Macroeconomic Consequences of Alternative Reforms to the Health Insurance System in the U.S. *

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Abstract

This paper examines the macroeconomic and welfare implications of alternative reforms to the U.S. health insurance system. In particular, I study the effect of the expansion of Medicare to the entire population, the expansion of Medicaid, an individual mandate, the removal of the tax break to purchase group insurance and providing a refundable tax credit for insurance purchases. To do so, I develop a stochastic OLG model with heterogenous agents facing uncertain health shocks. In this model individuals make optimal labor supply, health insurance, and medical usage decisions. Since buying insurance is endogenous, my model captures how the reforms may affect the characteristics of the insured as well as health insurance premiums. I use the Medical Expenditure Panel Survey to calibrate the model and succeed in closely matching the current pattern of health expenditure and insurance demand as observed in the data. Numerical simulations indicate that reforming the health insurance system has a quantitatively relevant impact on the number of uninsured, hours worked, and welfare.

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1 Introduction

One of the major social policy issues facing the United States in the first decade of 21^{st} Century is the large number of Americans lacking health insurance. There is wide agreement that reforming the current health care system is desirable and several proposals have been discussed among economists and in the political arena. A reform of the health insurance system could potentially affect macroeconomic variables by distorting the labor market through changes in tax rates, creating deadweight loss, reducing the number of uninsured, and raising the aggregate health expenditure. The aim of this study is to analyze the macroeconomic impacts and welfare implications of alternative reforms to the health insurance system in the U.S. The reform proposals I consider here are: i), the expansion of Medicare to the entire population; ii), the expansion of Medicaid; iii), an individual mandate; iv), the removal of the tax break to purchase the group insurance and v), providing a refundable tax credit for insurance purchases. The reforms mentioned in this paper are building blocks of current, existing reform proposals in the U.S. Alternative sources of revenue to fund these reforms are also considered. I calibrate my model to the current U.S economy and conduct several policy experiments in which the health insurance system is reformed according to one of the above proposals. I find that the impact of various reforms on the aggregate labor supply varies between -9.1% and 6.8%, depending on how they are funded.

National health expenditures accounted for 16.3% of U.S. GDP in 2007, compared to 5.2% in 1960 (Department of Health & Human Services, 2006). The rapid growth of medical costs leaves a large fraction (18% in 2006 according to Kaiser 2007) of the population without health insurance. The lack of insurance has serious negative consequences that include lack of access to needed care, declining health, and, for some people, the assumption of crushing financial burdens. Uninsured adults are far more likely to postpone accessing health care or to forgo it altogether and are less able to afford prescription drugs or follow through with recommended treatments. A 2003 report by the Institute of Medicine states that the uninsured have a more rapid decrease in general health and a higher risk of dying prematurely than the insured. According to their estimation the cost for diminished health and shorter life span due to lack of insurance was between \$65 and \$130 billion in 2003. There are also financial externalities imposed by the uninsured on the insured through uncompensated care, whose costs were estimated to be about \$41 billion in 2004.

These facts have encouraged policymakers to consider substantial changes to the U.S. health care system. In recent years alternative proposals have been brought forth in an effort to cover the uninsured. Expansion of health insurance coverage has important effects on the macroeconomy. First, an expansion would require the government to increase taxes, leading to reduced economic activity (employment). The change in tax rates would be different under the different proposals. Second, the newly insured will consume more medical services and have better health status through better health care access and lower prices (uninsured are financially charged more). The expansion therefore decreases the health disparity and increases aggregate health status and labor productivity, which encourages economic activity. The third effect of expansions of any type is to shift some individuals from existing private insurance coverage to either the newly subsidized form of private coverage or to public coverage. Fourth, the expansion will also affect agent's saving behavior (and thus the aggregate capital stock and factor price) because health insurance influences precautionary saving motives.

There are many empirical studies that explore the impacts of health care reforms among other industrialized economies.[1] However, little attention has been paid to quantify the macroeconomic consequences of reforming the health insurance system in the U.S. In this paper I attempt to fill the gap in the literature by addressing two questions: first, what would be the impacts of these reforms on the aggregate labor supply, saving behavior, and health care utilization? Second, what are the welfare implications of such policy reforms? To tackle these questions I construct a stochastic overlapping generation general equilibrium model with heterogenous agents facing uncertain health shocks. In this model individuals make optimal labor supply, health insurance, and medical usage decisions. Since buying insurance is endogenous, my model captures how the reforms may affect the characteristics of the insured as well as health insurance premiums. An individual mandate can lower the insurance premium by forcing agents, who are healthy and previously uninsured, to purchase insurance. While removing the tax subsidy to purchase insurance can result in a collapse of the pooling in private insurance market and a rise in premium.

My work is a contribution to the literature of dynamic equilibrium model with heterogenous agents. The classic works of Bewley (1986), Imrohoroglu (1992), Huggett (1993) and Aiyagari (1994) have set up a framework to study uninsurable labor productivity risk. Many recent papers introduce exogenous health expenditure shocks into Bewley-type models to add realism. For example, Palumbo (1999) and De Nardi, French and Jones (2006) incorporate heterogeneity in medical expenses in order to understand the pattern of saving among the elderly. Jeske and Kitao (2007) study the welfare costs of a tax policy change associated with health insurance. A few papers endogenize health expenditures as investments in health following the seminal work of Grossman (1972). Suen (2006) endogenizes households' medical expenditure decision to explain the rapid growth in health expenditure. Jung and Tran (2008) uses an OLG model built upon Jeske and Kitao (2008) to analyze the effect of the Health Saving Accounts on the health expenditure and

[1] See for example Gruber and Hanratty (1995), Cheng and Chiang (1997).

individual's insurance decision.

The labor supply decision is absent from most of the existing macro-literature regarding health, and consequently labor income tax revenues are obtained distortion free. I add to this literature by setting up a model in the tradition of Aiyagari (1994) but with idiosyncratic health shocks and endogenous labor supply. My model enables me to compare the welfare effect of policy experiments, changes in the aggregate health expenditure as well as labor supply. Moreover, the model can take into account important general equilibrium effects of a reform compared with previous works; the distortion of a change in taxes, the interaction between the medical usage demand and labor supply that affects factor prices. My paper is also related to the literature on taxation and labor supply (Prescott (2004), Rogerson (2007)). In my paper, the government adjusts tax rates to fund the reforms, which creates distortion on the labor supply. The main contribution of my work is to develop a tool to quantify the effects of alternative health care reforms.

The paper most closely related to mine is Jeske and Kitao (2007) who study the effects of tax policy on the health insurance decision of households in a general equilibrium framework with exogenous health expenditure and labor supply. However, many empirical findings have linked health policies with individual labor supply and health expenditure decisions, see for example Decker and Remler (2004). Therefore, it is important to endogenize health expenditure and labor supply in order to quantitatively examine the impacts of such reforms on aggregate employment and output. Indeed, I find that the expansion of Medicare to the entire population generates a change in hours worked as big as -9.1% when the reform is funded through a labor tax. Suen (2006) endogenizes households' medical expenditure decisions to explain the rapid growth in health expenditure. However, working agents are endowed with exogenous units of labor and supply inelastically to the market as in Jeske and Kitao (2007). Finally, the focus of my paper is to build up a general framework that allows us to study the effects of alternative reforms to the health insurance system, which are not addressed by Jeske and Kitao (2007) or Suen (2006).

The benchmark model is calibrated to approximate the macroeconomic aspects of the U.S. economy as well as the health insurance system in the U.S. From the benchmark model, the percentage of uninsured, aggregate employment, output, saving, and medical usage are computed and compared to those generated from a number of alternative models where a reform to the health insurance system is adopted at the national level.

The paper is organized as follows: section 2 introduces the model; section 3 explains the calibration of the model; section 4 details some reform proposals and presents the numerical results both from the benchmark and from policy experiments; the last section concludes.

2 Benchmark Model

2.1 Demographics

This economy has overlapping generations of agents who live a maximum of three periods as *young*, *middle-aged*, and *old*. Let $g \in \{1, 2, 3\}$ denote the age. In the first period, the measure of newly born agents is normalized to 1. Individuals alive in period t survive to the next period with a certain probability. For old people this probability is always 0. For young and middle-aged people, the survival probability is given by $\rho(h_g)$, which depends on the health status h_g at the end of age g as described below. The population of young individuals grows at a constant rate n, implying that the population of young in period t is $(1+n)^t$. I denote the relative size of age g to the population as μ_g, which is determined in the equilibrium.

2.2 Agent types

All individuals enter the economy with the same level of health $\bar{h}_0$, an idiosyncratic endowment e_0, and idiosyncratic health types i_h. Health type determines the probability of drawing a certain health shock $\varepsilon_t \in \Omega_\varepsilon = \{\varepsilon^1, ..., \varepsilon^{N_\varepsilon}\}$. The probability distribution of the shock is assumed to be age-type-dependent. Specifically, the probability of drawing $\varepsilon \in \Omega_\varepsilon$ by type i_h agent at age g is denoted by $p_{g,i_h}(\varepsilon)$, with $\Sigma_{\varepsilon\in\Omega_\varepsilon} p_{g,i_h}(\varepsilon) = 1$ for all (g, i_h). A typical history of shocks up to time t is denoted by $\sigma_t \equiv \{\varepsilon_0, ..., \varepsilon_t\}$, with $\sigma_{t+1} = \{\sigma_t, \varepsilon_{t+1}\}$. Agents are endowed with a fixed amount of time per period that can be allocated to leisure or labor. Agents participate in the labor market during the first two periods and receive a wage income $\tilde{w}e^{\zeta h}l$. Here ζ measures the effect of health on labor productivity.[2] Health is an important form of human capital. It can enhance workers' productivity by increasing their physical capacities, such as strength and endurance, as well as their mental capacities. I postulate a positive relationship between health and productivity.

During their work stage agents receive income in the form of wages and profit Π_t from the firm. They can also save a_g units of the consumption good using a storage technology with gross rate of return $R_{t+1} = 1 + r$. Retired agents have income through previous saving and profit, and consume all of their income at their last period of life.

The type of an agent is a triple (g, i_h, x), where $g \in \{1, 2, 3\}$ is age; $i_h \in \{healthy, unhealthy\}$ is health risk type; and $x \in R_+$ is their disposable resources at the beginning of each period defined as follows:

[2]See Bloom and Canning (2005). They model the human capital of the worker by $v = e^{\phi_s s + \phi_h h}$, where s represents years of schooling and h represents health. Here we normalize the effect of schooling.

$$x = \begin{cases} e_0, & if\ g = 1 \\ (1+r)a_1, & if\ g = 2 \\ (1+r)a_2 & if\ g = 3 \end{cases}$$

2.3 Preferences

Preferences over stochastic sequences of consumption, leisure and health are given by

$$U = E_t \sum_{g=1}^{3} \beta^{g-1} \Pi \rho(h_{g-1}) \cdot u(c_g, L_g, h_g) \tag{1}$$

where β denotes the discount factor, ρ survival probability, c consumption, L leisure and h health status. E_t denotes the conditional expectation with the information available when the agent is born.

2.4 The evolution of health

I use the idea of health capital introduced by Grossman (1972a). The price of medical care p_m is exogenously given so that each unit of consumption good can be transformed into $\frac{1}{p_m}$ units of medical care. In my model medical care m can be used to produce new units of health. Each agent chooses an optimal amount of health expenditure m to build up health capital h. The accumulation process of health is given by:

$$h' = (1 - \delta_h)h + \frac{\varepsilon}{\exp[A_m m^{\varsigma}]}. \tag{2}$$

where A_m measures the medical technology. I assume that technological progress in the production of medical service A_m is exogenously given.

In Jeske and Kitao (2007) the health expenditure is an exogenous random shock. Each period in time individuals must pay the full amount for necessary health care after the shock, independent of their income level and current health stock. I, instead, endogenize medical expenditures. Hence, agents may choose the optimal amount of health care usage to build up health stock. For agents who have the same levels of health and face the same health shocks, richer agents will spend more on health care to build up better health stock[3]. Richer individuals have higher levels of consumption

[3]Wobus, Diana Z. and Gary Olin (2005) found that the average health expenditures per person with expense decrease as you have higher income level in 2002. However, the low income has lower health insurance coverage rate and worse health status. For people age under 65, the un-insurance rate among person in families with income less than 200% of poverty line is 24.5%, while the number is only 8.7% among person in middle and high income families. The price of medical services is much higher for uninsured due to the cost shifting (see Anderson (2007)), which implies the prices of medical care paid by low income families are higher. There are 52.4% people from low income families who report their health status are very good or excellent, compared to 69.1% for middle and high income

and lower marginal utility from consumption goods, therefore they will substitute some health for consumption goods.

Conditional on being alive at the current age with end of period health stock h, a given agent will survive to the next period with probability $\rho(h)$. Death is certain when health falls below zero ($\rho(h) = 0$ if $h \leq 0$). I assume that $\rho'(h) > 0$. Deceased agents leave their savings a as an accidental bequest that is collected by the government as revenues.

2.5 Medical expenses and health insurance

Young agents can have one out of three possible insurance states labeled as $in = \{1, 2, 3\}$. Private health insurance is $in = 1$, $in = 2$ denotes that the agent has Medicaid, and $in = 3$ indicates the agent has no insurance. The out of pocket health expenditure will be $(1 - \tilde{q}(p_m m, 1))p_m m$ if the agent chooses to buy insurance and $(1 - \tilde{q}(p_m m, 2))p_m m$ when he/she is covered by the government program. It will cost the entire expenditure $p_m m$ ($\tilde{q}(p_m m, 3) = 0$) if the agent does not have insurance. Here $\tilde{q}(p_m m, in)$ is function that represents the coinsurance rate and varies with the health insurance state in as we discuss in the following subsection. Agents take it as exogenously given and it is calibrated from the data. Retired agents are insured under Medicare.

2.5.1 Private health insurance

To simplify the analysis, the only available private health insurance I considered is the Employer-Sponsored Health Insurance *(EHI)*. Even when an employer offers health insurance, not all workers get coverge. Some choose not to enroll, perhaps because they are young or very healthy and feel that health insurance is not a pressing need, and others' incomes are so low that they cannot afford insurance. These tradeoffs will be present in the benchmark simulation.

Once an agent chooses to purchase EHI a constant premium π_E must be paid to the insurance company, and a fraction $q_E(p_m m)$ of the total medical expenditure will be paid by the health insurance company. The premium is not dependent on prior health history or any individual states. This accounts for the practice that group health insurance does not price-discriminate the insured by such individual characteristics.

2.5.2 Public health insurance

The government supplies two type of health insurances, Medicaid and Medicare, to the individuals.

person. Taking these factors into account, it is plausible that rich agent consumes more medical service than the poor agent given the same level of health shock.

Medicaid Medicaid is a joint federal-state program that provides health insurance coverage to low-income children, parents, seniors and people with disabilities. The main criterion for Medicaid eligibility is limited income and financial resources. I assume that young and middle-aged individuals are eligible to receive Medicaid if their disposable resources at the beginning of the period is lower than the poverty line Y_{ma}. There is also an exogenous probability χ of getting a Medicaid offer. This captures the fact that Medicaid is only eligible for child and adults with children. The program will cover the fraction $q_{ma}(p_m m)$ of the total medical expenditure. Medicaid is a part of government spending.

Medicare I assume that all retirees are enrolled in the Medicare program. Each retiree pays a fixed premium π_{mr} for Medicare and the program will cover the fraction $q_{mr}(p_m m)$ of the total medical expenditures. Medicare is funded by the Medicare tax τ_{mr} that is proportional to the worker's labor income.

2.6 The representative agent's problem

A representative agent of generation $g = \{1,2\}$ enters each period with characteristics $s_g = (i_h, x, h_{g-1}, i_{ma})$, where i_h is the risk type of the agent, x is the disposable resources, h_{g-1} is the health status at the beginning of the period, and i_{ma} is the indicator function that signals the availability of the Medicaid benefit in the current period. Since all old agents are enrolled in the Medicare program and leave the labor market, their characteristics simply are $s_3 = (i_h, x, h_2)$. The distribution of households over their state space is given by $f_g(s_g, \sigma_t)$, which is endogenously determined in the equilibrium and evolves over time.

Agents observe s_g at the beginning of the period. They take prices as given and make the insurance decision $in_g(s_g)$ and choose a set of state-contingent decision rules, which can be denoted by $\{c_g(s_g,\varepsilon_g), a_g(s_g,\varepsilon_g), m_g(s_g,\varepsilon_g), L_g(s_g,\varepsilon_g)\}$, to solve the following problem.

$$\max E_t \left\{ \sum_{g=1}^{3} \beta^{g-1} \Pi \rho(h_{g-1}) \cdot u\left[c_g(s_g,\varepsilon_g), L_g(s_g,\varepsilon_g), h_g(s_g,\varepsilon_g)\right] \mid \sigma_t \right\} \tag{3}$$

subject to the budget constraint and a no-borrowing constraint

$$\begin{aligned} &(1+\tau_c)c_1(s_1,\varepsilon_1) + [1-\tilde{q}(p_m m_1, in)] \cdot p_m m_1(s_1,\varepsilon_1) + \tilde{\pi}(in) + a_1(s_1,\varepsilon_1) \\ &\le e_0 + \Pi_t + (1-0.5\tau_{mr})\left[\tilde{w}_t e^{\zeta h_1} l_1(s_1,\varepsilon_1) - 1_{\{in=1\}}\tilde{\pi}(in)\right] - T(y_1) \end{aligned} \tag{4}$$

$$a_1(s_1,\varepsilon_1) \ge 0 \tag{5}$$

when young;

$$
\begin{aligned}
&(1+\tau_c)c_2(s_2,\varepsilon_2)+[1-\tilde{q}(p_m m_2,in)]\cdot p_m m_2(s_2,\varepsilon_2)+\tilde{\pi}(in)+a_2(s_2,\varepsilon_2)\\
\le\ & R_{t+1}a_1(s_2,\varepsilon_2)+\Pi_{t+1}+(1-0.5\tau_{mr})\left[\tilde{w}_{t+1}e^{\zeta h_2}l_2(s_2,\varepsilon_2)-1_{\{in=1\}}\tilde{\pi}(in)\right]-T(y_2) \qquad (6)
\end{aligned}
$$

$$
a_2(s_2,\varepsilon_2)\ge 0 \qquad (7)
$$

when middle-aged; and

$$
\begin{aligned}
&(1+\tau_c)c_3(s_3,\varepsilon_3)+[1-q_{mr}(p_m m_3)]\cdot p_m m_3(s_3,\varepsilon_3)+\pi_{mr}\\
\le\ & R_{t+2}a_2(s_3,\varepsilon_3)+\Pi_{t+2}-T(y_3) \qquad (8)
\end{aligned}
$$

when old, where

$$
h_g = (1-\delta_h)h_{g-1}+\frac{\varepsilon_g}{\exp[A_m m_g^{\zeta}(s_g,\varepsilon_g))]} \qquad (9)
$$

$$
\tilde{w}_t = (1-0.5\tau_{mr})w_t \qquad (10)
$$

$$
\Pi_t = \frac{(1-\alpha)Y_t}{\sum_{g=\{1,2,3\}}\mu_g\int f_g ds_g} \qquad (11)
$$

$$
\tilde{\pi}(in) = \begin{cases} \pi_E, & \text{if } in=1\\ \pi_{ma}, & \text{if } in=2\\ 0 & \text{if } in=3 \end{cases} \qquad (12)
$$

$$
\tilde{q}(p_m m_1,in) = \begin{cases} q_E(p_m m_1), & \text{if } in=1\\ q_{ma}(p_m m_1), & \text{if } in=2\\ 0 & \text{if } in=3 \end{cases} \qquad (13)
$$

$$
y_g = \begin{cases} \tilde{w}_t e^{\zeta h_1}l_1(s_1,\varepsilon_1)+\Pi(\sigma_t)-1_{\{in=1\}}\tilde{\pi}(in), & \text{if } g=1\\ ra_1(s_1,\varepsilon_1)+\tilde{w}_{t+1}e^{\zeta h_2}l_2(s_2,\varepsilon_2)+\Pi(\sigma_{t+1})-1_{\{in=1\}}\tilde{\pi}(in), & \text{if } g=2\\ ra_2(s_2,\varepsilon_2)+\Pi(\sigma_{t+2}) & \text{if } g=3 \end{cases} \qquad (14)
$$

The timeline for the generation who was born in period t is shown in Figure 1.

Each agent born at t is endowed with e_0. They save some storage goods $\{a_g(\sigma_{t+g-1},s_g)\}_{g=1,2}$ to attain desirable amounts of consumption. Equation (10) presents the individual's after-Medicare-tax adjusted wage rate. Agents survive to the next period with probability $\rho(h_g)$. The firm needs to share the Medicare tax τ_{mr} with the agent. Hence, in equilibrium a fraction $0.5\tau_{mr}$ of tax is subtracted from the wage. Profit Π_t will be uniformly distributed to the household as payment as

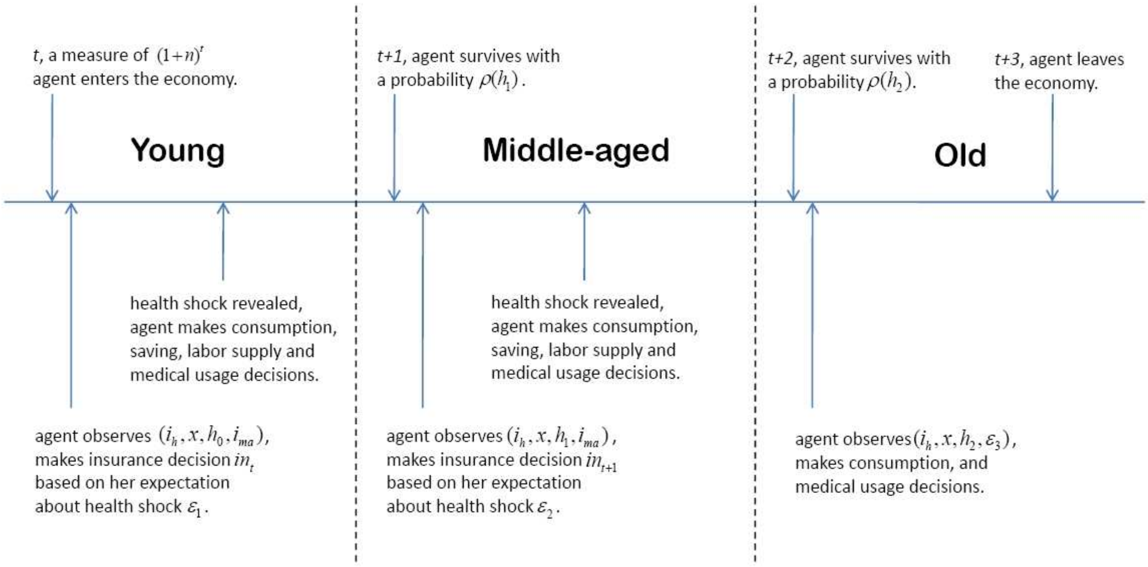

Figure 1: Timeline for the generation born in period t

displayed in equation (11). Equations (12) and (13) explain the insurance premium paid by the individual and the co-payment rate, which vary with his health insurance state. Income taxes are imposed on the labor income paid to a worker plus accrued interest on savings and profit from the firm. Equation (14) represents the income tax base, which depends on the agent's age. $T(\cdot)$ is a progressive income tax function.

2.7 Aggregate production function

The consumption goods are produced by a neoclassical production function. The aggregate production function takes a nested Cobb-Douglas specification in the following form.

$$Y_t = A_t E_t^{\alpha} \tag{15}$$

$$E_t = \sum_{g=\{1,2\}} \mu_g(t) \int \left[e^{\xi h_g} l_g(s_g, \varepsilon_g) \right] f_g ds_g \tag{16}$$

where A_t is a total factor productivity, and E_t is an aggregate efficiency labor input, which depends on individual worker's health status. The firm's profit maximization problem is

$$\max_{\{E_t\}} A_t E_t^{\alpha} - w_t E_t. \tag{17}$$

Profits Π_t are distributed back to households in a lump-sum payment.

2.8 The government

I impose a government balanced budget constraint period by period. The government has three different types of outlays: general public consumption, Medicaid and Medicare expenses. The government collects revenues from various sources: income taxation according to a progressive tax function $T(\cdot)$, consumption taxation at rate τ_c, Medicare taxation at rate τ_{mr}, Medicare premium π_{mr}, Medicaid premium π_{ma}, and accidental bequests B collected from deceased agents.

$$\begin{aligned} &G_t + \sum_{g=\{1,2\}} \mu_g(t) \int [q_{ma}(p_m m_g) p_m m_g - \pi_{ma}] \cdot 1_{\{in=3\}} f_g ds_g + \mu_3(t) \int [q_{mr}(p_m m_3) p_m m_3 - \pi_{mr}] \, f_3 ds_3 \\ &= R_t B_t + \sum_{g=\{1,2\}} \mu_g(t) \int \tau_{mr} \left[\tilde{w}_t e^{\xi h_g} l_g - 0.5 \cdot 1_{\{in=1\}} \pi_E \right] f_g ds_g + \sum_{g=\{1,2,3\}} \mu_g(t) \int [\tau_c c_g + T(y_g)] \, f_g ds_g \end{aligned} \tag{18}$$

where y_g is the taxable income for age g agent.

2.9 Health insurance company

The health insurance company is competitive. Hence, in equilibrium the premium π_E is charged such that expected expenditures on the insured are precisely covered.

$$\pi_E = \frac{\sum_{g=\{1,2\}} \mu_g(t) \int \left[q_E(p_m m_g) p_m m_g \cdot 1_{\{in=1\}} \right] f_g ds_g}{\sum_{g=\{1,2\}} \mu_g(t) \int 1_{\{in=1\}} f_g ds_g} \tag{19}$$

Notice the coverage ratio functions $q_E(\cdot)$ are taken as exogenously given.

2.10 Stationary competitive equilibrium

Let $i_h \in I^2 = \{healthy, unhealthy\}, x \in \mathbb{R}_+, h_g \in \mathbb{R}_+, i_{ma} \in I^2 = \{0,1\}, \varepsilon_g \in \mathbb{R}_-$. The state space for age $g = \{1,2\}$ year old agents is $S_g = I^2 \times \mathbb{R}_+ \times \mathbb{R}_+ \times I^2 \times \mathbb{R}_-$, and the state space for the old is $S_3 = I^2 \times \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{R}_-$.

Definition 1 *A* ***stationary competitive equilibrium*** *is i) fiscal variables* $\{G, \tau_c, T(\cdot), \tau_{mr}\}$*; ii) a sequence of prices for medical services* p_m*; iii) health insurance choices* $\{in(s_g)\}_{g=1,2}$*, a set of state-contingent decision rules* $\{c_g(s_g, \varepsilon_g), a_g(s_g, \varepsilon_g), m_g(s_g, \varepsilon_g), L_g(s_g, \varepsilon_g)\}_{g=1,2,3}$ *for the agents; iv) a state-contingent sequence of labor demand* E*; v) insurance premium* π_E*; vi) distributions of agents* $f_g(s_g)$ *over the state space* S *such that*

1. $\{in(s_g), c_g(s_g, \varepsilon_g), a_g(s_g, \varepsilon_g), m_g(s_g, \varepsilon_g), L_g(s_g, \varepsilon_g)\}_{g=1,2,3}$ *solve the consumers problem (3) taking prices and taxes as given;*

2. given the distribution f_g^* of households, the insurance companies choose π_E such that the budget constraint of insurance companies (19) holds;

3. the government sets τ_{mr}, and $T(\cdot)$ such that (18) holds;

4. given price w, the labor market clears

$$E = \sum_{g=\{1,2\}} \mu_g \int e^{\zeta h_g} l_g(s_g, \varepsilon_g) f_g ds_g \tag{20}$$

5. the accidental bequests matches the remaining assets.

$$B = \sum_{g=\{1,2\}} \mu_g \int a_g(s_g, \varepsilon_g) \cdot (1 - \rho(h_g, \varepsilon_g)) f_g ds_g \tag{21}$$

6. the aggregate resource constraint holds

$$\begin{aligned} G + \sum_{g=\{1,2,3\}} \mu_g \int \left[c_g(s_g, \varepsilon_g) + p_m m_g(s_g, \varepsilon_g)\right] f_g ds_g + \sum_{g=\{1,2\}} \mu_g \int a_g(s_g, \varepsilon_g) f_g ds_g \\ = \mu_1 \int e_0 f_1 ds_1 + \sum_{g=\{1,2\}} \mu_g \int R_t \cdot a_g(s_g, \varepsilon_g) f_g ds_g + Y + B \end{aligned} \tag{22}$$

7. there is a consistency between beliefs and the actual prices.

8. the relative size of age g to the population μ_g is recursively determined by

$$\mu_g = \frac{\int \rho(h_{g-1},, \varepsilon_{g-1}) f_{g-1} ds_{g-1}}{1+n} \mu_{g-1} \tag{23}$$

9. the law of motion for the distribution of agents over the state space S satisfies

$$f_g^{t+1} = \int \rho(h_{g-1}, \varepsilon_{g-1}) f_{g-1}^t ds_{g-1} \tag{24}$$

3 Calibration

In this section I outline the calibration of the model. Table 1 summarizes the values and describes the parameters.

Most parameters can be independently estimated. However, there are 16 parameters that cannot be determined independent of each other as I discuss below. These include parameters of preference $(\gamma_{3,g}, \eta)$, the health production function (A_m, ζ), the survival probability function (a_ρ, b_ρ), the magnitude of the negative health shock $(\varepsilon^1, \varepsilon^2)$, the probability distribution of the shock p_{g,i_h} and the price of medical service p_m. Hence, I use a minimization procedure to determine these parameter values. More specifically, I pick parameter values such that the distance between key moments in the stationary distribution of the benchmark model and the real-world statistics listed in Table 5 are minimized. Formally, let ψ denotes the vector of parameters, and Γ be the vector of selected real-world moments. Given ψ, a prediction $\hat{\Gamma}(\psi)$ on Γ can be computed in the stationary distribution of the benchmark. The minimization procedure can be defined as the following problem:

$$\min_{\psi} \left\| \hat{\Gamma}(\psi) - \Gamma \right\| \tag{25}$$

3.1 Data sources

The data used for estimating the process of health insurance decision and health production come from the Household Component of the Medical Expenditure Panel Survey (MEPS), which is based on a series of national surveys conducted by the U.S. Agency for Health Care Research and Quality (AHRQ). The MEPS consists of eight two-year panels from 1996/1997 up to 2003/2004 and includes data on demographics, income and most importantly health status and insurance.

3.2 Demographics

One period is defined as 20 years. Agents enter the economy at the age of 25 ($g = 1$) and survive up to the maximum age of 85 ($g = 3$). In line with Suen (2006), I assume that the survival probability function $\rho(\cdot)$ takes the form of the cumulative Weibull distribution function:

$$\rho(h) = 1 - \exp(-a_\rho h^{b_\rho}) \tag{26}$$

with $a_\rho > 0$ and $b_\rho > 0$. The endogenous survival probability rules out the case that agents survive to the next period with negative health stock.

I consider a yearly population growth of 1.25%. Together with the survival probability $\rho(h)$, the ratio of retired people to active population (the dependency ratio) is equal to 18.6% (19.2% according to the 2000 Population Census for the United States). The initial level of health at age 1, $\bar{h}_0$, is assumed to be constant over time and is normalized to 100.

3.3 Preferences and technology

Agents have period utility over consumption, leisure and health:

$$u(c_g, L_g, h_g) = \log c_g + \gamma_{2,g} \log L_g + \gamma_{3,g} \frac{h_g^{1-\eta}}{1-\eta} \tag{27}$$

The parameter $\gamma_{2,g}$ is age-dependent and I choose parameter values such that the average fraction of the time endowment allocated to market work is 0.33, which implies $\gamma_{2,1} = 1.3$, and $\gamma_{2,1} = 0.85$. Notice old agents retire from the labor market and they spend all time on leisure. For simplicity I set $\gamma_{2,3} = \gamma_{2,1}$. $\gamma_{3,g}$, which is age-dependent as is $\gamma_{2,g}$, measures the importance of health and η denotes the coefficient of relative risk aversion of health.

The annual subjective discount factor is taken to be 0.97, so $\beta = (0.97)^{20} = 0.5936$. The average annual interest rate in the U.S is 4%, so $r = (1 + 0.04)^{20} - 1 = 1.19$.

3.4 Production of health and health shocks

The health measure h used in this paper is the Physical Component Summary scores formed from the answers to the Short-Form 12 questions. For people aged between 25 and 85, the lowest health level is 4.56 and the highest level is 72.17 in the MEPS data.[4] This paper assumes that human beings can live up to 85 years without any accident or illness. We choose δ_h such that $72.17 \times (1 - \tilde{\delta}_h)^{60} = 4.56$, where $\tilde{\delta}_h$ refers to annual health depreciation rate. I also assume that the depreciation rate increases with age. Therefore I choose depreciation rate of $\{0.4, 0.4, 0.5\}$.

The transition of agent's health is described by equation (2). Agents can offset the negative effect of a health shock by purchasing medical care. The productivity of medical care is captured by A_m, and the price of medical care is p_m. Both are exogenously given.

Brown (2006) found that uninsured people in California pay 65% more for common prescription drugs than the federal government does for the same medications. Anderson (2007) found that the uninsured patients pay up to 2.5 times for hospital service than health insurers. I assume that uninsured consumers pay a 60% higher price for medical services than the insured, so that $p_m^u = 1.6 \times p_m^i$. This is similar to Jung and Tran (2008). I assume that the relative price of medical service p_m is the weighted average price paid by the insured and the uninsured, i.e. $p_m = (1-\theta)p_m^i + \theta p_m^u$, where θ is the fraction of uninsured in the population. According to Kaiser (2007), the value of θ was 18% in 2006. Therefore, I pick $p_m^i = 0.9145 p_m$, and $p_m^u = 1.4605 p_m$.

I differentiate agents into two groups, which are high-risk and low-risk, by using the estimation procedure of Bundorf, M. Kate et al (2005).[5] The health shocks take two possible values $\{\varepsilon^1, \varepsilon^2\}$. For the same age cohort high-risk people are different from low-risk people in terms of the probabilities $p_{g,i_h}(\varepsilon)$ of getting the same shock ε. The health shocks $\varepsilon \in \Omega_\varepsilon = \{\varepsilon^1, \varepsilon^2\}$ and the probability distribution of the shock $p_{g,i_h}(\varepsilon)$ are chosen so that the health insurance take-up rate (percentage of workers buying private insurance per age-type group) and the share of health expenditure in

[4] As for how to calculate these summary scores, please refer to Ware et al, How to Score the SF-12(r) Physical and Mental Health Summary Scales, QualityMetric,Inc., Lincoln, RI.

[5] Please refer to the technical appendix of Bundorf, M. Kate et al (2005) for the detailed procedure.

GDP is approximated.

3.5 Health insurance

Private health insurance The coverage rate increases in the health expenditures incurred by the patients. Similar to Jeske and Kitao (2007) I assume that the coverage ratio is a function of total health expenditure $p_m m$ and takes the following form.

$$q_E(p_m m) = \beta_0^E + \beta_1^E \log(p_m m) + \beta_2^E [\log(p_m m)]^2 \tag{28}$$

I estimate the set of parameters $\{\beta_0^E, \beta_1^E, \beta_2^E\}$ using the MEPS data. I rank the health expenditure and use 5 bins for health expnediture data. I specify the bins of uniform size. Therefore the first bin contains individuals whose health expenditure is between zero and 20-quantile. The 20% spending the most on health care belongs to the fifth bin. I plug in the health expenditure data to attain the average coverage ratio for each bin.

The coverage ratios of Medicaid and Medicare are estimated by the same procedure. I report the parameter values and coverage ratios for each expenditure grid in table 3 and 4. In table 4, the standard errors in brackets and all coefficient estimates are significant at the 1% level. The insurance premium π_E is determined in the equilibrium to ensure zero profits for the insurance company.

Medicaid I use Medicaid as a proxy of public health insurance for the non-elderly population, which includes S-CHIP. I use the MEPS data to calculate the acceptance rate of Medicaid $\chi = 0.6$. The beneficiaries of Medicaid typically do not pay anything for enrolling in the program. I pick $\pi_{ma} = 0$ in the simulation.

Medicaid is funded by general government revenue. The income level characteristic of Medicaid is typically 100% to 133% of the federal poverty line (FPL) and SCHIP is 200%.[6] I set $Y_{ma} = \$12,000$ or about 34% of annual per capita GDP in the benchmark.

Medicare I assume that every old agent is enrolled in Medicare. Medicare taxes are levied on all labor income and split between employer and employee contributions. The Medicare premium was $799.20 annually in 2004 or about 2.11% of annual GDP. The Medicare tax rate τ_{mr} is determined within the model so that the government budget is balanced.

[6]Source: Genevieve M. Kenney, Jennifer M. Haley, Alexandra Tebay. Children's Insurance Coverage and Service Use Improve. Urban Institute. July 31, 2003. http://www.urban.org/publications/310816.html

3.6 Firms

I choose a standard labor share in production of $\alpha = 0.66$ from NIPA. Total factor productivity is normalized to $A = 8$ such that the average labor income equals 10 in the benchmark. In line with Bloom and Canning (2005), I assume that individual worker's health status affects the efficiency of labor input by a factor of $e^{\xi h}$. Therefore, labor income is given by $we^{\xi h}l$, where w is the average wage rate. I estimate the parameter ξ that fits the following equation using the MEPS data.

$$\log(LaborIncome) = \xi h + \log(AverageWage \times WorkingHours) + \epsilon \tag{29}$$

where h is the Physical Component Summary scores that measure the individual's health status ranging from 0 to 100. I normalize the average labor income observed in the data to be 10.0 and I calculate $\xi = 0.1393$ in the benchmark.

3.7 Government

The value for G is exogenously given and is fixed across all policy experiments. I calibrate it to 27.5% to match the share of government consumption, social security and gross investment excluding transfers, at federal, state and local levels (The Economic Report of the President, 2004). This number is bigger than the standard value of 18% because I do not model a Social Security program and Social Insurance as in Jeske and Kitao (2007). The consumption tax rate is 5.67% as in Mendoza, Razin, and Tesar (1994).

The income tax function follows the functional form studied by Gouveia and Strauss (1994), which is given as

$$T(y) = b_0 \left(y - (y^{-b_1} + b_2)^{-1/b_1} \right) + \tau_y y \tag{30}$$

Parameter b_0 is the limit of marginal taxes in the progressive part as income goes to infinity, b_1 denotes the curvature of marginal taxes and b_2 is a scaling parameter. I use the parameters estimated by Gouveia and Struss (1994), which are $\{b_0, b_1, b_2\} = \{0.258, 0.768, 0.716\}$. When they calibrate the tax function, the income has been normalized to the range of $[0, 1]$. In my model, I divide taxable income of every agent by the maximum income observed in the simulated economy to get the normalized income. Then I use this normalized income directly in (30) to get the tax rate. The parameter τ_y in the proportional term of the income tax equals 10% in the benchmark.

4 Numerical results

All potential reforms start from the same initial steady state calibrated to the current U.S. economy and end in a different final steady state with an alternative health insurance system. Therefore, I first compare moments of associated invariant distributions. Then I discuss the quantitative aspects of the transitions and welfare analysis associated with each of the reforms considered.

4.1 Benchmark model

Table 3 reports the main features of the benchmark simulation. Under the baseline parameterizations the model is able to match the main features of the current economy in the U.S. The fraction of insured agents among all young and middle-aged agents is 84.8%, which is slightly higher than 82% in the data. Among non-elderly, 12.3% are covered by the Medicaid program (12.9% in the data). The model overstates total health expenditure as a ratio of GDP, which is about 15.8% according to Department of Health & Human Services (2006). The model reports 16.6%. The model matches working hours fairly well, which is 30.6% of total non-sleeping time (33.3% in the data). The gross saving rate is 25.8% (21% in the data).

Next, I examine the model's predictions on the life-cycle patterns of medical spending and consumption. Panel 1 of Figure 2 displays medical spending over various age groups. According to MEPS, the average health expenditure is roughly constant from ages 25 to 64 and almost triples afterwards. The benchmark model is able to replicate the increasing pattern. However, the magnitude of the health expenditure is bigger than in the data, especially for non-elderly agents. In the steady state, a representative agent age between 25 to 44 spends $\$5,697$ or about 14.5% of per capita GDP (7.48% in the data). Agents between ages 45 to 64 years old on average spend $\$6,783$, or about 12.7% of per capita GDP (11.02% in the data). Agents over 65 spend $\$13,283$, or about 29.8% of per capita GDP (32.59% in the data).

Panel 2 of Figure 2 shows the consumption over various age groups. Fernandez-Villaverde and Krueger (2002) estimated the life-cycle consumption profiles using data from the Consumer Expenditure Survey. They found that non-durable consumption peaked at age 52 and was about 29% higher than at age 25. The current model is able to generate similar hump-shaped patterns. However the peak level is only about 13.7% higher than that in ages between 25 and 44.

4.2 Policy experiments

I now conduct experiments to determine the effect of reforming the health insurance system. I am interested in changes in health expenditure as a ratio of GDP, the change in taxes that balances

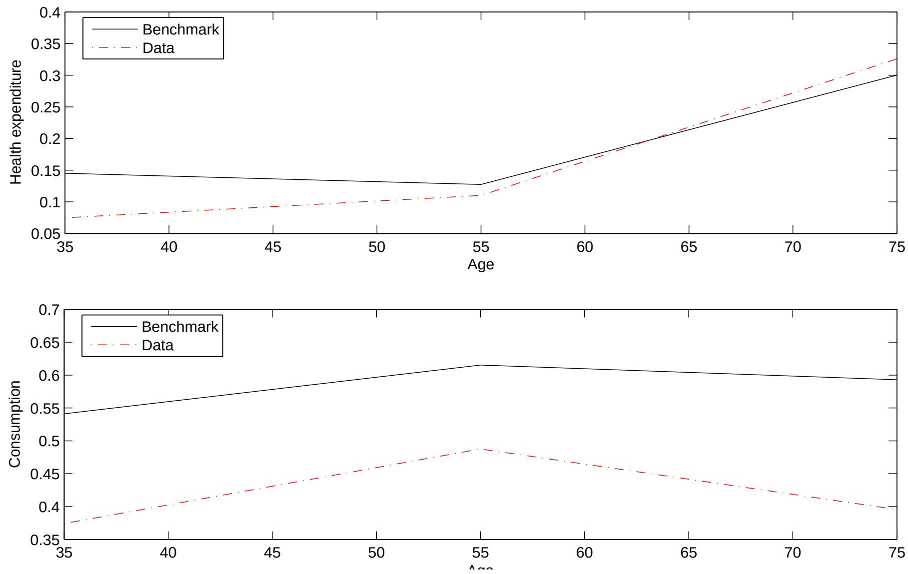

Figure 2: Health expenditure and consumption life profiles

the government budget, aggregate labor supply, aggregate health status, savings rate and output. I treat changes in government revenue as follows: expenditures G, consumption tax rate τ_c, the progressive part of income tax function $T(\cdot)$ and the proportional income tax rate τ_y remain unchanged from the benchmark. I adjust the medicare tax τ_{mr} to balance the government's budget.

In each experiment I first compute a steady state outcome under the stationary equilibrium and then the transition dynamics. In line with Conesa and Krueger (1999), I measure the welfare effect of a reform by computing the consumption equivalent variation (CEV). I quantify the welfare change of a given policy reform for an individual of type (i_h, x, i_{ma}) by asking by how much (in percent) this individual's consumption has to be increased in all future periods and contingencies (keeping health expenditure, leisure and health insurance status constant) in the old steady state so that his expected life-time utility equals that under a specific policy reform. I denote it with $CEV(i_h, x, i_{ma})$. For example, a $CEV(i_h, x, i_{ma})$ of -10% implies that if the given policy reform is put into place, then an individual of type (i_h, x, i_{ma}) will experience an decrease in welfare due to the reform equivalent to sacrifice 10% of his consumption in the initial steady state with leisure, health insurance and health expenditure constant at the initial steady-state choices.

Alternative sources of revenue to fund these reforms are also considered. I first consider supporting the reform by adjusting the income tax. I also conduct companion experiments where the government funds the reform through a payroll tax and through a lump-sum transfer separately.

4.2.1 Policy experiment A: expansion of Medicare to the entire population

In this experiment the private health insurance and the Medicaid program are abolished. Non-elderly will be covered by a uniform health insurance program, which is sponsored by the government, with premium π_{mr} and coverage rate $q_E(\cdot)$. Specifically, non-elderly pay for a premium that equals 2.11% of the per capita GDP. A fraction $q_E(p_m m)$ of their health expenditure will be paid by the government. Compared to the benchmark, 72.5% of non-elderly who purchase private insurance pay an actuarially fair premium π_E, which is about 10.9% of the per capita GDP.

I assume that the price for medical service equals the average price for medical service in the equilibrium of the benchmark, which means $p_m^{\exp} = p_m^{ben} = (1-\theta)p_m^i + \theta p_m^u$. The medical technology A_m is constant and exogenously given. I can also consider a case in which the technology slows down (or speeds up) as a result of the reform.

Experiment results are summarized in Table 6. The top section displays some statistics on aggregate variables: the fraction of insured non-elderly, the Medicare tax rate, the average effective income tax rate, average working hours, average effective working hours, and the health expenditure as a ratio of GDP. The lower section displays the welfare effects of each reform. *% w/ CEV > 0* indicates the fraction of young agents in the benchmark that would experience a welfare gain (positive *CEV*) if the alternative reform is taken place.

Expansion of Medicare to the entire population achieves a universal coverage as shown in the fraction of insured non-elderly. The aggregate health expenditure as a ratio of GDP increases by 0.3%. This is because those newly insured non-elderly will consume more medical service and incur higher amounts of health expenditure as the reform provides them with cheaper health insurance. The program needs to cover 15.2% of the non-elderly who would be uninsured in the benchmark and to pay for part of the expenditure of the insured, who pay a premium of π_{mr} after the reform, which is about 20% of the premium they paid in the benchmark. Therefore, the government raises the proportional income tax rate by 4.5%. As a consequence, average working hours decreases by 4.8% to 28.7. The average health stock of the non-elderly increases from 46 to 47, which implies a long life expectancy and a higher saving incentive. A decreased exposure to the health shocks lowers the precautionary saving demand, but this effect is dominated by the previous one and the aggregate saving rate slightly increases by 0.8%.

Although the proportional income tax rate τ_y is higher than in the benchmark, the cheaper health insurance program from the government is enough to compensate this cost for most agents. As shown in *% w/ CEV > 0,* 72.6% of young agents would experience a welfare gain from this reform, and the average welfare effect is in the order of 2.6% in terms of consumption in every state. However, low income agents, especially those with Medicaid offers, will suffer because the new insurance program from such a reform is less generous than Medicaid. On average, low-income individuals would experience a welfare loss equivalent to 4.27% of consumption. While agents who have income above the poverty line have a welfare gain of 5.96% of consumption.

Table 6 : Policy experiment A

	Bench.	A-1	A-2
Insured non-elderly (in %)	84.8	100	100
Medicare tax (in %)	2.5	2.5	2.5
Ave. income tax (in %)	24.6	29.4	30.39
Ave. Working hrs.	30.6	28.7	28.5
Ave. Effective Working hrs.	61.06	57.3	56.97
Health exp. (in % of GDP)	16.6	16.91	17.7
π_E (in % of per capita GDP)	10.1	2.11	2.11
Output	100	97.96	98.06
Aggregate saving rate (in %)	25.8	26.6	26.9
Average consumption	100	97.1	95.6
Average health stock	46.6	46.88	46.84
CEV from transition			
all young (in %)	–	2.6	2.8
young w/ $e_0 > Y_{ma}$ (in %)	–	5.96	4.85
young w/ $e_0 \leq Y_{ma}$ (in %)	–	-4.27	-1.39
% w/ CEV > 0 (young)	–	72.6	76.7

A-1: Medicare expansion.

A-2: Medicare expansion with Medicaid.

I also consider a experiment A-2 to test whether an expansion of Medicare can improve all individuals' well-being. In this experiment, the government offers low-income agents with Medicaid and keeps the rest the same as in experiment A-1. Specifically, non-elderly whose incomes are below the poverty line will be covered by Medicaid. Agents whose income are above the poverty line need to pay a premium equal to 2.11% of the per capita GDP. A fraction $q_E(p_m m)$ of their health expenditure will be paid by the government. Apparently, the tax rate needs a bigger increase. This can be explained by the fact that this reform is more generous to low income individuals and they will spend more in health. However, the benefit from such a guaranteed Medicaid coverage cannot offset the loss due to a higher tax rate, which is used to supply generous Medicaid program to low income agents. As shown in CEV from transition, young agents with $e_0 \leq Y_{ma}$ still experience a welfare loss, but at a much smaller magnitude of 1.39%. The welfare gain of higher income young agents decreases to 4.85% from 5.96% in experiment A-1. On average, young agents have a welfare gain in the order of 2.8% in terms of consumption in every state. From this experiment, it seems possible to make expansion of Medicare a welfare improving program for everybody by appropriately funding the reform.

4.2.2 Policy experiment B: expansion of public health insurance

Policy experiment B involves expansion of the public health insurance, including Medicaid/S-CHIP (Jonathan Gruber, 2001). Approaches that follow this model generally build on existing public programs by raising income limits to include many more needy people and do away with all tests of eligibility except income. In experiment B-1, I increase the Medicaid offer rate to $\chi = 1$. Specifically, agents who meet the maximum income requirement will be covered by Medicaid with probability 1, compared to a probability of 0.6 in the benchmark. While in experiment B-2, I leave the Medicaid offer rate χ unchange and increase the maximum income requirement to 300% of the poverty line. I report experiment results in Table 7.

When the government extends Medicaid to include all agents who meet the maximum income requirement, the spending in Medicaid as a ratio of GDP increases from 1.65% to 2.46%. As these newly insured people consume more medical services than in the benchmark, aggregate health expenditure increases as well. The proportional income tax rate has been raised by 1.5% to match this spending. As a consequence, average working hours decrease by 1.3%. Medicaid expansion alone cannot achieve "universal health care". This reform will leave 10.5% of the non-elderly without insurance coverage. These agents choose not to purchase private insurance because they are relatively healthy and expect to have a smaller health shock.

When the government increases the maximum income requirement in experiment B-2, some previously insured agents will choose to apply for Medicaid and at the risk of being uninsured. Consequently, the insured as a fraction of non-elderly decreases to 81.2%. However the aggregate health expenditure increases to 17.4% of GDP. This is because Medicaid is more generous than private insurane in terms of the coverage ratio. The expansion of Medicaid by raising the income standard requires a bigger increase in income tax rate as it covers another 18% of non-elderly. The average working hours decreses by 3%.

Table 7 : Policy experiment B

	Bench.	B-1	B-2
Insured non-elderly (in %)	84.8	89.5	81.2
Medicare tax (in %)	2.5	2.5	2.5
Ave. income tax (in %)	24.6	25.9	30.6
Ave. Working hrs.	30.6	30.2	29.7
Ave. Effective Working hrs.	61.1	60.4	59.3
Health exp. (in % of GDP)	16.6	17.02	17.4
π_E (in % of per capita GDP)	10.8	10.8	9.7
Output	100	99.9	98.7
Aggregate saving rate (in %)	25.8	25.9	27.2
Average consumption	100	99.2	97.1
Average health stock	46.6	46.7	46.79
CEV from transition			
all young (in %)	–	−0.28	−2.4
young w/ $e_0 > Y_{ma}$ (in %)	–	−1.07	−1.64
young w/ $e_0 \leq Y_{ma}$ (in %)	–	1.34	−2.73
% w/ CEV > 0 (young)	–	10.96	0

B-1: Public health insurance expansion 1.

B-2: Public health insurance expansion 2.

Now let's look at the welfare effect. Public insurance expansion as in experiment B-1, which includes all agents who meet the maximum income requirement, is beneficial to low-income agents. They experience a welfare gain in the order of 1.34% in terms of consumption in all states in B-1. They benefit from these reforms with a guaranteed public insurance coverage and in exchange pay a higher income tax. Given the small size of the program, the benefit is enough to compensate for the loss due to a tax increase. This type of reform is welfare decreasing for high income agents who do not qualify the maximum income requirement. This is because their health benefits are intact and they need to pay for a higher tax to support the expanded Medicaid program. They will suffer a loss equivalent to more than 1% in terms of consumption in all states.

While to increase the maximum income requirement makes everybody worse off. Agents whose income is below the existing maximum income requirement have the same public insurance coverage as in the benchmark. However they are are required to pay for a higher tax rate. As a consequence, they experience a welfare loss of the order of 2.73% in terms of consumption in all states. High income agents benefit from the reform with a cheaper insurance or a chance of being covered by Medicaid depending on their income level. While the cost of higher income tax cannot be offset by this benefit. Consequently, they experience a welfare loss of the order of 1.64% in terms of consumption, which is in a smaller magnitude compared with low income agents who do not benefit from this reform.

4.2.3 Policy experiment C: individual mandate

Table 8 : Policy experiment C

	Bench.	C
Insured non-elderly (in %)	84.8	100
Medicare tax (in %)	2.5	2.5
Ave. income tax (in %)	24.6	25.2
Ave. Working hrs.	30.6	30.66
Ave. Effective Working hrs.	61.1	61.3
Health exp. (in % of GDP)	16.6	17.04
π_E (in % of per capita GDP)	10.8	9.5
Output	100	100.2
Aggregate saving rate (in %)	25.8	26.7
Average consumption	100	99.1
Average health stock	46.6	47.1
CEV from transition		
all young (in %)	–	−0.63
young w/ $e_0 > Y_{ma}$ (in %)	–	−0.29
young w/ $e_0 \leq Y_{ma}$ (in %)	–	−1.32
% w/ CEV > 0 (young)	–	0

In this experiment about 15% of non-elderly are forced to purchase private insurance, who are relatively healthier. Their entry into the insurance market makes the risk pool better and the insurance premium lower. Consequently, the price of private insurance decreases by 12%. The aggregate health expenditure as a ratio of GDP increases to 17.04% as everybody has insurance coverage. The aggregate health status becomes better and the average working hours increases by 0.2% even though the reform requires an higher income tax rate. In terms of welfare, an individual mandate makes everybody worse off. Such a reform imposes a higher income tax rate, whose cost cannot be offset by a cheaper insurance for high income agents. Among low income agents, only a small fraction holds private insurance. Consequently they benefit less from the cheaper insurance and they experience a welfare loss at the magnitude of 1.32% in terms of consumption in all states, compared with a loss at the order of 0.29% for high income agents.

4.2.4 Policy experiment D: abolishing tax deductibility of private insurance premiums and providing a tax credit

Compared with the above experiments, policy experiment D-1 is a market-based reform rather than a government program. Under this experiment, the deductibility of the insurance premium for income tax is abolished. Taxes are now collected on the entire portion of the premium and the taxable income is given as

$$y_g = \begin{cases} \tilde{w}_t e^{\zeta h_1} l_1(s_1, \varepsilon_1) + \Pi(\sigma_t), & \text{if } g = 1 \\ r a_1(s_1, \varepsilon_1) + \tilde{w}_t e^{\zeta h_2} l_2(s_2, \varepsilon_2) + \Pi(\sigma_t), & \text{if } g = 2 \\ r a_2(s_2, \varepsilon_3) + \Pi(\sigma_t) & \text{if } g = 3 \end{cases} \tag{31}$$

At the same time, the government will provide agents with a refundable tax credit in experiment D-2. This tax credit is only given to agents who purchase private insurance.

Experiment results are summarized in Table 9. Removing the tax subsidy in D-1 leads to a partial collapse of the private insurance market as found by Jeske and Kitao (2007). The fraction of non-elderly who purchase private insurance falls from 72.5% to 37.5%.[7] More than 1/3 of the non-elderly opt out of the private insurance market and choose to be self-insured. Those are the agents in a better health condition who face a lower probability of suffering a bad health shock. The exit of these agents out of the insurance market deteriorates the risk pool and the price of the private insurance jumps by 15%. The aggregate health expenditure as a ratio of GDP falls 1.2% as those self-insured spend less on health. The income tax rate falls as the income base increases with the removal of the tax deductability for premium. As a consequence, average working hours slightly increase by 0.5%.

[7] This experiment is similar to experiment A in Jeske and Kitao (2007). The magnitude of the decrease here is bigger than in their paper. This result can be explained by the fact that I model the health expenditure as endogenous decision. The demand for medical services by healthy individuals is more elastic to price change than unhealthy individuals as found by Bajari, Hong and Khwaja (2006). A model with exogenous health expenditure as in Jeske and Kitao (2007) cannot capture this effect and the change in the number of insured will be smaller.

A tax credit creates incentives for individuals to purchase private insurance as in experiment D-2. The fraction of insured non-elderly jumps to 94.2% as the tax credit goes to agents who purchase private insurance. Consequently, the price of private insurance falls to 9.68% of per capita GDP and the health expenditure rises to 16.89% of GDP.

Table 9 : Policy experiment D

	Bench.	D-1	D-2
Insured non-elderly (in %)	84.8	49.1	94.2
Medicare tax (in %)	2.5	2.5	2.5
Ave. income tax (in %)	24.6	23.1	27.5
Ave. Working hrs.	30.6	30.76	29.8
Ave. Effective Working hrs.	61.1	61.11	59.43
Health exp. (in % of GDP)	16.6	15.38	16.89
π_E (in % of per capita GDP)	10.8	12.14	9.68
Output	100	100.01	99.15
Aggregate saving rate (in %)	25.8	25.76	26.17
Average consumption	100	102.4	98.3
Average health stock	46.6	46.35	46.78
CEV from transition			
all young (in %)	–	1.76	−0.22
young w/ $e_0 > Y_{ma}$ (in %)	–	1.58	0.81
young w/ $e_0 \leq Y_{ma}$ (in %)	–	2.14	−2.3
% w/ CEV > 0 (young)	–	73.97	67.1

C-1: Abolish private insurance deductibility from income tax base.

C-2: Abolish private insurance deductibility from income tax base and provide credit for individuals who purchase private insurance.

In terms of welfare, the removal of the subsidy for purchasing private health insurance is welfare improving, as 74% of the young would experience a welfare gain. For most individuals, a lower income tax rate is enough to compensate for the welfare loss due to the lower insurance coverage and increased exposure to health shocks. On average a young individual will benefit from this reform in the order of 1.76% in terms of consumption in all states. In D-2, A tax credit to private insurance buyers would encourage health insurance market participation. While the proportional tax rate τ_y is higher than in the benchmark due to the tax credit, it cannot be offset by the benefit from the higher insurance coverage. On average, a young agent would experience a welfare loss equivalent to 0.22% in terms of consumption.

4.3 Alternative approaches of funding the reforms

4.3.1 Income tax v.s. payroll tax

In order to understand how the macroeconomic effects of these proposals change in response to how the government finances the reform, I also consider funding the reform by changing the payroll tax τ_{mr}. Now, government expenditure G, consumption tax rate τ_c and the progressive part of income tax function $T(\cdot)$, as well as the proportional tax rate τ_y remain unchanged from the benchmark. I adjust the payroll tax rate τ_{mr} to balance the government's budget.

As shown in average working hours in table 10, to adjust the payroll tax creates bigger distortions compared with income taxes.[8] Notice I change some policy targets in order to make the experiment meaningful. In experiment A, the Medicare premium doubles from 2.11% of GDP to 4.22%. Otherwise the payroll tax rate will skyrocket and partially crash the labor market as some agents will leave the market. To finance the reform with payroll tax requires the Medicare tax to increases from 2.5% to 7.87%. As a consequence, average working hours decrease by 5.6%. The welfare of an average agent decreases compared to funding the reform through the income tax change.

Given the relatively small size of the Medicaid program, public insurance expansion (experiment B-1, B-2) requires a gradual increase in the Medicare tax. Average working hours decrease by 4.6% in B-1 and 6.5% in B-2 (1.3% and 0.9% when the reforms are funded through payroll taxes). Again, welfare decreases compared to the experiments when the government funds the reform through income tax.

Similar to experiment A, the tax credit has been decreased to $500 in D-2. When reform D-1 is funded through the labor tax, a larger tax rate drop leads to a 6.7% rise in average working hours and the young agent experiences a welfare gain of more than double. Even though the tax credit in D-2 is much smaller than in the experiment when the reform is funded through income tax, we still can observe a decrease in working hours of 3.3%.

Table 10 : Policy experiments - Payroll tax

[8] There is no capital in my model. The profit Π is distributed back to the agent as a payment, which is inelastic supply to the individual. The interest rate is exogenous and the demand for saving is inelastic as well. Furthermore, the tax base of income tax is broader than labor tax. These facts explain why tax labor income creates more distortion than to tax income.

	Bench.	A-1	A-2	B-1	B-2	C	D-1	D-2
Insured non-elderly (in %)	84.8	100	100	89.5	84.6	100	49.1	74.7
Medicare tax (in %)	2.5	7.87	11.2	7.81	2.7	5.56	−7.77	9.3
Ave. income tax (in %)	24.6	24.7	24.5	24.1	24.6	24.2	26.2	24.6
Ave. Working hrs.	30.6	28.87	27.8	29.18	30.5	30.06	32.67	28.9
Ave. Effective Working hrs.	61.1	57.73	55.8	58.4	60.93	60.15	64.86	57.5
Health exp. (in % of GDP)	16.6	16.84	17.73	17.06	16.59	17.06	15.33	16.32
π_E (in % of GDP)	10.8	4.22	4.22	10.05	10.1	9.66	12.17	10.5
Average consumption	100	97.2	95.1	97.4	99.9	98	105.9	95.8
Average health stock	46.6	46.88	46.83	46.69	46.82	47.4	46.39	46.4
CEV from transition								
all young (in %)	–	1.81	2.52	−1.57	1.09	−1.32	3.84	−3.5
% young w/ $e_0 > Y_{ma}$	–	5.45	4.37	−1.92	3.09	0.76	2.89	−2.87
% young w/ $e_0 \leq Y_{ma}$	–	−5.63	1.26	−0.85	0.11	−2.46	5.78	−4.8
% w/ CEV > 0 (young)	–	72.6	76.7	9.59	15.07	0	75.3	0

A-1: Medicare expansion.

A-2: Medicare expansion with Medicaid.

B-1: Public health insurance expansion 1.

B-2: Public health insurance expansion 2.

C: Individual mandate.

D-1: Abolish private insurance deductibility from income tax base.

D-2: Abolish private insurance deductibility from income tax base and provide credit for individuals who purchase private insurance.

4.3.2 Changing tax rates vs. Lump-sum transfer

The analysis so far indicates that the change in taxes may play a dominant role in how the reform affects the macroeconomy. In order to isolate the effect of tax changes, I also conducted companion exercises in which the government funds the reform through a lump sum transfer. In the companion experiments, the tax rates are kept intact as in the benchmark. The government returns a lump sum transfer to each individual. The transfer is determined so that the government's budget is balanced.

The results in Table 11 confirm the above conjecture. The greatest labor supply effect is observed in experiment D-1 with a 2.3% decrease in average working hours, compared to an average 4% change when the reforms are funded through the income tax.

Table 11 : Policy experiments - Lump sum transfer

	Bench.	A-1	A-2	B-1	B-2	C	D-1	D-2
Insured non-elderly (in %)	84.8	100	100	89.5	80.44	100	49.1	94.2
Medicare tax (in %)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Ave. income tax (in %)	24.6	25.4	25.4	24.7	25.0	24.6	25.2	25.3
Ave. Working hrs.	30.6	30.56	30.6	30.66	31.08	30.81	29.89	30.7
Ave. Effective Working hrs.	61.06	60.97	61.2	61.26	61.94	61.53	59.41	61.2
Health exp. (in % of GDP)	16.6	16.67	17.5	16.98	17.3	16.81	15.46	16.8
π_E (in % of GDP)	10.1	2.11	2.11	10.1	9.7	9.66	11.18	9.64
Average consumption	100	99.3	98.6	99.8	98.9	99.6	101.2	99.6
Average health stock	46.6	46.82	46.85	46.7	46.8	46.96	46.3	46.78
CEV from transition								
all young (in %)	–	2.73	3.0	0.25	−2.51	−0.38	1.75	−0.14
% young w/ $e_0 > Y_{ma}$	–	5.97	4.94	−1.1	−1.44	−0.1	1.59	0.81
% young w/ $e_0 \leq Y_{ma}$	–	−3.89	−0.87	1.49	−3.04	−0.95	2.07	−2.1
% w/ CEV > 0 (young)	–	72.6	76.7	10.96	0	5.48	73.97	67.12

A-1: Medicare expansion.

A-2: Medicare expansion with Medicaid.

B-1: Public health insurance expansion 1.

B-2: Public health insurance expansion 2.

C: Individual mandate.

D-1: Abolish private insurance deductibility from income tax base.

D-2: Abolish private insurance deductibility from income tax base and provide credit for individuals who purchase private insurance.

Health insurance reforms that can decrease the number of uninsured (as in A-1, A-2, B-1, C, and D-2) will improve the aggregate health status even though the effect might be small. As the insured consume more medical service, the aggregate health spending rises as well. Better health encourages labor supply as labor productivity increases with health stock. As shown in experiment C, average working hours increase by 0.7% as average health stock increases by 0.5%. Among the reforms I considered, only experiment B-2 and D-1 fail to decrease the number of the uninsured. Aggregate health expenditure decreases as fewer people have insurance coverage in experiment D-1. The average health stock falls as well. In experiment C-1, poorer health status discourages labor supply and the average working hours decreases by 2.3%, which is substantial.

In terms of welfare, the implication is almost identical to when the government finances the reforms with the income tax, but with a slightly different magnitude.

5 Conclusion

I build a micro-founded dynamic general equilibrium model to study the impact of alternative health care reform proposals on the aggregate labor supply, health expenditure, saving, welfare, and on the fraction of adults with no health insurance. As opposed to some papers in the literature, I consider a model with a labor-leisure choice. This is important because a health care reform affects the demand for medical usage, which in turn affects the individual's health status and labor productivity. A reform may create distortions on the labor supply by requiring additional tax revenues to fund such reform. The magnitude of the distortion depends on the details of the reform as well as how to fund the reforms.

As policymakers evaluate alternative approaches to reforming the health insurance system in the U.S., they should consider several tradeoffs: the reduction in the number of uninsured, alternative distortions of the labor market, deadweight loss and the cost of raising public funds to cover government programs. These complicated tradeoffs can only be fully captured in a general equilibrium framework, similar to the one employed in my analysis. My results suggest that Medicare expansion and an individual mandate are good candidates for achieving universal health care, while a removal of the tax subsidy to purchase private insurance would result in a significant reduction in the insurance market. For all proposals studied, the aggregate health expenditure rises as the number of insured increases. Funding the reform through payroll taxes does not seem promising because such a policy can heavily distort the labor market, especially in the case of the expansion of Medicare and providing tax credit to the insured.

Regarding quantitative implications of the reforms, I find that the impact on the aggregate labor supply may vary between -9.1% and 6.8%, depending on the details of the reforms and how they are funded. In some reforms, such as the expansion of Medicare to the entire population and the expansion of Medicaid, cheaper insurance means a better health risk pool, lower premiums and better health, which in turn increases labor productivity and working hours. However, some reforms require higher taxes which result in lower working hours, for example the expansion of Medicare and an individual mandate. Quantitatively, I find that the expansion of Medicaid funded with income taxes results in the smallest change in hours worked because the government only needs to collect tax revenue to include about 5% of the non-elderly into the public insurance program. Similarly, the change with the strongest impact on hours worked is the removal of the tax break to purchase the group insurance funded through the labor tax. This is because a larger fraction of non-elderly (72.5%) pay a tax for the insurance premium, which is income tax free in the benchmark. Consequently, a lower labor tax rate is needed to balance the government budget.

In terms of welfare implications, an increase in insurance coverage does not always improve welfare. Both Medicare expansion and individual mandate can achieve universal insurance coverage. Medicare expansion improves the aggregate welfare by offering cheaper insurance. In contrast, an individual mandate may deteriorate welfare even though the risk pooling becomes more inclusive and the premiums go down as agents are forced to purchase insurance. This is because the government needs to increase other taxes so that the newly insured can enjoy the subsidy for purchasing insurance. The removal of the tax subsidy to purchase private insurance makes agent better off by lowering the tax rate, which is enough to compensate the loss due to lower insurance coverage.

Since I focus on the effect of reforming the health insurance system, I chose not to alter the health production sector along the transition. However, as the demand for medical service changes after the reform is instituted, the supply side may be affected as well. An interesting extension of the current paper would be to ask how medical technology and the price of medical services are determined and how they will be affected by health insurance reforms.

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6 Appendix

6.1 Computation algorithm to stationary equilibrium

Given the parameter values as shown in the text, I compute the stationary equilibrium as follows:

Step 1. Discretize the state space $S = (i_h, x, h, i_{ma}, \varepsilon)$.

Step 2. Start with an arbitrary pair of the steady state values of aggregate labor supply E, tax rate τ_{mr}, bequest B, and EHI premium π_E. Define $\Theta = \{E, \tau_{mr}, B, \pi_E\}$. Compute the value w.

Step 3. Agents solve their optimization problem.

Step 4. Simulate the economy:

4.1. Set $t = 0$, there are N_{ppl} agents live in the economy, who are randomly assigned the values of $(i_h, x, h_{g-1}, i_{ma}, \varepsilon_g)$ if young or middle-aged, and $(i_h, x, h_{g-1}, \varepsilon_g)$ if retired.

4.2. Given shocks agents choose whether to insure, how much to save, and how much to spend;

4.3. New period starts, $t = t + 1$, $g = g + 1$, the government collects the assets left behind by the accidentally deceased.

4.4. A sequence of time series is generated by repeating step 4.2 & 4.3;

4.5. Store the distribution of $\{(i_h, x, h_g, i_{ma}, \varepsilon_g, in_g)\}_{g=1}^3$ with $\{\Psi_g\}_{g=1}^3$;

4.6. Stop the process if the economy enters the stationary distribution.

Step 5. Compute the insurance premium π_E^{new}, aggregate labor supply E^{new}, bequest B^{new}, and tax rate τ_{mr}^{new} based on the distribution $\{\Psi_g\}_{g=1}^3$ according to equations (19), (16), (21), and (**??**). Denote $\Theta' = \{E^{new}, \tau_{mr}^{new}, B^{new}, \pi_E^{new}\}$.

Step 6. Find the fixed point of Θ by iteration. If $\|\Theta' - \Theta\| > \delta$, set $\Theta = \frac{(\Theta + \Theta')}{2}$ and return to step 3. Otherwise set $\Theta^* = \Theta'$ and define

$$c_g = G_{c_g}(in, i_h, x, h_{g-1}, i_{ma}, \varepsilon_g; \Theta^*) \tag{32}$$

$$l_g = G_{l_g}(in, i_h, x, h_{g-1}, i_{ma}, \varepsilon_g; \Theta^*) \tag{33}$$

$$m_g = G_{m_g}(in, i_h, x, h_{g-1}, i_{ma}, \varepsilon_g; \Theta^*) \tag{34}$$

$$a_g = G_{a_g}(in, i_h, x, h_{g-1}, i_{ma}, \varepsilon_g; \Theta^*) \tag{35}$$

$$in_g = G_{in}(i_h, x, h_{g-1}, i_{ma}, \varepsilon_g; \Theta^*) \tag{36}$$

6.2 Calibration

Table 1: Parameters of the model

Parameter	Description	Values
n	population growth rate	1.25%
$\{a_\rho, b_\rho\}$	parameters in survival probability	$\{0.35895, 1.0\}$
β	discount factor	0.97
$\gamma_{2,g}$	preference on leisure	$\{1.3, 0.85, 1.3\}$
$\gamma_{3,g}$	preference on health	$\{0.05, 0.5, 2.5\}$
η	relative risk aversion over health	1.35
$\{A_m, \vartheta\}$	health production	$\{1.96, 0.52\}$
ξ	parameter in health on labor	0.1393
ε_g	health shock	see table 2
δ_h	health depreciation	see text
p_m	price for medical service	see text
A	total factor productivity	8.0
α	labor share	0.66
r	interest rate	4%
$\{b_0, b_1, b_2\}$	income tax parameters (progressive part)	$\{0.258, 0.768, 0.716\}$
τ_y	income tax parameter (proportional part)	10%
τ_c	consumption tax	5.67%
τ_{mr}	medicare tax	2.5%
G	government expenditure	27.5% of GDP
$q_{ma}(\cdot)$	Medicaid coverage rate	see text
π_{ma}	Medicaid premium	see text
$q_{mr}(\cdot)$	Medicare coverage rate	see text
π_{mr}	Medicare premium	see text
$q_E(\cdot)$	private insurance coverage rate	see text
π_E	private insurance premium	see text

Table 2: Health shocks per age group

Age	Shock 1	Shock 2
25-44	-0.5	-10.0
45-64	-2.5	-10.0
65-85	-10.0	-20.0

Table 3: Coverage ratio for each expenditure grids

bin	1	2	3	4	5
$q_E(p_m m)$	0.55487	0.61017	0.65671	0.70503	0.78060
$q_{ma}(p_m m)$	0.76524	0.81319	0.85763	0.88673	0.94784
$q_{mr}(p_m m)$	0.49942	0.57952	0.63345	0.69578	0.77799

Table 4: Parameter values in the coverage ratio functions

	q_E	q_{ma}	q_{mr}
β_0	0.63632(0.00144)	0.83671(0.00353)	0.51344(0.00416)
β_1	0.05444(0.00079)	0.02315(0.00165)	0.03223(0.00266)
β_2	0.00546(0.00371)	0.00349(0.00067)	0.01477(0.00094)
R^2	0.0863	0.0475	0.1634

6.3 Numerical results

Table 5: Data vs. model

Parameters	Data	Benchmark
All insured (in % of non-elderly)	82	84.8
w/ Private insurance (in % of non-elderly)	71.1	72.5
w/ Medicaid (in % of non-elderly)	12.9	12.3
Health Expenditures (in % of GDP)	15.8	16.6
Labor supply (in % of total time)	33.3	30.6
Ratio of retired to active population (in %)	19.2	18
Marginal income tax at 10% quantile	15	20
Marginal income tax at 50% quantile	26	25.4
Marginal income tax at 99% quantile	35	27
Medicare tax (in %)	2.9	2.5
Ave. insurance premium (in % of per capita GDP)	10.9	10.1
Size of Medicaid & Medicare (in % of GDP)	4.6	4.8
Consumption and health expenditure profiles		see figure 2
Gross saving rate (in %)	21	25.8

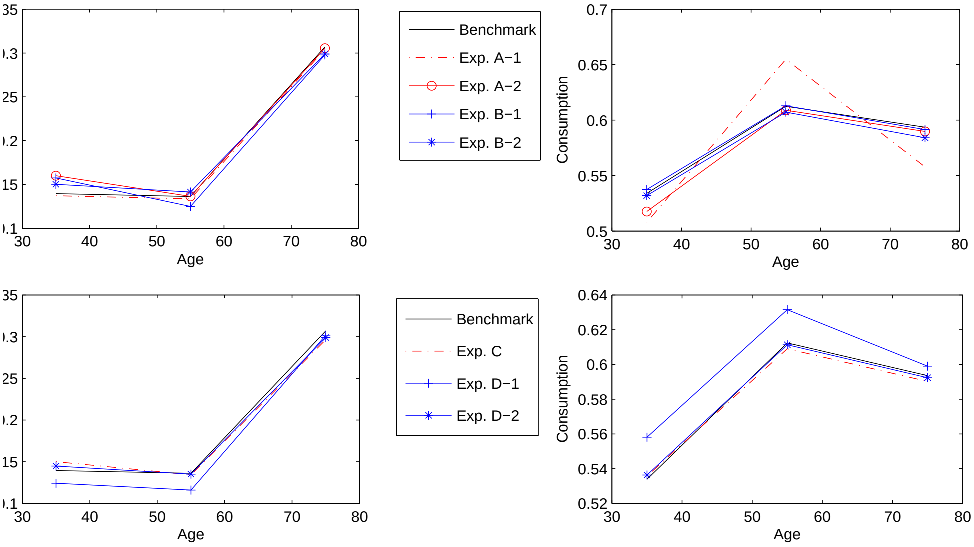

Figure 3: Life cycle profiles of health expenditure and consumption

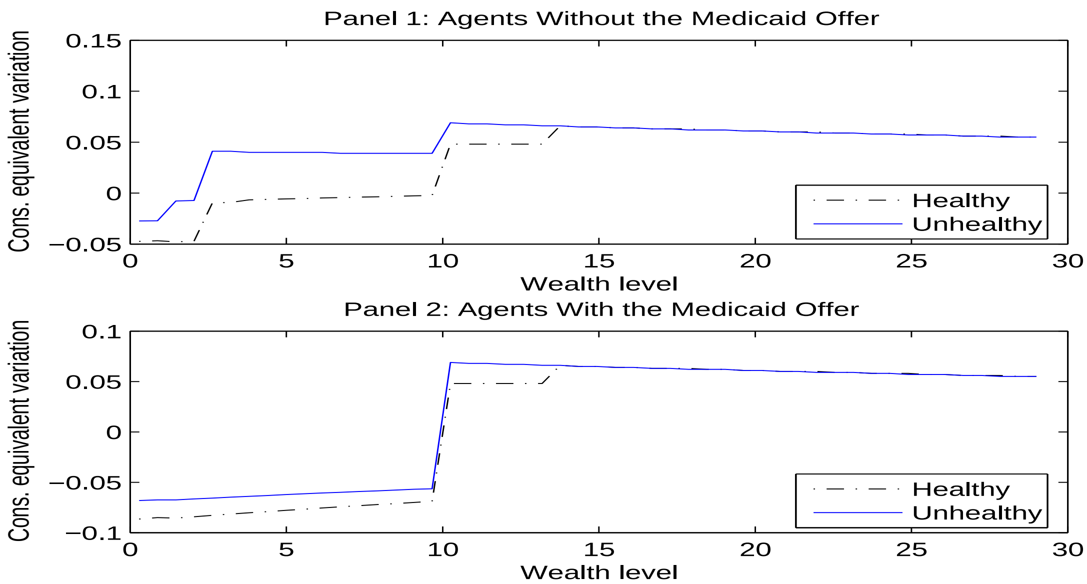

Figure 4: Welfare effects of reform A-1

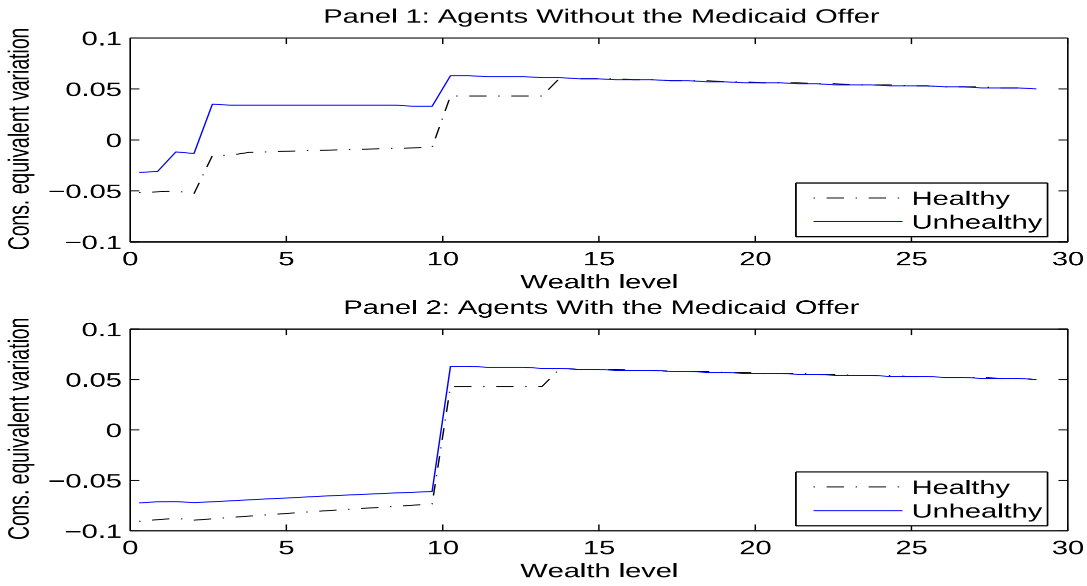

Figure 5: Welfare effects of reform A-2

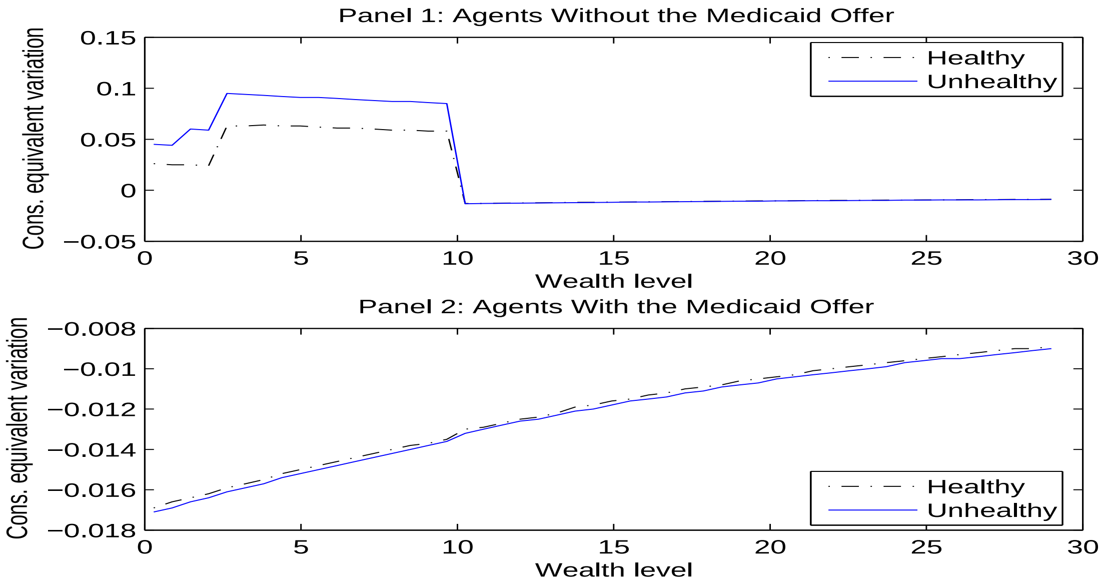

Figure 6: Welfare effects of reform B-1

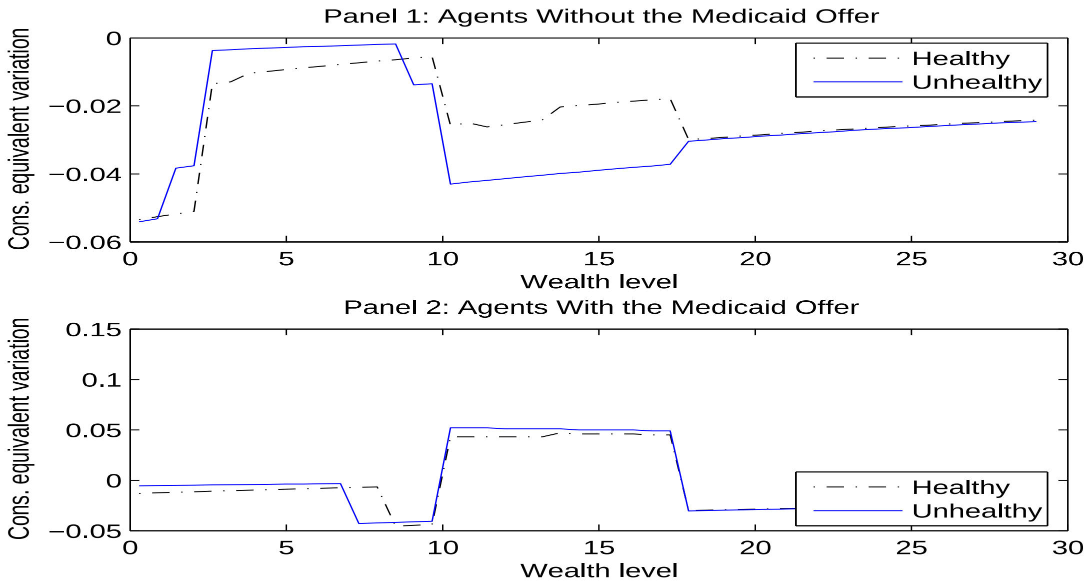

Figure 7: Welfare effects of reform B-2

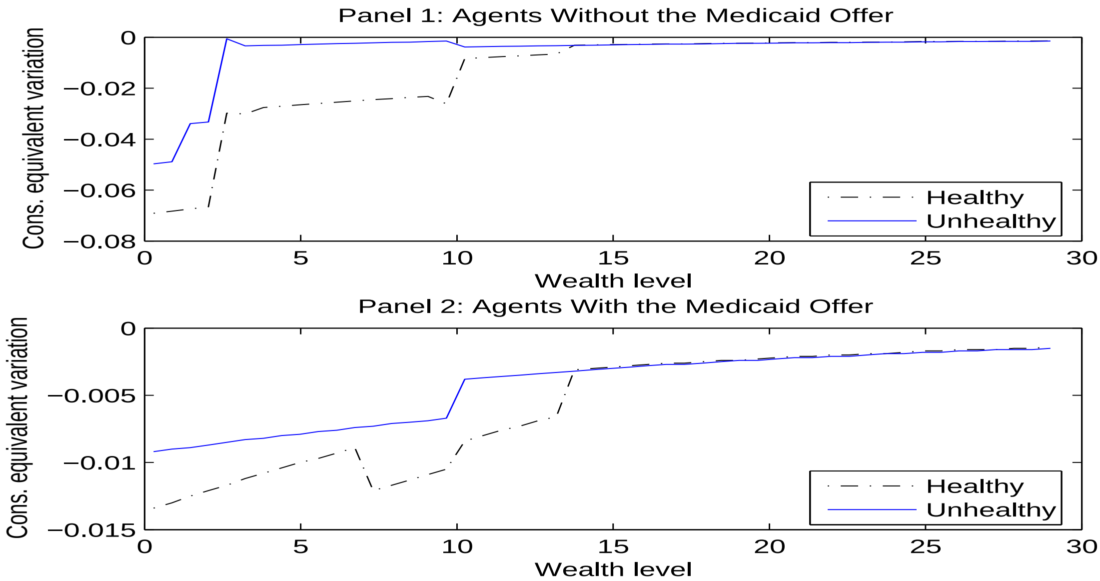

Figure 8: Welfare effects of reform C

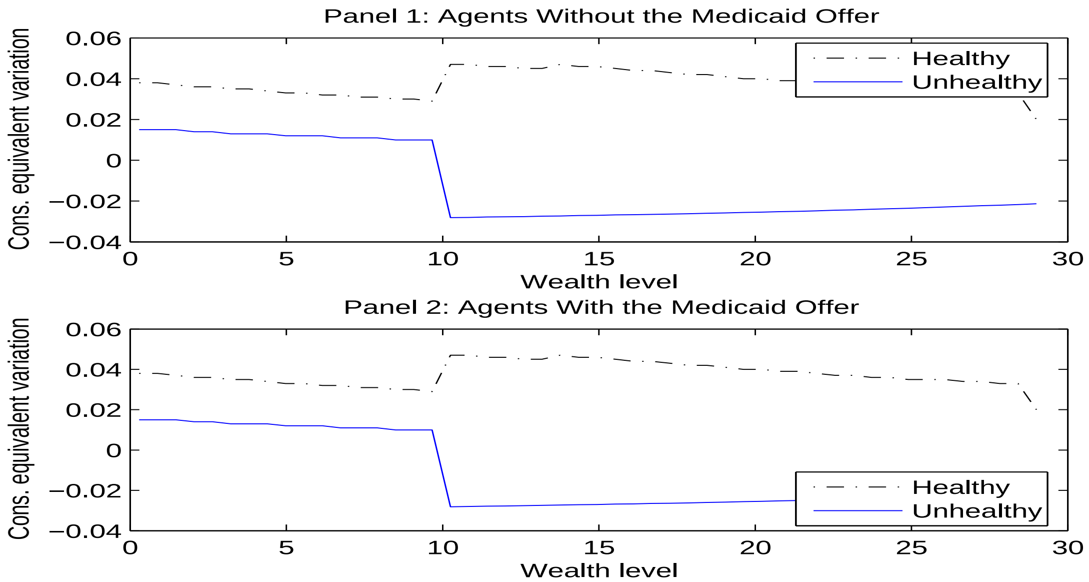

Figure 9: Welfare effects of reform D-1

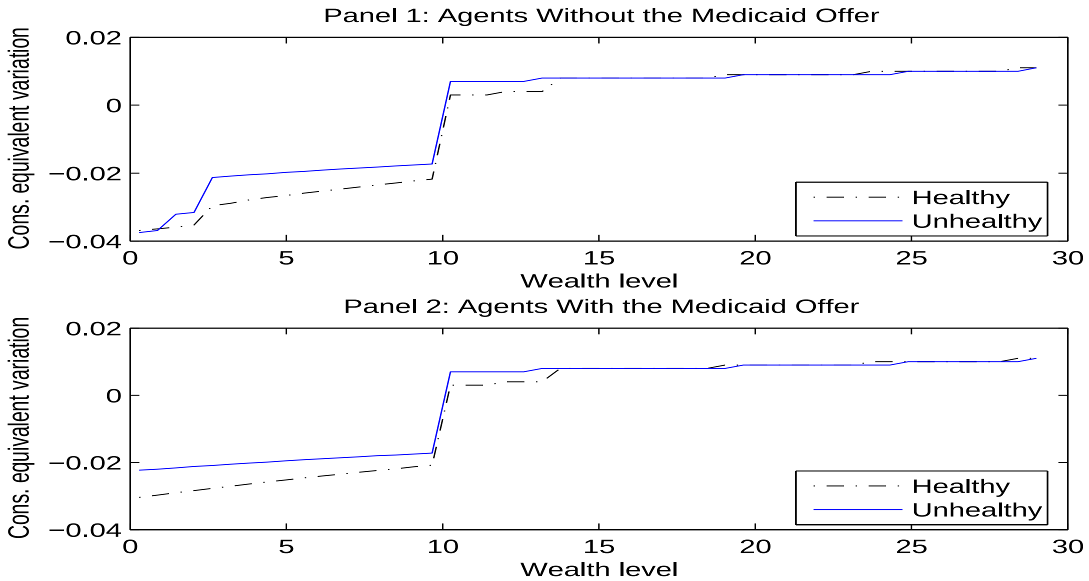

Figure 10: Welfare effects of reform D-2