each panel, we considered only individuals who answered all three questions about health status in both years.[19] We estimated the health transition probabilities using the logit method. We regressed next period's health status on a constant, age, age squared, age

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

[19]For purposes of confidentiality, ages in MEPS are top-coded at 90 years from 1996 to 2000 and at 85 years from 2001 to 2010. This means that, for example, we cannot know with certainty what is the age of an individual who appears aged 90 in 1998, or who appears aged 85 in 2002. To avoid problems arising from this issue, we applied the same rule to all panels and disregarded all individuals who appeared aged 85 and over.

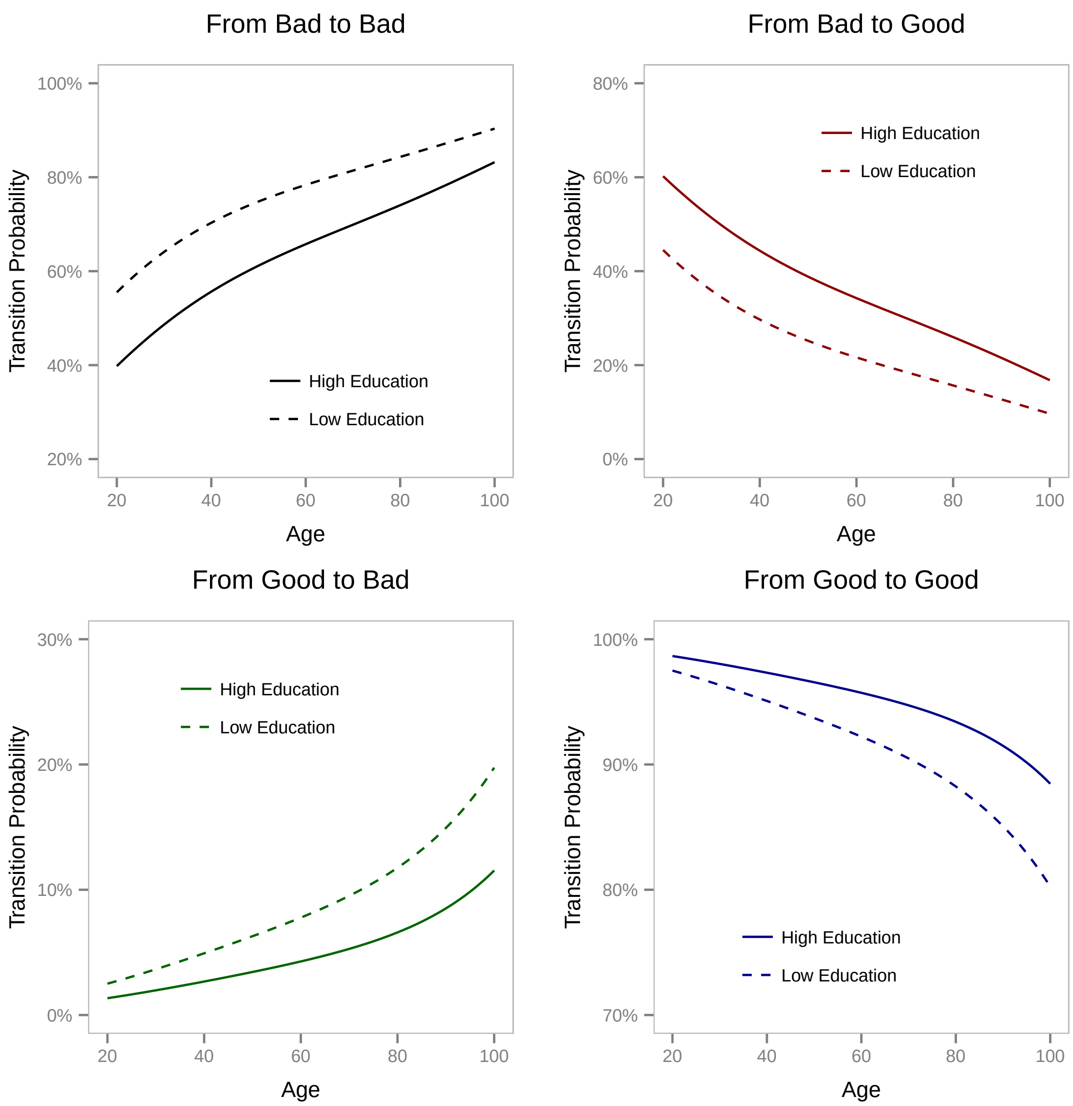

Figure 5: Transition probabilities of health status by age and education level. Top left: From bad health to bad health. Top right: From bad health to good health. Bottom left: From good health to bad health. Bottom right: From good health to good health.

cubic, education level, current health status, and age times current health status.[20] The probabilities for ages greater than or equal to 85 were predicted out of the sample using the estimated equation. To deal with the complexity of the sample design of MEPS, our estimation took into account the longitudinal sample weights, the primary sampling unit (PSU), and the stratum of the PSU.[21] The estimated probabilities are presented in Figure 5.

[20]We also estimated the same equation using the probit method. The resulting probabilities are very similar.

[21]Since all panels were pooled, we adjusted the longitudinal weights by dividing it by the number of panels used. This is done in order to normalize the population totals to the average over the data set we used.

6.3 Demography

In this economy, a period corresponds to one year. We assumed that agents enter the economy at age 20 ($j = 1$) and can survive to a maximum age of 100 ($J = 81$). We set the population growth rate η so that the fraction of agents aged 65 and over equaled 12.55% in equilibrium. This target was calculated using population data from Table B–34 of Council of Economic Advisers (2013). We used the average of the fractions from 1996 to 2010. The final value of η is 2.75%.

We used the HRS database to estimate the survival probabilities. This database focuses on a sample of older individuals and follows them over a long period of time, providing the ideal sample to estimate survival probabilities and how they relate to other variables. Similar to MEPS, the HRS also contains a question on subjective health status, which is important as we want to estimate survival probabilities by health status and want the health status of the two databases to be consistent.[22] We used data of all the six cohorts and all the ten waves available in the HRS database.[23] We only considered individuals who were age-eligible in each cohort, that is, individuals aged 50 and over at the time of each wave. The survival probabilities were estimated using the population-averaged logit method. We regressed next period's survival status on a constant, age, age squared, age cubic, education level, health status, and age times health status.[24] We assumed that the time-series correlation for observations of each individual are the same regardless of how many years apart the observations are.[25]

Because HRS observations are two years apart, these estimates are interpreted as the probability of surviving in the next two years given age, education level, and health status observed in the current interview period. We need to transform these estimates into annual survival probabilities. Moreover, we also need to extrapolate the estimates to individuals aged 20 to 49. We describe the details of these adjustments in the online appendix that accompanies this article. The estimated probabilities are presented in Figure 6.

[22] Despite the similarity, there is a subtle difference between the questions of perceived health status in both databases. MEPS is concerned about the health status relative to others in the same age group, while HRS is concerned about the perception of individuals in relation to themselves. In order to check their comparability, Attanasio et al. (2010) applied the same definition of health status we used to compare the transition probabilities of health status by age and education level in both data sets. They found that the similarity across both samples is considerable.

[23] The data used are the HRS cohort from 1992 to 2010, the AHEAD cohort from 1993 to 2010, the CODA cohort from 1998 to 2010, the WB cohort from 1998 to 2010, and the EBB cohort from 2004 to 2010. To keep the two-year interval between responses, we disregarded the responses of the AHEAD cohort in 1995 and the responses in 1992 of the individuals who were in the HRS cohort in 1992 but moved to the AHEAD cohort in 1993.

[24] We also estimated, with the same equation, using the population-averaged probit method, the random-effects logit method, and the random-effects probit method. The resulting probabilities are very similar using any of these methods.

[25] This may be adequate to this data because the correlations of next period's survival status varied little with the lag length. Our estimation also considered panel-robust standard errors.

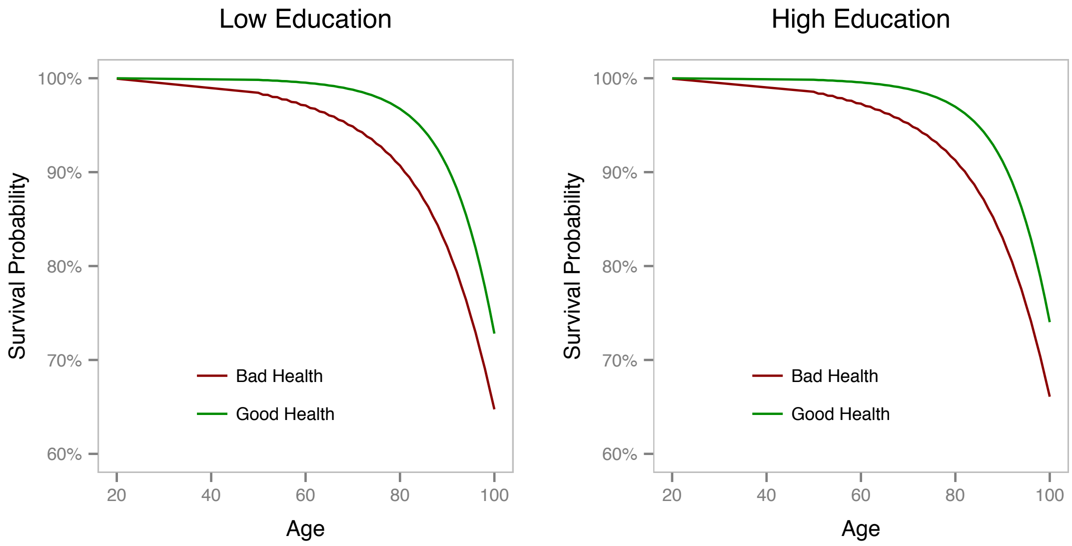

Figure 6: Survival probabilities by age, education level, and health status.

6.4 Medical Expenditures

We used the MEPS database to estimate the sets of medical expenditures and their distribution. We used the cross-sectional data from 1996 to 2010. For each cross-section, we considered only individuals aged 20 and over, with strictly positive sample weights, who answered all the three questions about perceived health status in a given year.[26] To establish the medical expenditures of each individual, we considered the variable that accounts for total expenditures on health care, which includes out-of-pocket expenditures plus what is covered by insurance, but do not includes insurance premiums. All values were converted to 2010 dollars using the CPI for medical care.[27]

In order to keep the sample size large enough, we divided our sample into five age groups: 20–29, 30–39, 40–49, 50–64, and 65 or over. We assigned the representative age of each age group to the mid-point of a corresponding interval. For each age group and health status, we approximated the distribution of medical expenditures by a histogram with bins corresponding to the percentiles 1^{st}–60^{th}, 61^{st}–90^{th}, and 91^{st}–100^{th}.[28] Within each bin, we calculated the weighted average of medical expenditures using the sample weights. Then, for each bin and health status, we fitted a second order polynomial over these estimates in order to extrapolate the estimated medical expenditures to all ages. Finally, for each age and health status, we used the estimates of each bin to form the three-point set of medical expenditures $\mathcal{M}_{j,h}$. The probabilities are given by the size of the bins. The estimated medical expenditures are presented in Table 1 and Figure 7.

We set the relative price of medical expenditures π so that medical expenditures per

[26] Unlike health status, we considered the regular sample weights, not the longitudinal ones, since now we made a cross-sectional estimation.

[27] We used the CPI for medical care instead of the CPI for all items because of the fact that inflation for medical care has been higher than general inflation.

[28] This approximation was made in order to capture the long tail of the distribution of medical expenditures and a small probability of incurring very large and catastrophic expenditures.

Table 1: Estimated medical expenditures in 2010 dollars by health status and age group

Health Status	Age Group	1^{st}–60^{th}	61^{st}–90^{th}	91^{st}–100^{th}
Bad Health	20–29	573.05	5,381.29	35,919.26
	30–39	927.97	7,443.46	41,469.40
	40–49	1,456.87	9,936.09	49,010.30
	50–64	2,562.88	14,015.86	63,508.13
	65+	4,163.66	20,127.19	68,482.20
Good Health	20–29	143.57	1,619.63	10,418.35
	30–39	231.42	2,168.09	12,829.43
	40–49	356.23	2,680.07	14,235.42
	50–64	790.52	4,573.39	20,881.18
	65+	1,699.26	7,626.15	30,999.27
Probabilities		60%	30%	10%

capita of our model was equal to \$7,800 in equilibrium. This target was calculated using health expenditures data from the National Health Expenditure Accounts (NHEA) and population data from the Council of Economic Advisers (2013).[29] We converted health expenditures to 2010 dollars using the CPI for medical care and took the average of health expenditures per capita from 1996 to 2010. The final value of π is 2.0855.

6.5 Labor Productivity

We used the MEPS database to estimate the set of labor productivities. We used the cross-sectional data from 1996 to 2010. For each cross-section, we considered only individuals aged between 20 and 64, with strictly positive sample weights, and with strictly positive wage income. All wages were converted to 2010 dollars using the CPI for all items. We first calculated the weighted average of wages from the whole sample, which turns out to be \$40,396 in 2010 dollars. Next, we approximated the distribution of wages by a histogram with bins corresponding to the percentiles 1^{st}–25^{th}, 26^{th}–50^{th}, 51^{st}–75^{th}, 76^{th}–95^{th}, and 96^{th}–100^{th}.[30] Within each bin, we calculated the weighted average of wages using the sample weights. Our labor productivities are then calculated as the ratio of these averages to the average of the whole sample. The final five-point set of labor productivities is $\mathcal{Z} = \{0.2453,\ 0.6198,\ 1.0309,\ 1.7342,\ 3.5826\}$.

[29] It is well known that MEPS significantly underestimates medical expenditures at the aggregate level compared to those reported in the NHEA (Selden et al. (2001), Sing et al. (2006), and Bernard et al. (2012)). The NHEA relies on surveys of providers, while MEPS statistics are based on surveys of households, which tend to underreport the spending and utilization of medical services. Therefore, it is important to adjust our medical expenditures estimates to be consistent with data at the national level.

[30] This approximation was made in order to capture the long right tail of the wage distribution.

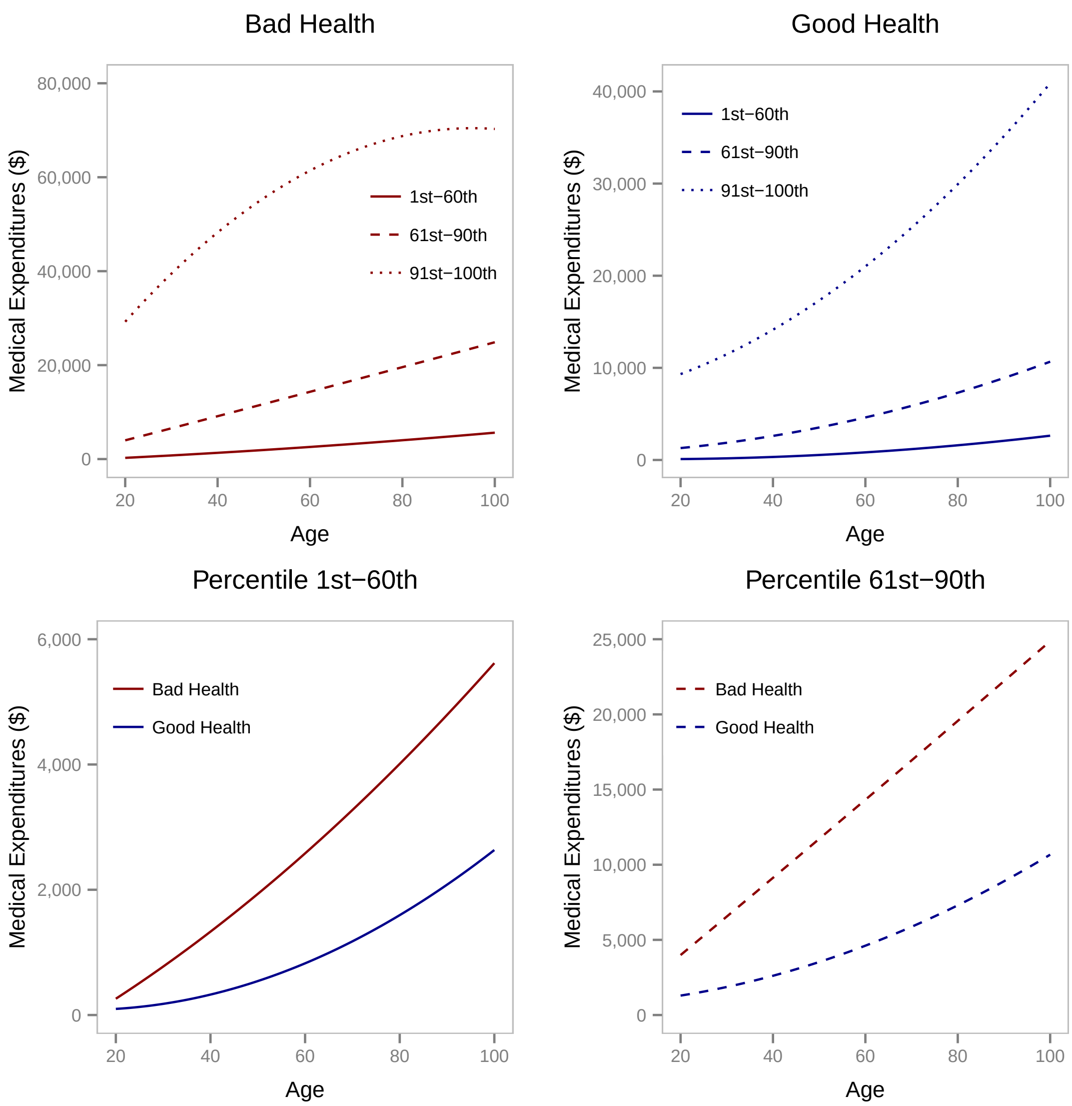

Figure 7: Estimated medical expenditures by age and health status. Top left: Fixed bad health status, varying age and percentiles. Top right: Fixed good health status, varying age and percentiles. Bottom left: Fixed percentile 1^{st}–60^{th}, varying age and health status. Bottom right: Fixed percentile 61^{st}–90^{th}, varying age and health status.

6.6 Stochastic Process for Labor Productivity and EHI Offer

We used the MEPS database to estimate the joint transition probabilities of labor productivity and EHI offer status. During a year, individuals are interviewed three times and report whether they were offered health insurance at the workplace. We assumed that individuals have received an EHI offer in a given year if they reported receiving an offer in at least one interview. We used data of the two-year panels from 1996–1997 up to 2009–2010. For each panel, we considered only individuals aged between 20 and 64, with strictly positive wage income in both years, and who answered all three EHI offer questions in both years.

Our transition probabilities depend on age and education level. In order to keep

the sample size large enough, we divided our sample into five age groups: 20–29, 30–39, 40–49, 50–64, and 65 or over. Because we have five values for labor productivities and two values for EHI offer statuses, the joint Markov process was defined over ten states. Then, for each age group and education level, constructing the transition matrix is simply calculating the weighted fractions of individuals who made the transition from a state (z, ι) in the first year to a state (z', ι') in the second year.[31] The joint transition matrices can be obtained upon request from the authors.

6.7 Assets

We used the SCF database to estimate the set of assets and the initial distribution of assets. We pooled all the cross-sectional data from 1989, 1992, 1995, 1998, 2001, 2004, 2007, and 2010. We considered only the records of household heads aged 20 and over. Assets were identified from this database as the net worth, and these values were converted to 2010 dollars using the CPI for all items. In the model, assets can only take positive values, so we converted negative net worth values to zero. We first sorted the sample in ascending order by net worth. Then, we divided the ordered sample into 51 groups with the same amount of total net worth, and one specific group containing all zero net worth. The set of assets is formed by the average net worth of each group. The initial distribution of assets are the fractions of individuals aged 20 in each group. These fractions were calculated using the sample weights.

6.8 Preferences

The time endowment ℓ was set to 8,760 hours, which is the total hours in a year considering 365 days per year and 24 hours per day. The time of part-time job l^P was set to 1,008, which is the total hours of a part-time job in a year considering 252 workdays per year and 4 hours of work per day. Similarly, considering 8 hours of work per day, we set the time of full-time job l^F to 2,016. We set the intertemporal discount factor β so that the capital-output ratio of our model was equal to 3.02 in equilibrium. This target was calculated using output data from the Council of Economic Advisers (2013) and capital data from Feenstra et al. (2013). We took the average of the ratios from 1996 to 2010. The final value of β is 0.9855. The parameters of the utility function were taken from French (2005), which structurally estimated the parameters of the same functional form using a model with several features similar to ours. The share of consumption in utility γ was set to 0.615, the risk aversion parameter σ was set to 7.69, the time cost of work ϕ_1 was set to 240, and the time cost associated with bad health status ϕ_2 was set to 202.

6.9 Health Insurance

We used the MEPS database to estimate the coinsurance rates. We used the cross-sectional data from 1996 to 2010. For each cross-section, we considered only individuals

[31]The weighted fractions were calculated using the longitudinal sample weights.

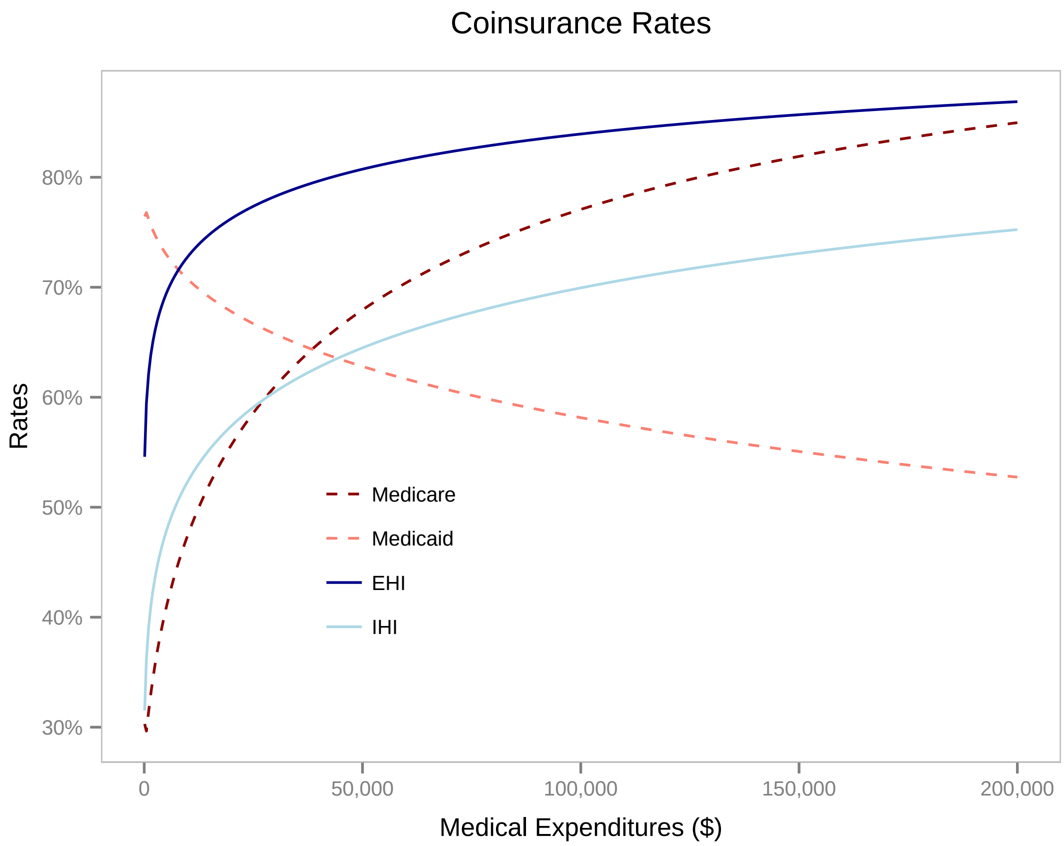

Figure 8: Coinsurance rates by type of coverage and medical expenditures.

with strictly positive sample weights and who have incurred strictly positive medical expenditures. In our model, agents aged 65 and over are automatic enrolled into Medicare, and cannot have another type of health insurance. Besides, agents aged between 20 and 64 may have Medicaid, EHI, and IHI. Therefore, we only considered individuals aged 65 and over when estimating the coinsurance rates of Medicare, and only considered individuals aged between 20 and 64 when estimating the coinsurance rates of Medicaid, EHI, and IHI.

In MEPS, the questions about the source of health insurance coverage are asked retrospectively for each month of the year. There are specific questions about Medicare, Medicaid, and EHI. We considered individuals as having Medicare, Medicaid, or EHI if they reported having it for all months. Unfortunately, there is no specific question about IHI coverage. To determine if an individual has IHI coverage, we used the questions about nongroup insurance, self-employed insurance, and "source unknown" private insurance. We considered individuals as having IHI coverage if they reported having at least one of these three insurances for all months.

Because coinsurance rates are values between zero and one, we followed Papke and Wooldridge (1996) and used the Generalized Linear Model (GLM) with a logit link and the binomial family. For each type of health insurance, we regressed the coinsurance rates on a constant, logarithm of medical expenditures, and square of the logarithm of

medical expenditures.[32] To deal with the complexity of the sample design of MEPS, our estimation took into account the sample weights, the primary sampling unit (PSU), and the stratum of the PSU. To obtain the final coinsurance rates, we applied the estimated equation to the medical expenditures estimated in Section 6.4. The estimated coinsurance rates are presented in Figure 8.

The Medicare premium p^{MC} refers to the Part B premium, and we set its value to \$1,326, which is the annualized monthly value of 2010 according to Table A-I of Davis et al. (2014). The Medicare's administrative cost φ was set to 1.6083%, which is the average from 1995 to 2010 of the costs reported by the Medicare Boards of Trustees found in Table 1 of Sullivan (2013).

The Medicaid and Medically Needy income thresholds were set to fractions of the Federal Poverty Level (FPL). To determine the FPL, we used data of the poverty guidelines for the 48 contiguous states and the district of Columbia from 1996 to 2010. These data were collected from the website of the U.S. Department of Health & Human Services.[33] Because the FPL varies with household size, for each year, we calculated the average FPL weighted by the household size distribution. We used household size data from Table 62 of U.S. Census Bureau (2012a). For each year, we divided the average FPL by the corresponding output per capita. We took the average of these ratios and set the FPL f to 36.27% of the output per capita generated by the model.

The Medicaid income threshold y^{MA} was determined using data from Table 3 of Kaiser Family Foundation (2013a). This table presents the thresholds as a percent of the FPL for jobless and working parents by state. Because the threshold of our model does not depend either on employment status or the state, we calculated the average threshold weighted by the employment status distribution and by the population of each state. The employment status distribution was calculated using data from Table B36 of the Council of Economic Advisers (2013). We only considered the labor force aged 20 years or more and took the average of the distribution from 1996 to 2010. The population by state was collected from Table 1 of U.S. Census Bureau (2012b) and we used the values of 2010. The final value of y^{MA} was set to 85.64% of the FPL.

The Medically Needy income and asset thresholds were determined using data from Table 1 of Kaiser Family Foundation (2012). This table presents both thresholds for singles and couples by state. The income threshold is presented as a percent of the FPL. We assumed that singles are households of size one and couples are households of size greater than one. We calculated the average thresholds weighted by the household size distribution and by the population of each state. Because the table values are for 2009, we used the population values of 2009 and converted the asset threshold values to 2010 dollars using the CPI for all items. The final value of y^{MN} was set to 53.15% of the FPL and the final value of a^{MN} was set to \$3,416.

[32] We used the logarithm because the scale of medical expenditures is much greater than the scale of coinsurance rates.

[33] See http://aspe.hhs.gov/poverty/figures-fed-reg.cfm.

The private insurance administrative cost κ was set to 12%, which is the value reported by the Congressional Budget Office (2008) and Cutler and Ly (2011). The IHI fixed cost $\varkappa$ was set to \$30.87. This is the same value calculated by Pashchenko and Porapakkarm (2013) but converted to 2010 dollars using the CPI for all items. The fraction of the EHI premium paid by the employer ω was calculated using data from Exhibit 6.22 of Kaiser Family Foundation (2013b), which provides data of the average percentage of premiums paid by covered workers for single and family coverage from 1999 to 2013. Because data is of the fraction paid by employees, not employers, we calculated the complement of these fractions. We took the average of the complements from 1999 to 2010 and set the final value of ω to 78.46%.

6.10 Production Sector

We set the total factor productivity A so that the output per capita of our model was equal to \$44,855 in equilibrium. This target was calculated using output and population data from the Council of Economic Advisers (2013). We converted the output values to 2010 dollars using the GDP implicit price deflator provided by the same source. We took the average of the outputs per capita from 1996 to 2010. The final value of A is 5.4475. The share of capital in the output α was set to 0.3358 and the depreciation rate δ was set to 0.0713. These are averages of the values used by related articles in the literature.

6.11 Government

We set the government debt D so that the debt-to-capital ratio of our model was equal to 13.62% in equilibrium. This target was calculated using debt-to-output ratio data from Table B–79 of the Council of Economic Advisers (2013) and the capital-output ratio as explained in Section 6.8. The debt data used was the federal debt held by the public. We took the average of the debt-to-output ratios from 1996 to 2010. Then, we divided the final debt-to-output ratio by the final capital-output ratio to obtain the final debt-to-capital ratio. The government expenditures G were set so that they represent 18.77% of the output in equilibrium. This target was calculated using output and government expenditures data from Table B–1 of the Council of Economic Advisers (2013). We took the average of the ratios from 1996 to 2010.

The fraction ξ used as limit to deduct medical expenditures was taken from the Internal Revenue Service (2010), and its official value in 2010 was 7.5%. The marginal income tax rates and the income brackets were collected from the Tax Foundation (2013). The official values for the marginal income tax rates in 2010 were $\{\tau_1, \tau_2, \tau_3, \tau_4, \tau_5, \tau_6\} = \{10\%, 15\%, 25\%, 28\%, 33\%, 35\%\}$. For the income brackets, we took the average of the values corresponding to singles, married filing jointly or qualified widow(er), married filing separately, and head of household. The final values are $\{y_1, y_2, y_3, y_4, y_5\} = \{\$11,362,\ \$45,387,\ \$101,500,\ \$169,068,\ \$326,943\}$. We set y_0 equals to zero and y_6 equals to infinity. The Social Security tax rate τ^{SS} and the Medicare tax rate τ^{MC} were

Table 2: Set of average lifetime earnings

1	2	3	4	5	6	7	8	9	10
0	3,044	6,088	9,132	24,432	39,732	55,032	72,288	89,544	106,800

collected from the Social Security Administration (2014). For both rates, we added the contributions of the employee and the employer. The final value for τ^{SS} is 12.4% and the final value for τ^{MC} is 2.9%.

The retirement age R was set to 46, which represents an age of 65 in the real world. The other parameters were collected from the Official Social Security Website. The Social Security Wage Base y^{SS} was set to \$106,800, which is the official value of 2010.[34] The bend points of the benefit function $\{x_1, x_2\}$ were set to \$9,132 and \$55,032, respectively, which are the official annualized values of 2010.[35] The parameters $\{\theta_1, \theta_2, \theta_3\}$ were set to their official values, which are 90%, 32%, and 15%, respectively.[36] To estimate the set of average lifetime earnings $\mathcal{X}$, we first formed a set containing the value zero, the two bend points of the benefit function, and the Social Security Wage Base. Between each of these points, we added two more points equally spaced to form a final set with 10 elements. The final values are presented in Table 2.

We set the minimum level of consumption $\underline{c}$ so that the share of uninsured in our model was equal to 12.34% in equilibrium. This target was calculated using the MEPS database, and we took the average of the shares from 1996 to 2010. The final value of $\underline{c}$ is \$6,784.

6.12 Health Care Reform

All parameters of the reform were taken from the two laws that established it: the Patient Protection and Affordable Care Act (H.R. 3590) and the Health Care and Education Reconciliation Act of 2010 (H.R. 4872). The fractions of income of the affordable health insurance criteria d^I and d^E were set to 8% and 9.5%, respectively. The fractions of the FPL that determine the income categories of the premium tax credit were set to $\{g_1, \dots, g_7\} = \{100\%, 133\%, 150\%, 200\%, 250\%, 300\%, 400\%\}$. For each income category, the law specifies the interval of maximum premium spending as a percentage of income. We set the fractions of income spent on insurance to be the average of the intervals specified by the law. The final values are $\{\varepsilon_1, \dots, \varepsilon_6\} = \{2\%, 3.5\%, 5.15\%, 7.175\%, 8.775\%, 9.5\%\}$.

The parameters of the individual mandate were set to the values from 2016 onwards, which represents the end of the transition period. The value υ was set to \$695, the fraction of taxable income ν was set to 2.5%, and the maximum penalty ρ was set to

[34]See http://www.ssa.gov/oact/cola/cbb.html.
[35]See http://www.ssa.gov/oact/cola/bendpoints.html.
[36]See http://www.ssa.gov/oact/cola/piaformula.html.

\$2,085. The fraction of the FPL used in the Medicaid expansion ζ was set to 138%.[37] The fraction used as a limit to deduct medical expenditures ξ was raised to 10%.

7 Results

Overall, the model replicates very closely the health insurance coverage, as one can see from Table 3. The largest difference between model and data is less than two percentage points. In addition, our model (see Figure 9) also replicates insurance coverage very well at different ages, education levels, and health conditions. Even without forcing the match, the model is quite adherent to data. For instance, we reproduce the fact that the share of low educated persons without insurance is way higher than that of high educated individuals, and that both shares decrease with age.

Table 3: Health insurance coverage (%)

	Uninsured	**Medicare**	**Medicaid**	**Private**
Data	12.34	12.16	12.53	62.97
Benchmark	12.34	12.55	10.89	64.21

Notes: Data values are from the Medical Expenditure Panel Survey (MEPS). Averages from 1996 to 2010.

Our model is also consistent with U.S. macroeconomic data, replicating some relevant U.S. macroeconomic variables quite closely, as presented in Table 4. In the case of output and medical expenditures per capita, capital-output ratio, and the share of government expenditures to output, the match was forced. However, without using any targeting strategy, the model is able to replicate per capita income taxes, Social Security benefit, Medicare coverage, and average work hours. Factor prices are also replicated closely without any targeting strategy.

Figure 10 presents the life cycle profiles of assets and private health insurance premiums. The left panel shows that the assets' profile is consistent with the inverted U-shape format commonly documented in the literature. Assets are important in our analysis because they act as insurance against health shocks. The endogenous private health insurance premiums are also consistent with what one would expect. The right panel shows that IHI premiums are increasing with age. In addition, for every age, IHI premiums for bad health individuals are always greater than those for good health individuals. This is expected since older and poor health people are more likely to have higher medical expenditures.

[37] Notice that the text of the law says 133% of the FPL. However, there is a special deduction to income equal to five percentage points of the FPL. This raises the eligibility threshold to 138% of the FPL.

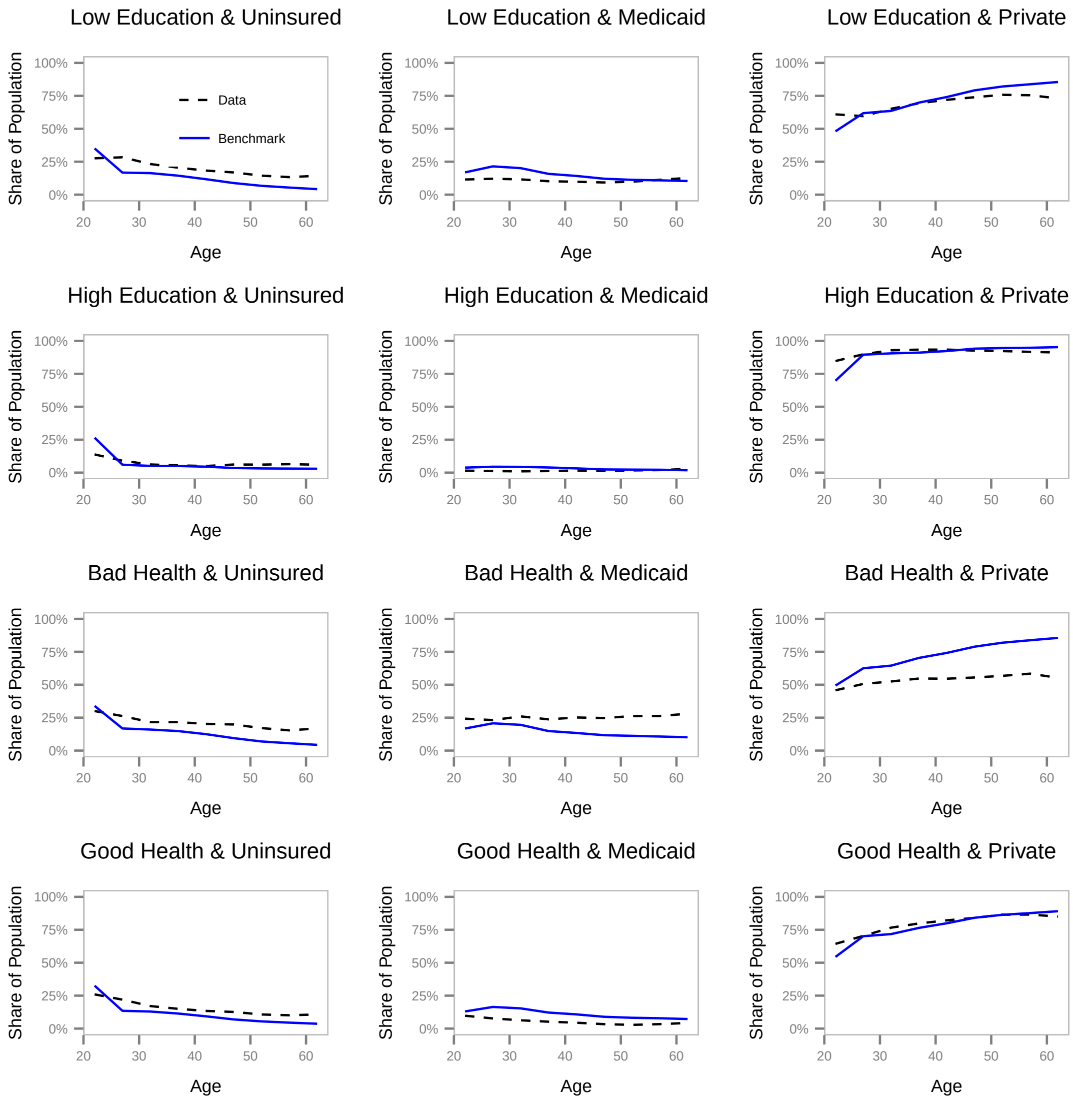

Figure 9: Observed and simulated health insurance coverages by age, education level, and health status. Notes: Data values are from the Medical Expenditure Panel Survey (MEPS). Averages from 1996 to 2010.

8 Policy Analysis

In this section we present the main results of the policy changes – PPACA and cost reductions – comparing steady states before and after their implementation. We describe the effects on health insurance coverage, government budget, and welfare of individuals. We simulate the PPACA changes as a whole, but also of its components alone. In all experiments, we hold constant the share of government spending as a percent of output, letting the consumption tax rate free in order to rebalance government budget. Since Medicaid expansion, a major change of the PPACA, is a state policy, we chose a more decentralized tax rate to rebalance government budget.

Table 4: Observed and simulated macroeconomic variables

	Data	**Benchmark**
Output	44,855	44,828
Capital	135,454	135,417
Medical expenditures	7,800	7,801
Average work hours	1,764	1,997
Income taxes	4,528	4,770
Government expenditures	8,440	8,413
Social Security benefit	1,920	1,970
Medicare coverage	1,360	1,165
Interest rate	3.39%	3.99%
Hourly wage rate	17.99	15.38

Notes: Data values are from the Council of Economic Advisers (2013), Feenstra et al. (2013), and National Health Expenditure Accounts (NHEA). Financial values are in per capita terms. Averages from 1996 to 2010.

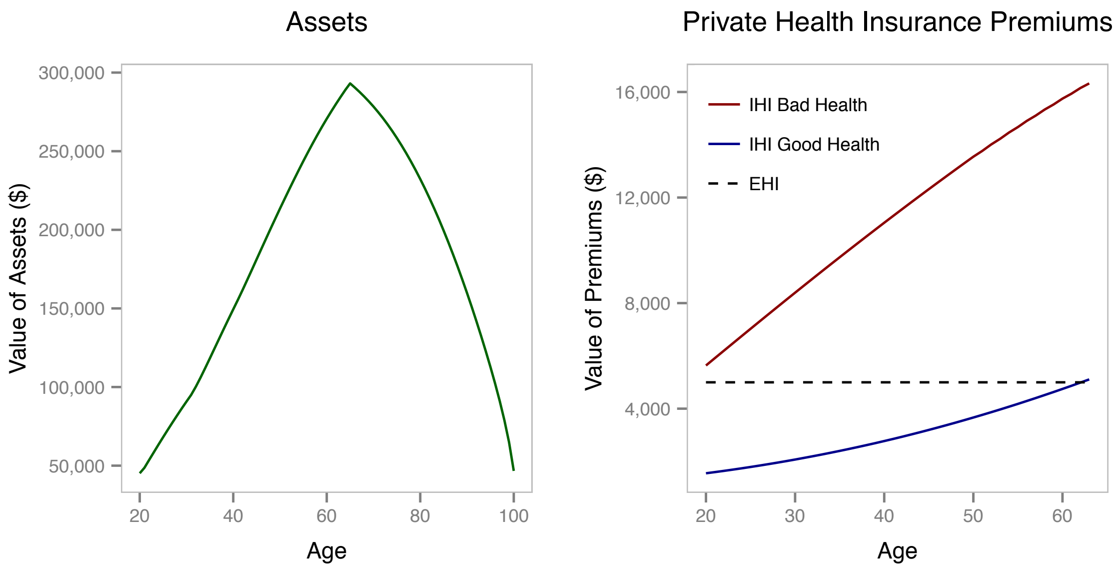

Figure 10: Life cycle profiles of assets and private health insurance premiums.

8.1 Health Insurance Coverage

Table 5 presents the health insurance coverage generated by each policy. We found that, in the long run, the PPACA reduces uninsured population from 12.34% to 4.21%. This result is mainly driven by the Medicaid expansion, as Medicaid population increased more than twofold, going from 10.89% to 26.26%. The IHI market share increased from 3.72% to 5%, and premium tax credits and individual mandate were the main causes, even with the health insurance regulation acting in the opposite direction. In contrast, driven mostly by the Medicaid expansion, the EHI market shrank almost 10 percentage

Table 5: Health insurance coverage after policies (%)

	Uninsured	**Medicaid**	**EHI**	**IHI**
Benchmark	12.34	10.89	60.49	3.72
PPACA	4.21	26.26	51.98	5.00
Premium Tax Credits	8.57	10.53	60.54	7.81
Individual Mandate	7.33	10.51	64.18	5.42
Medicaid Expansion	5.63	26.56	51.94	3.31
Health Insurance Regulation	15.81	10.88	60.47	0.28
Deductible Medical Expenditures	12.12	10.90	60.50	3.93
Rand Proposal	12.17	10.85	60.55	3.89
OECD Trend	9.91	9.73	62.86	4.94
5% Reduction	11.73	10.59	60.96	4.17
10% Reduction	11.20	10.33	61.51	4.41
15% Reduction	10.91	10.17	61.76	4.60
20% Reduction	10.64	10.01	62.05	4.75
25% Reduction	10.23	9.84	62.49	4.88

points, going from 60.49% to 51.98%. The increase in income threshold for claiming deduction of medical expenses had no significant effect on health insurance coverage.

Looking at each policy individually, Medicaid expansion increased the demand for Medicaid, as expected, raising its share by 143.9% and reducing uninsured population by 54.4%. It also caused a shrinkage of the private insurance market, reducing the market shares of EHI and IHI by 14.1% and 11.0%, respectively. Premium tax credits increased the demand for IHI, raising its share by 109.8% and reducing uninsured and Medicaid populations by 30.6% and 3.4%, respectively. Individual mandate increased the demand for private insurance, reducing uninsured population by 40.6% and raising the shares with EHI and IHI by 6.1% and 45.7%, respectively. Health insurance regulation increased IHI premiums for individuals with good health, which are the majority of the population, decreasing IHI market share by 92.4%. By itself alone, this policy would have increased uninsured population by more than three percentage points, practically destroying the IHI market.

Cost reductions were not as effective as the PPACA in reducing uninsured population. Even with large reductions, the share of uninsured people remains more than twice the one achieved by PPACA. Besides, premium tax credits, individual mandate, and Medicaid expansion were individually more effective than all cost reductions experiments. Medicaid coverage decreases with the size of the cost reduction, while private insurance coverage increases. Large reductions take the market share of the IHI market to levels

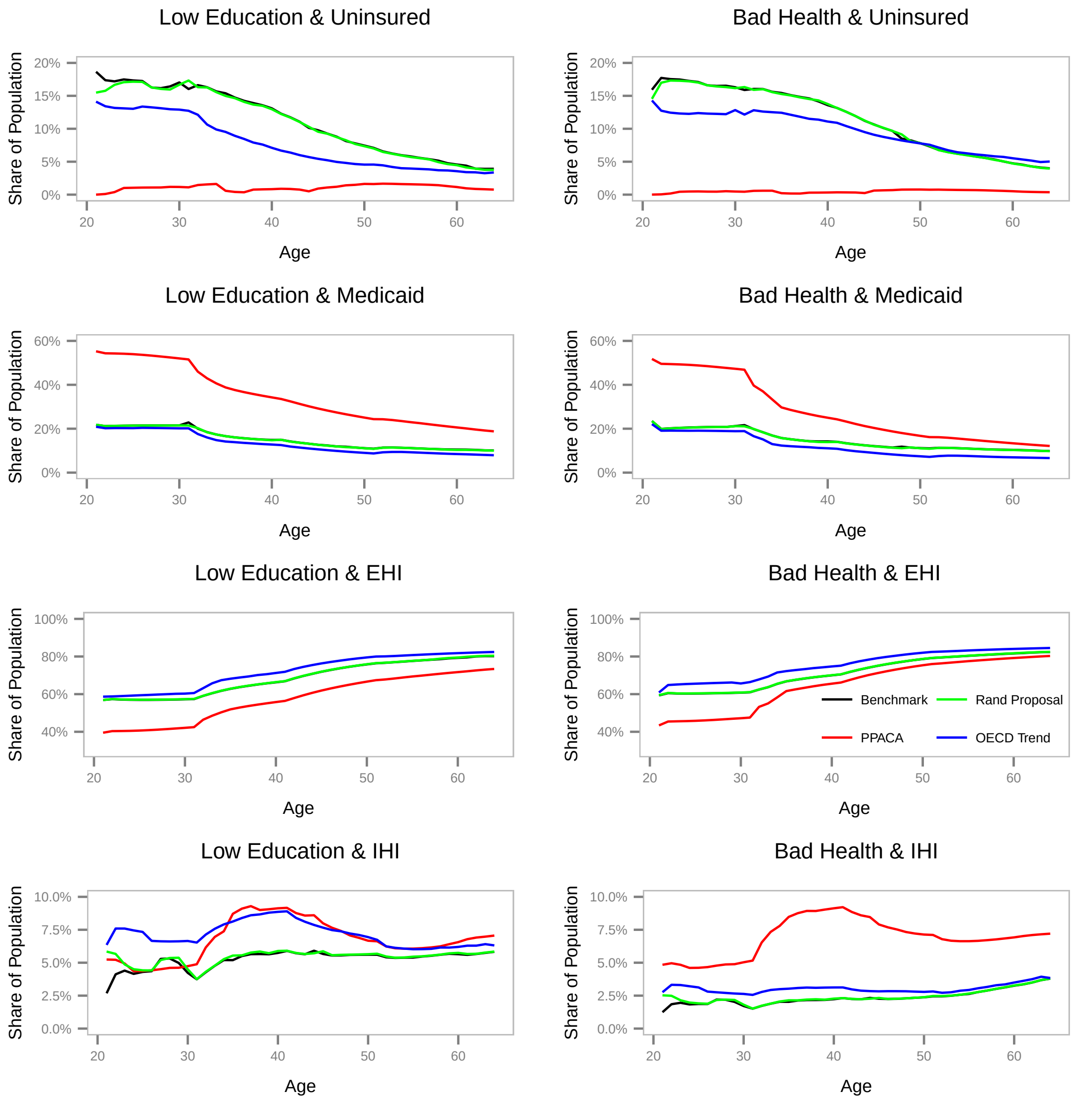

Figure 11: Simulated health insurance coverage by policy, age, low education, and bad health.

close to the PPACA. These results are mainly driven by the fall in insurance premiums, which reflect the decline in health care costs of insurers. Besides, cheaper medical costs alleviate the budget of individuals, leaving more resources for the purchase of private insurance. However, less costly medical expenditures induce more people to remain uninsured, which is not necessarily a bad situation in a scenario with lower costs. That is one reason why welfare analysis is important in this case.

These results extend throughout the life cycle. Figure 11 compares health insurance coverage by age for individuals with low education level and bad health status. The PPACA reduced uninsured population for all ages in both groups, reaching very low levels over the life cycle. Medicaid coverage increased substantially for both groups. Except for older adults, Medicaid coverage more than doubled for low educated population. The growth was also significant for the population with bad health status, more than doubling for young adults. The EHI market shrunk in both groups throughout the life cycle. For

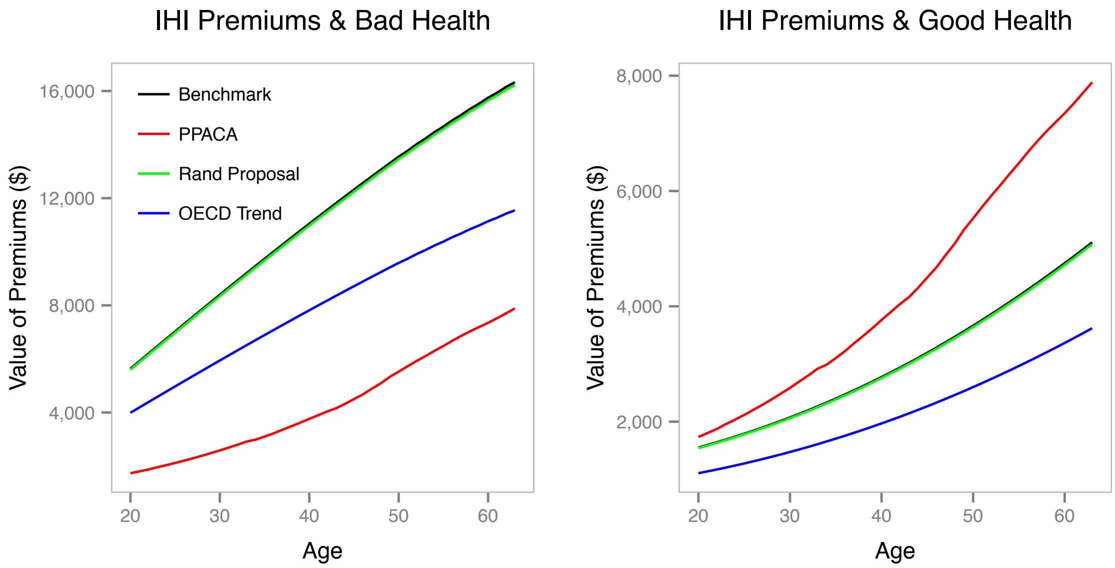

Figure 12: Simulated IHI premiums by policy, age, and health status.

almost all ages, the IHI market more than doubled for individuals with bad health status, and in some cases more than tripling. The increase was also expressive for low educated individuals.

Cost reductions generate a smaller impact on uninsured population throughout the life cycle for both groups. The fall of Medicaid coverage and the increase of private insurance also occur at all ages and in both groups. Interestingly, for large reductions, the rise in the IHI market is driven by low educated population. These individuals are less productive, receiving lower income throughout the life cycle, which generates a lower accumulation of wealth. In addition, they are also less likely to receive an EHI offer. Therefore, they are the ones that rely more on Medicaid and IHI. With a large drop in costs, IHI premiums become more affordable, leading more low educated individuals to purchase this type of insurance. Figure 12 presents the impact of the experiments on IHI premiums. Small cost reductions are not enough to produce considerable changes of behavior regarding insurance coverage. Thus, its results are very similar to the benchmark economy for all coverages and groups throughout the life cycle.

The PPACA is more effective on the poorest population, having smaller effects on wealthier individuals. Figure 13 compares health insurance coverage by level of assets. After the PPACA, uninsured population falls in all wealth levels, but the decline is greater for the poorest people. The growth of Medicaid population is also mostly driven by the poor. The EHI market shrunk for all asset levels, and its decline is very correlated with the rise of Medicaid. The IHI market increased for almost all wealth levels, driven mostly by the subsidies of premium tax credits and the individual mandate. With respect to the uninsured population, cost reductions had a smaller effect on the poorer than the PPACA. The effects were also smaller for Medicaid and EHI. Interestingly, specially for large reductions, the wealthier become more uninsured and buy less IHI. This can be

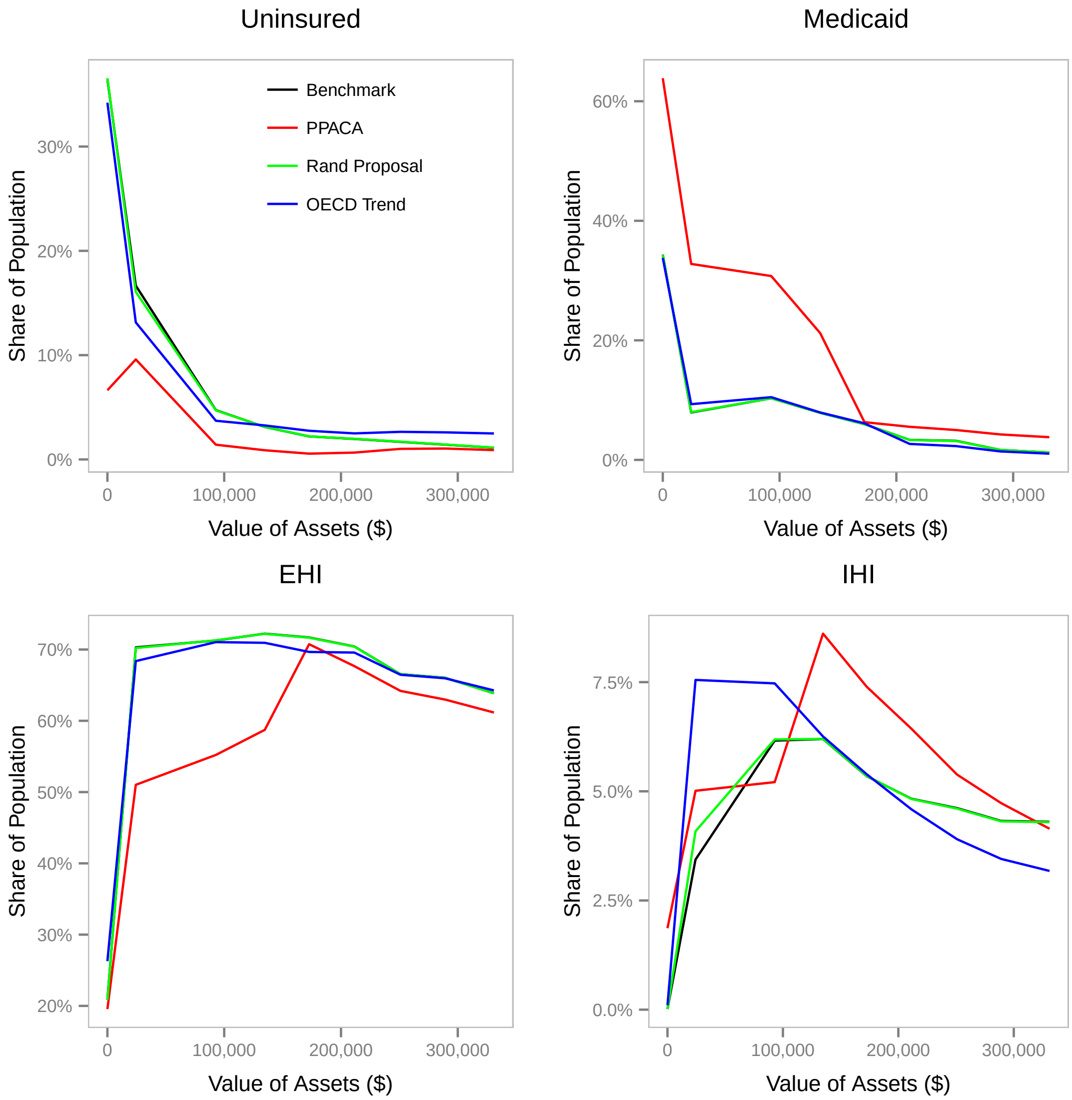

Figure 13: Simulated health insurance coverage by policy and assets.

explained by the fact that wealth acts as an insurance for medical expenses. With such cost reductions, wealthier individuals lose the incentive to purchase IHI and start to rely more on their wealth, becoming more uninsured.

8.2 Government Budget

Table 6 presents percentage variations in fiscal revenues and outlays after policies. The PPACA had a negative impact on government budget, mainly due to Medicaid Expansion. The increase in income and payroll tax collection, the savings with social insurance, and the new revenues from individual mandate's penalties were not enough to afford the rise in government, Medicaid, and Social Security spending, and new expenses with subsidies from the premium tax credits. To rebalance its budget, the government raised consumption tax rate by 5.07%, increasing consumption tax collection.

Table 6: Variations in government budget (%)

	PPACA	**Rand**	**OECD**	**5%**	**10%**	**15%**	**20%**	**25%**
Fiscal Revenues								
Income taxes	+2.51	+0.16	+6.31	+1.14	+2.22	+3.30	+4.36	+5.41
Consumption taxes	+6.10	−0.85	−31.94	−6.22	−12.15	−17.41	−22.54	−27.62
Social Security taxes	+1.69	+0.14	+5.14	+1.02	+1.96	+2.84	+3.67	+4.47
Medicare taxes	+1.69	+0.14	+5.16	+1.03	+1.97	+2.85	+3.68	+4.49
Fiscal Outlays								
Government spending	+0.36	+0.07	+1.85	+0.49	+0.90	+1.20	+1.46	+1.69
Debt service	−0.05	+0.14	+3.51	+0.96	+1.76	+2.35	+2.85	+3.25
Social Security benefit	+0.92	+0.08	+2.76	+0.57	+1.10	+1.57	+2.01	+2.42
Medicare coverage	0.00	−0.64	−29.45	−5.00	−10.00	−15.00	−20.00	−25.00
Medicaid coverage	+122.25	−1.16	−39.70	−8.36	−16.08	−22.60	−28.89	−34.89
Social insurance	−29.71	−1.84	−53.48	−12.65	−24.25	−32.46	−40.03	−47.57
Consumption tax rate	+5.07	−1.18	−40.59	−8.53	−16.36	−23.16	−29.53	−35.59

Cost reductions, in turn, had a positive effect on government budget, mainly due to savings with public insurance. The drop in costs reduced public spending with Medicare and Medicaid. It also reduced medical expenditures paid by individuals, increasing the amount of resources available to them, generating savings with social insurance. Despite the increase in government, Social Security, and debt expenses, savings with public insurances and the revenue growth from income and payroll taxes alleviated public budget, allowing the government to reduce consumption tax rate. For instance, the Rand Proposal reduced consumption tax rate by 1.3%, showing that feasible cost reductions can generate positive effects on public finances.

8.3 Welfare

We measured welfare gains or losses by the consumption equivalent variation (CEV) of newborns under the veil of ignorance. This measure is calculated as the uniform percent change in the baseline consumption that would make newborns to remain indifferent between living in a world with or without the policy changes. It can be formally defined by

$$W = \left(\frac{\sum_{\tilde{s}} V^A(1, \tilde{s}) \lambda^A(1, \tilde{s})}{\sum_{\tilde{s}} V^B(1, \tilde{s}) \lambda^B(1, \tilde{s})} \right)^{\frac{1}{\gamma(1-\sigma)}} - 1,$$

where $\{V^B, \lambda^B\}$ and $\{V^A, \lambda^A\}$ are the value functions and distributions of agents before and after policy changes, respectively, and $\tilde{s}$ is the state vector without age.[38] To better understand the welfare effects, we further measure the CEV of newborns by health status and labor productivity.

Table 7 presents the CEV of newborns after policies. The PPACA and cost reductions are welfare improving for all groups. The welfare gains are very similar among newborns with bad and good health. After the reform, the second least productive newborns are the most benefited. These are the individuals whose income during working life was not high enough to purchase private insurance and not low enough to make them eligible for Medicaid. After the Medicaid expansion, many of them can be public insured without cost. Welfare gains are increasing with the size of cost reduction and with productivity. After cost reductions, highly productive newborns are more benefited as they are more likely to have private insurance, taking further advantage due to fall in insurance premiums.

We now ask which cost reduction would be equivalent to the PPACA in terms of welfare improvement. Looking at table 7, it seems that a reduction of 5% produces similar welfare effects as those generated by the reform. To be more precise about that, we did the following exercise. We took the size of the reductions we evaluated as the independent variable, and the CEV produced by each reduction as the dependent variable. We then fitted a curve over this data to explain the relation between these two variables. We found that a linear curve fits very well this data. We used the estimated linear relation to calculate the reductions that yield the CEVs produced by the PPACA. We found that a reduction of 5.21% is enough to produce the same welfare effects for all newborns as the reform.

Table 7: CEV of newborns (%)

	PPACA	**Rand**	**OECD**	**5%**	**10%**	**15%**	**20%**	**25%**
All	+1.97	+0.25	+10.77	+1.89	+3.76	+5.57	+7.36	+9.17
Bad health	+1.95	+0.24	+10.41	+1.82	+3.65	+5.41	+7.14	+8.88
Good health	+1.97	+0.25	+10.79	+1.89	+3.76	+5.58	+7.38	+9.19
1st Productivity	+1.72	+0.21	+8.76	+1.56	+3.09	+4.57	+6.03	+7.49
2nd Productivity	+2.21	+0.25	+10.69	+1.87	+3.72	+5.52	+7.31	+9.10
3rd Productivity	+1.93	+0.27	+11.86	+2.05	+4.09	+6.07	+8.05	+10.05
4th Productivity	+1.81	+0.30	+12.97	+2.25	+4.49	+6.69	+8.85	+11.04
5th Productivity	+1.59	+0.32	+13.88	+2.42	+4.82	+7.18	+9.50	+11.83

[38] Our welfare measurement is considering only steady state variations, and abstracts from transition costs associated with policy changes. Although it is interesting to analyze the transition path of policy changes, due to computational complexity, we did not perform such analysis.

9 Conclusion

This article uses a general equilibrium framework with heterogeneous agents to simulate and compare the long run effects of health care cost reductions and the Patient Protection and Affordable Care Act (PPACA). We study the effects on health insurance coverage, government budget, and welfare of individuals. Our model fits key aspects of the data very well and is quite rich. Due to computational complexity, we limit ourselves to steady state analysis, although we recognize the importance of transition path analysis of policy changes.

We found that all policies were able to reduce uninsured population, with the PPACA being more effective than cost reductions. In fact, most of the PPACA components are individually more effective than cost reductions, with the Medicaid expansion being the most effective. The impacts on government budget followed opposite directions. The PPACA increased public deficit mainly due to the Medicaid expansion, forcing tax hikes. On the other hand, cost reductions alleviated the fiscal burden of public insurance, reducing public deficit and taxes. Regarding welfare effects, the PPACA as whole and cost reductions are welfare improving. High welfare gains would be achieved if the U.S. medical costs followed the same trend of the OECD countries. Besides, feasible cost reductions generate considerable welfare gains, proving to be a good alternative. On average, we found that a cost reduction of 5% is enough to produce similar welfare effects as those generated by the PPACA.

Appendix A Summary of Parameters

Table 8: Summary of Parameters

Parameter		Value	Reference
Maximum age	J	81	Maximum age equals 100 years old
Population growth rate	η	2.75%	% of pop. aged 65 and over equals 12.55%
Probability of high education	$\Lambda\left(e^H\right)$	28.28%	Barro and Lee (2012)
Probability of low education	$\Lambda\left(e^L\right)$	71.72%	Barro and Lee (2012)
Relative price of med. exp.	π	2.0855	Medical exp. per capita equals $7,800
Time endowment	ℓ	8,760	24h/day and 365 days/year
Time of part-time job	l^P	1,008	4h work/day and 252 workdays/year
Time of full-time job	l^F	2,016	8h work/day and 252 workdays/year
Intertemporal discount factor	β	0.9855	Capital-output ratio equals 3.02
Share of consumption in utility	γ	0.615	French (2005)
Risk aversion parameter	σ	7.69	French (2005)
Time cost of work	ϕ_1	240	French (2005)
Time cost of bad health	ϕ_2	202	French (2005)
Medicare premium	p^{MC}	$1,326	Davis et al. (2014)
Medicare administrative cost	φ	1.6083%	Sullivan (2013)
Federal poverty level	f	$16,257	FPL-output ratio equals 36.27%
Medicaid income threshold	y^{MA}	$13,923	Threshold-FPL ratio equals 85.64%

Table 8: Summary of Parameters

Parameter		Value	Reference
Medically Needy income threshold	y^{MN}	\$8,641	Threshold-FPL ratio equals 53.15%
Medically Needy asset threshold	a^{MN}	\$3,416	Kaiser Family Foundation (2012)
Private insurance adm. cost	κ	12%	Cutler and Ly (2011)
IHI fixed cost	$\varkappa$	\$30.87	Pashchenko and Porapakkarm (2013)
Employer's share of EHI premium	ω	78.46%	Kaiser Family Foundation (2013b)
Total factor productivity	A	5.4475	Output per capita equals \$44,855
Share of capital in output	α	0.3358	Average from related articles in literature
Depreciation rate	δ	0.0713	Average from related articles in literature
Government debt	D	\$18,446	Debt-to-capital ratio equals 13.62%
Government expenditures	G	\$8,413	Government-output ratio equals 18.77%
Fraction to deduct med. exp.	ξ	7.5%	Internal Revenue Service (2010)
1st marginal income tax rate	τ_1	10%	Tax Foundation (2013)
2nd marginal income tax rate	τ_2	15%	Tax Foundation (2013)
3rd marginal income tax rate	τ_3	25%	Tax Foundation (2013)
4th marginal income tax rate	τ_4	28%	Tax Foundation (2013)
5th marginal income tax rate	τ_5	33%	Tax Foundation (2013)
6th marginal income tax rate	τ_6	35%	Tax Foundation (2013)
1st income bracket limit	y_1	\$11,362	Tax Foundation (2013)
2nd income bracket limit	y_2	\$45,387	Tax Foundation (2013)
3rd income bracket limit	y_3	\$101,500	Tax Foundation (2013)
4th income bracket limit	y_4	\$169,068	Tax Foundation (2013)
5th income bracket limit	y_5	\$326,943	Tax Foundation (2013)
Social Security tax rate	τ^{SS}	12.4%	Social Security Administration (2014)
Medicare tax rate	τ^{MC}	2.9%	Social Security Administration (2014)
Retirement age	R	46	Retirement age equals 65 years old
Social Security wage base	y^{SS}	\$106,800	Official Social Security Website
1st bend point of S.S. benefit	x_1	\$9,132	Official Social Security Website
2nd bend point of S.S. benefit	x_2	\$55,032	Official Social Security Website
1st parameter of S.S. benefit	θ_1	90%	Official Social Security Website
2nd parameter of S.S. benefit	θ_2	32%	Official Social Security Website
3rd parameter of S.S. benefit	θ_3	15%	Official Social Security Website
Minimum level of consumption	$\underline{c}$	\$6,784	Share of uninsured equals 12.34%
IHI fraction of affordable HI	d^I	8%	H.R. 3590 and H.R. 4872
EHI fraction of affordable HI	d^E	9.5%	H.R. 3590 and H.R. 4872
1st PTC fraction of the FPL	g_1	100%	H.R. 3590 and H.R. 4872
2nd PTC fraction of the FPL	g_2	133%	H.R. 3590 and H.R. 4872
3rd PTC fraction of the FPL	g_3	150%	H.R. 3590 and H.R. 4872
4th PTC fraction of the FPL	g_4	200%	H.R. 3590 and H.R. 4872
5th PTC fraction of the FPL	g_5	250%	H.R. 3590 and H.R. 4872
6th PTC fraction of the FPL	g_6	300%	H.R. 3590 and H.R. 4872
7th PTC fraction of the FPL	g_7	400%	H.R. 3590 and H.R. 4872
1st fraction of income spent on HI	ε_1	2%	H.R. 3590 and H.R. 4872
2nd fraction of income spent on HI	ε_2	3.5%	H.R. 3590 and H.R. 4872
3rd fraction of income spent on HI	ε_3	5.15%	H.R. 3590 and H.R. 4872
4th fraction of income spent on HI	ε_4	7.175%	H.R. 3590 and H.R. 4872
5th fraction of income spent on HI	ε_5	8.775%	H.R. 3590 and H.R. 4872
6th fraction of income spent on HI	ε_6	9.5%	H.R. 3590 and H.R. 4872

Table 8: Summary of Parameters

Parameter		Value	Reference
IM penalty base value	υ	\$695	H.R. 3590 and H.R. 4872
IM fraction of taxable income	ν	2.5%	H.R. 3590 and H.R. 4872
Maximum IM penalty	ρ	\$2,085	H.R. 3590 and H.R. 4872
Medicaid expansion fraction of FPL	ζ	138%	H.R. 3590 and H.R. 4872
Fraction to deduct med. exp.	ξ	10%	H.R. 3590 and H.R. 4872

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