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Abstract: The U.S. tax policy on health insurance is regressive because it favors only those offered group insurance through their employers, who tend to have a relatively high income. Moreover, the subsidy takes the form of deductions from the progressive income tax system, giving high-income earners a larger subsidy. To understand the effects of the policy, we construct a dynamic general equilibrium model with heterogenous agents and an endogenous demand for health insurance. We use the Medical Expenditure Panel Survey to calibrate the process for income, health expenditures, and health insurance offer status through employers and succeed in matching the pattern of insurance demand as observed in the data. We find that despite the regressiveness of the current policy, a complete removal of the subsidy would result in a partial collapse of the group insurance market, a significant reduction in the insurance coverage, and a reduction in welfare coverage. There is, however, room for raising the coverage and significantly improving welfare by extending a refundable credit to the individual insurance market.

JEL classification: E21, E62, I10

Key words: health insurance, risk sharing, tax policy, adverse selection

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1 Introduction

Our paper studies the effects of the tax policy on the health insurance decision of households in a general equilibrium framework with a major innovation to previous work in the field, namely, the introduction of an endogenous health insurance decision and adverse selection. We then provide an example of a regressive policy that improves welfare. The premium for employer-based health insurance in the U.S. is both income and payroll tax deductible while individual health insurance purchased outside the workplace does not offer this tax break.[1] This tax policy is regressive in two ways. First, data indicate that labor income is positively correlated with the access to employer-based health insurance, thus workers with higher income are more likely to enjoy the tax break. We call this horizontal inequality. Second, conditional on being covered by employer-based health insurance, the policy is regressive because the progressive income tax code in the U.S. implies that individuals with higher income in a higher marginal tax bracket receive a larger tax break than those in a lower tax bracket. We call this vertical inequality.

We show that despite its regressiveness this tax policy is welfare improving. Our main result relies on the key difference between employer-based and individual health insurance. The former, also called group insurance, is required by law not to discriminate among employees based on health status, while in the latter insurance companies have an incentive to price-discriminate and offer lower rates to individuals in better health status. Insurance outside the workplace therefore offers less pooling and thus less risk-sharing than the employer-based insurance. Pooling in the group insurance, however, relies on healthy agents voluntarily cross-subsidizing agents with higher health expenditures. Taking away the tax subsidy thus encourages adverse selection. Specifically, healthy agents leave the group insurance, thereby causing a collapse of pooling in the group market and an overall welfare loss due to an increased exposure to the expenditure risks. We also study if alternative tax reforms can help eliminate some of the regressiveness while maintaining the pooling in the group

Our work is a contribution to the literature of dynamic equilibrium models with heterogenous agents. The classic work of Bewley (1986), İmrohoroğlu (1992), Huggett (1993) and Aiyagari (1994) has created a large literature studying uninsurable labor productivity risk. Many recent papers investigated issues such as risk-sharing among agents, wealth and consumption inequality and welfare consequences of market incompleteness.[2] We add to this literature by setting up a model in the tradition of Aiyagari (1994) but with idiosyncratic health expenditure risk which

[1] The value of the subsidy is substantial, about $133 billion in the year 2005, according to the Office of Management and Budget. The origin of the tax deductibility lies in the price and wage controls the federal government imposed during the World War II. Companies used the employer-provided health benefits as a non-price mechanism to compete for workers that were in short supply, thereby circumventing the wage controls. Subsequent to lifting the price and wage controls, employers kept providing health plans partly because they could be financed with pre-tax income. The tax deductibility was extended to health insurance premiums of self-employed individuals in 1986.

[2] See for example Fernández-Villaverde and Krueger (2004) and Krueger and Perri (2005).

is partially insurable according to the endogenous insurance decisions.

Health expenditure shocks have been helpful in adding realism to Aiyagari-type models. For example, Livshits, Tertilt, and MacGee (2007) and Chatterjee, Corbae, Nakajima, and Ríos-Rull (2005) argue that health expenditure shocks are an important source of consumer bankruptcies. Hubbard, Skinner, and Zeldes (1995) add health expenditure risk to Aiyagari's model and argue that the social safety net discourages savings by low income households. Only high income households accumulate precautionary savings to shield themselves from catastrophic health expenditures. Palumbo (1999) and De Nardi, French, and Jones (2005) incorporate heterogeneity in medical expenses in order to understand the pattern of savings among the elderly. Scholz, Seshadri, and Khitatrakun (2006) also include uncertain medical expenditures for retirees to study retirement savings.

What is common among papers in the existing macro-literature is that the health insurance decision is absent from the model and consequently a household's out-of-pocket expenditure process is treated as an exogenous state.[3] Our paper is also related to the literature on income taxation in incomplete markets with heterogeneous agents, particularly the macroeconomic implication and welfare and distributional effects of alternative tax systems.[4] A tax reform will generate a new path of factor prices, which affects heterogeneous agents in different ways.

In our paper we set up an overlapping generation general equilibrium model with endogenous health insurance demand to evaluate the merits of the tax-deductibility of group health insurance. Within our micro-founded framework, we conduct policy experiments based on optimized decision rules, which enables us to compare the welfare effect of policy experiments as well as the changes in the insurance demand. Moreover, we can take into account important general equilibrium effects. For example, our model can evaluate the fiscal consequences of policy reforms. Eliminating the subsidy results in a lower tax rate on other sources of income which can reduce distortions in other sectors, or alter the demand for social welfare programs such as Medicaid. It is difficult to compute welfare consequences of these policy experiments without an optimizing model of the household. Changing the tax treatment of health insurance premiums will also affect agents' savings behavior (and thus the aggregate capital stock and factor prices) directly through marginal taxes as well as indirectly because health insurance influences the precautionary savings motives. In each policy experiment, we first compute a steady state outcome to analyze the long-run effect and then explicitly compute the transition dynamics between the

[3]Papers that deal with health insurance policy outside of a heterogenous agent framework include Kotlikoff (1989) and Gruber (2004). Kotlikoff builds an OLG model where households face idiosyncratic health shocks and studies the effect of medical expenditures on precautionary savings. He considers different insurance schemes, such as self-payment, insurance, or Medicaid, which agents take as exogenously given. In our paper, we combine all three of them into one model and let households decide how they want to insure against health expenditure shocks. Gruber measures the effects of different subsidy policies for non-group insurance on the fraction of uninsured by employing a micro-simulation model that relies on reduced-form decision rules for households.

[4]See for example Domeij and Heathcote (2004), Castañeda, Díaz-Giménez, and Ríos-Rull (2003), Conesa and Krueger (2006), Conesa, Kitao, and Krueger (2006).

calibrated benchmark and the new steady state implied by an alternative policy in order to accurately assess the welfare consequences on the current generations.

Our quantitative analysis shows that completely removing the tax subsidy would substantially decrease the health insurance coverage and negatively affect welfare because of a partial collapse of the group insurance market. This is due to adverse selection, whereby the healthy agents drop out of the group insurance market as they are no longer willing to subsidize higher risk agents in the same pool. This flight out of group insurance and into the individual contract with less pooling will be exacerbated by the increase in the group insurance premium, once the healthiest agents drop out. Indeed, there is a historical example of such a collapse of a pooling insurance contract in the face of competition from other contracts with price discrimination. In the 1950s Blue Cross and Blue Shield offered individual insurance that was community-rated, i.e., it was offered at a price independent of health conditions. However, other companies soon entered the market, screening applicants and offering lower rates to relatively healthy agents. Blue Cross and Blue Shield were left with the bad health risks and were forced to discontinue the community rating in the individual insurance market.[5] A similar mechanism of adverse selection is at work in our model.

At this point a reader may wonder how we reconcile our main result with recent research that has found very little evidence of adverse selection.[6] Our results do not contradict these findings at all! Quite the opposite, in our benchmark economy we find almost no adverse selection in the employer provided health insurance. We show that one of the reasons for the absence of adverse selection in group health insurance is the current tax treatment of health insurance that facilitates the risk-sharing we observe.

There are other ways to reduce inequality inherent in the current policy without completely removing the tax subsidy. We show that eliminating vertical inequality by removing the regressiveness of tax benefits will reduce the benefit of group insurance for those facing a high marginal tax rate and increase the benefit for those with a low tax rate.

To restore horizontal equity and provide a level field irrespective of access to group insurance, there are many paths the government could take. Various reform proposals are being debated in the policy arena, such as extending the deductibility to the non-group insurance market or providing a credit for any insurance purchase. We simulate our economy to evaluate such reforms and find they are effective in raising the insurance coverage and improving welfare to varying degrees. An increase in the coverage is beneficial, despite the general equilibrium effect of lower aggregate output and consumption, due to the reduction in the precautionary savings. We find that a reform that provides a lump-sum subsidy to those without employer-based insurance to purchase individual insurance effectively reduces the regressiveness of the system and increases the coverage without triggering a flight out of the group insurance market, thereby maintaining

[5]Thomasson (2004) provides a historical background of the events.

[6]See, for example Cardon and Hendel (2001) and Bajari, Hong, and Khwaja (2006).

the benefits of pooling risk.

The paper proceeds as follows. Section 2 introduces a simple two-period model to highlight the intuition of our results. Specifically, it shows that the total welfare effect of a subsidy on a group insurance plan is ambiguous: on the one hand the subsidy enhances risk-sharing among those agents offered a group insurance plan and on the other hand it regressively redistributes from those offered group insurance to those without an offer. Section 3 introduces the full dynamic model. Section 4 details the parameterizations of the model. Some parameters will be estimated within the model by matching moments from the data and others will be calibrated. Section 5 presents the numerical results of the computed model both from the benchmark and from policy experiments. In Section 6 we consider extensions of the model and discuss several sensitivity analyses of the benchmark calibration. The last section concludes.

2 A simple two-period model

We start with a simple two-period model with endogenous health insurance demand to provide the intuition of our results. Specifically, we demonstrate that changing the tax treatment of the health insurance premium has ambiguous welfare effects; depending on the parameter values a subsidy on the group health insurance premium can have negative or positive welfare effects. Many assumptions we employ in this basic model for the sake of simplicity will be relaxed in the subsequent section.

Suppose there are two firms and a measure one of individuals who live for two periods and consume a single consumption good in the second period. Assume that ex-ante identical agents face an idiosyncratic health risk. With some probability, agents will fall into a bad health state and must pay health expenditures equivalent to a unit of the consumption good in period 2. In period 1, agents observe a noisy signal of their health expenditure shock. Specifically, a measure $\frac{1}{2}$ has a probability p^H of suffering from the expenditure shock and the remaining agents have a probability p^L, where $p^H > p^L$. Assume that all agents have access to the market of individual health insurance (IHI) where a competitive and risk-neutral insurance company offers an insurance contracts at price p^i based on the observed signal $i \in \{L, H\}$. Notice that all risk-averse agents will choose to sign up for insurance.

Agents receive a life-time labor income Y from a firm for whom they work. In period 1, one half of the agents are matched with a firm of type 1 that offers a group health insurance (GHI) contract at price p^{GHI} to all employees independent of their signals. Workers in firm 1, therefore, have a choice between the GHI and the IHI contract. The other half of the agents work in a firm of type 2 that does not offer such a group insurance contract and thus has access only to the IHI contract.

Consider a policy of providing a subsidy s for the purchase of group insurance contract.

Clearly agents in firm 1 will sign up for the GHI contract if the price for insurance is lower than their premium p^i in the individual market.[7] Let the subsidy be $s = \left(p^H - p^L\right)/2$. Then one can show that all agents in firm 1, even those with signal p^L, sign up for GHI: the average expenditure per agent is $\left(p^H + p^L\right)/2$ and the premium is $p^{GHI} = \left(p^H + p^L\right)/2 - s = p^L$, just low enough to make even the healthy individuals with p^L indifferent between signing up for the group insurance and purchasing an individual contract. Also notice that for any subsidy value smaller than s, healthy agents would leave the GHI contract and instead go to the individual market. This would induce the exact same phenomenon as in the 1950s Blue Cross and Blue Shield example. Healthy agents seek insurance in the individual market, which leaves only the bad risks in the group contract: the same adverse selection downward spiral that plagued Blue Cross and Blue Shield.

Assume that the government imposes a lump-sum tax on the workers in firm 1 to finance the cost of subsidy, i.e. $\tau = s$. Such a policy has no effect on the agents in firm 2 so that we can isolate and focus on the redistributional effect of the policy among those with the GHI offer in firm 1.

	consumption		
	no subsidy	with subsidy	change
p^L	$Y - p^L$	$Y - p^L - s$	$-s$
p^H	$Y - p^H$	$Y - p^L - s$	$+s$

The subsidy removes a mean-preserving spread in consumption, thus the welfare effect of a subsidy policy on the agents in firm 1 evaluated in terms of consumption equivalent variation is unambiguously positive. To quantify the welfare effect of such a policy, assume that agents derive utility from the consumption in the second period according to the preference $u(c) = c^{1-\sigma}/(1-\sigma)$ with $\sigma = 3$, earn the life-time income $Y = 2$ and face the health risk as shown in the table below. The magnitude of the welfare gain depends on the variance of the health shocks that the policy helps alleviate: The greater the uncertainty of the health status, the larger are the potential welfare gains of the subsidy. As shown in the next table, the welfare change (measured in terms of consumption equivalent variation) rises with the probability p^H.[8]

	Case 1	Case 2	Case 3
p^L	0.10	0.10	0.10
p^H	0.15	0.20	0.30
welfare effect	+0.027%	+0.110%	+0.464%

[7] For simplicity we assume that whenever agents are indifferent between the two contracts they pick the GHI.

[8] As we demonstrate in the full dynamic model, the removal of the subsidy not only induces the healthy agents to leave the group insurance market, but may also leave a sizeable number of unhealthy agents uninsured, for example in the presence of borrowing constraints. In this case the welfare effects are significantly larger.

Income uncertainty and regressive policy: Now assume that in addition to the uncertainty about health expenditures, agents are heterogeneous in income as well. A firm of type 1 pays a wage Y_1 and type 2 pays Y_2, where $Y_1 \geq Y_2$, i.e., people with a GHI offer tend to earn more.[9] Notice that since people earn more at firm 1, the subsidy is a regressive policy from the perspective of an agent before the realization of the income shock.[10] Consider the same policy of providing the subsidy for GHI, namely a subsidy s just large enough to make the agents with a low health risk sign up for the contract, i.e. $s = (p^H - p^L)/2$.

In contrast to the example above, assume that the subsidy is financed by a lump-sum tax on every agent in the economy, even those in firm 2.[11] With $\sigma = 3$ and p^L and p^H set at 0.1 and 0.2, respectively, we find that the welfare effect of the subsidy depends on the degree of income uncertainty:

	Case A No income uncertainty	Case B Income uncertainty
Y^1	2.0	2.5
Y^2	2.0	2.0
Welfare effect		
all (ex-ante)	+0.024%	-0.425%
offered GHI	+1.462%	+1.132%
not offered GHI	-1.354%	-1.354%

This exercise highlights the tradeoff that a benevolent government faces between creating more risk-sharing among agents who are offered a GHI contract and regressive redistribution between agents of different income levels. On the one hand there is a welfare gain from increased risk-sharing among agents employed by firm 1. On the other hand, there is a welfare loss from the regressive tax policy. If the wages in the two firms are identical as in case A, the positive effect of increased risk-sharing in firm 1 dominates even if it is financed with the lump-sum tax on every agent, causing an ex-ante welfare gain. In contrast, if the income in firm 1 is large enough as in case B, the welfare loss from lower risk-sharing over income uncertainty dominates ex-ante welfare. The marginal utility of workers in firm 1 with high income is too low and thus the welfare gain from pooling in the GHI contract is smaller than the welfare loss of agents in firm 2.

As we demonstrate with this basic model, the welfare effect of the group insurance subsidy

[9] In the panel data we present below we find that people with a GHI offer have a labor income about 2.15 times higher than those without a GHI offer.

[10] As mentioned in the introduction, in the real world the GHI tax subsidy also displays regressiveness among those offered. A progressive income tax means a larger tax benefit for those with higher income. To keep the example as simple as possible we abstract from heterogeneity of income within the firms.

[11] We choose the lump-sum tax for simplicity and refer the introduction of a realistically modeled tax function to the full dynamic model in the subsequent sections.

is ambiguous. Since this subsidy is regressive, it impedes risk-sharing between agents in the two firms. However, a subsidy can overcome the adverse selection problem in the GHI contract and thus enhance risk-sharing among agents within firm 1. Without the subsidy, healthy agents in firm 1 are unwilling to pool their risk with unhealthy agents and rather chase the lower insurance premium. This behavior is ex post optimal but lowers ex ante welfare.[12] Determining the welfare consequences of abolishing the tax-deductibility under the current U.S. tax code therefore requires a quantitative exercise based on a carefully calibrated dynamic model. The basic model provides intuition, but fails to capture key aspects of the economy and institutions that make the insurance markets in the U.S. unique. The agents' insurance demand depends on the magnitude and persistence of the health risks and income uncertainty they face over their life-cycle and the gain from the policy intervention depends on the calibration of such risks. Moreover, increased exposure to the health risk induces risk-averse agents to save more for precautionary reasons. In general equilibrium, this changes factor prices and ultimately affects welfare. The basic model discussed does not capture these features of the U.S. economy and health care market. In the next section, we present a quantitative dynamic general equilibrium model that achieves this task.

3 The full dynamic model

3.1 Demographics

We employ an overlapping generations model with stochastic aging and dying. The economy is populated by two generations of agents, the young and the old. The young agents supply labor and earn the wage income. Old agents are retired from market work and receive social security benefits.[13] The young agents become "old" and retire with probability ρ_o every period and old agents die and leave the economy with probability ρ_d. We will later calibrate the probabilities so as to match the current age structure of the two generations.

We assume the population remains constant. Old agents who die and leave the model are replaced by the entry of the same number of young agents. The initial assets of the entrants are assumed to be zero. This demographic transition pattern generates a fraction of $\frac{\rho_d}{\rho_d+\rho_o}$ of young people and a fraction of $\frac{\rho_o}{\rho_d+\rho_o}$ of old people. All bequests are accidental and they are collected by the government and transferred to the entire population in a lump-sum manner.

[12]One way to circumvent this problem would be to force agents to sign insurance contracts before they find out their signal. This corresponds to health insurance contracts that bind healthy agents to a pooling arrangement. This can be achieved by either signing long-term contracts or the type of contracts Cochrane (1995) suggests. Alternatively, the government could impose a national health care system.

[13]In the computation, we distinguish the old agents who just retired in the previous period from the rest of the old agents and call the former as "recently retired" agents and the latter as "old" agents. The distinction between the two old generations is necessary because recently retired agents have a different state space in terms of health expenditure payment from the rest of the old agents as we discuss below.

3.2 Endowment

Agents are endowed with a fixed amount of time and the young agents supply labor inelastically. Their labor income depends on an idiosyncratic stochastic component z and the wage rate w, and it is given as wz. Productivity shock z is drawn from a set $\mathbb{Z} = \{z_1, z_2, ..., z_{N_z}\}$ and follows a Markov process that evolves jointly with the probability of being offered employer-based health insurance, which we discuss in the next subsection. Newly born young agents make a draw from the unconditional distribution of this process.

3.3 Health and health insurance

In each period, agents face an idiosyncratic health expenditure shock x.[14] Young agents have access to the health insurance market, where they can purchase a contract that covers a fraction $q(x)$ of the medical cost x. Therefore, with the health insurance contract, the net health expenditures will be $(1 - q(x))x$, while it will cost the entire x without insurance. Notice that we allow the insurance coverage rate q to depend on the size of the medical bill x. As we discuss in the calibration section, q increases in x due to deductibles and copayments. Agents must decide whether to be covered by insurance before they discover their expenditure shock.

Agents can purchase health insurance either in the individual market or through their employers. We call a contract purchased in the first market "individual health insurance (IHI)" as opposed to "group health insurance (GHI)" purchased in the workplace. While every agent has access to the individual market, group health insurance is available only if such a benefit plan is offered by the employer. Notice that we assume that the coverage ratios q are the same across the two types of contracts.

In our model we assume that there is an exogenous probability of getting a GHI offer.[15] Specifically, the probability of being offered health insurance at work and the labor productivity shock z evolve jointly with a finite-state Markov process. As shown in section 4.1, we do this because firms' offer rates differ significantly across income groups. Moreover, for workers, the availability of such benefits is highly persistent and the degree of persistence varies according to the income shocks. The transition matrix $\Pi_{Z,E}$ has the dimension $(N_z \times 2) \times (N_z \times 2)$, with an element $p_{Z,E}(z, i_E; z', i'_E) = prob(z_{t+1} = z', i_{E,t+1} = i'_E | z_t = z, i_{E,t} = i_E)$. i_E is an indicator function, which takes a value 1 if the agent is offered group health insurance and 0 otherwise.

If a young agent decides to purchase group health insurance through his employer, a constant

[14] An alternative way would have been to model health expenditures endogenously. For example Grossman (1972) models health much like a durable good that can depreciate, but can also be replenished at a cost. We did not feel that endogenizing health expenditures that way adds much to our model. Our main result is that there is a rationale to subsidize group health insurance to keep those with low health expenditure in the group insurance pool. Explicitly modeling health gives the same result: The government should subsidize group insurance to keep those with low health depreciation in the group insurance pool.

[15] An extension would be to allow agents to choose between two sectors, one that does and one that does not offer GHI. In section 6 we elaborate on how this changes our results.

premium p must be paid to an insurance company in the year of the coverage. 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.[16] We also allow the employer to subsidize the premium. More precisely, if an agent works for a firm that offers employer-based health insurance benefits, a fraction $\psi \in [0,1]$ of the premium is paid by the employer, so the marginal cost of the contract faced by the agent is only $(1-\psi)\,p$.[17] In the individual health insurance market, we assume that the premium is $p_m(x)$, that is, the premium depends on the current health expenditure state x.[18] This reflects the practice that in contrast to the group insurance market, there is price discrimination in the individual health insurance market. Specifically, IHI contracts normally are often contingent on age, prior conditions and specific habits (such as smoking) or even rule out payment for preexisting conditions.

Health insurance companies are competitive. They charge premium p and $p_m(x)$ that precisely finance the expenditures covered by the contract. Insurance companies are free to offer contracts different individuals in both group and individual markets and therefore we impose the no-profit conditions in each type of contract and there is no cross-subsidy across contracts. The premiums for group and individual insurance contracts (for each health status) satisfy:

$$(1+r)\,p = \frac{(1+\phi_G)\int \sum_{x'} p_y(x'|x)\,x'q(x')\,i_E i'_{HI}(s)\,\mu(s|j=y)ds}{\int i_E i'_{HI}(s)\,\mu(s|j=y)ds} \tag{1}$$

$$(1+r)\,p_m(x) = \frac{(1+\phi_I)\int \sum_{x'} p_y(x'|x)\,x'q(x')\,(1-i_E)\,i'_{HI}(s)\,\mu(s|x,j=y)ds}{\int (1-i_E)\,i'_{HI}(s)\,\mu(s|x,j=y)ds} \quad \forall x \tag{2}$$

where ϕ_G and ϕ_I denote a proportional markup for the group insurance contract and individual insurance contract respectively. We assume that this cost is a waste ('thrown away into the ocean') and does not contribute to anything.

We assume that all old agents are enrolled in the Medicare program. Each old agent pays a fixed premium p_{med} every period for Medicare and the program will cover the fraction $q_{med}(x)$

[16] Clearly, firms have an incentive to price-discriminate, i.e., charge a higher insurance premium to individuals with an adverse health condition, but labor regulations prevent such discrimination. U.S. Department of Labor Release 01-14 states: "[N]ondiscrimination provisions generally prohibit a group health plan or group health insurance issuer from [...] charging an individual a higher premium than a similarly situated individual based on a health factor. Health factors include: health status, medical condition (including both physical and mental illnesses), claims experience, receipt of health care, medical history, genetic information, evidence of insurability (including conditions arising out of acts of domestic violence), and disability."

[17] Notice that the subsidy, too, could be modeled as the outcome of a worker-firm bargaining process. However, we assume that the employer subsidy is given exogenously, calibrated in the benchmark to the value observed in the data. In the policy experiments we rely on empirical estimates on how employers alter the generosity of the subsidy when the premium changes in equilibrium. See Section 5.2 for details.

[18] There are other important features and issues in the individual insurance market. In particular, limited information of insurers on the health status of individuals could cause adverse selection, raise the insurance premium and shrink the market as analyzed in Rothschild and Stiglitz (1976). Other general issues that pertain to both group and individual insurance markets include coverage exclusion of pre-existing health conditions, overuse of medical services due to generous deductible and copayments (moral hazard), etc. We do not model them in the benchmark economy in order to keep the model tractable.

of the total medical expenditures. Young agents pay the Medicare tax τ_{med} that is proportional to the labor income. We assume that old agents do not purchase individual health insurance and their health costs are covered by Medicare and their own resources, plus social insurance if applicable.[19]

Health expenditures x follow a finite-state Markov process. For the two generations $j = y$ (young) or o (old), expenditure shocks are drawn from the generation-specific set $\mathbb{X}^j = \{x_1^j, x_2^j, ..., x_{N_x}^j\}$, with a transition matrix Π_x^j. We assume that if a young agent becomes old, he makes a draw from the set $\mathbb{X}^o$ according to the transition matrix of the old agents, conditional upon the state in the previous period.

3.4 Preferences

Preferences are assumed to be time-separable with a constant subjective discount factor β. Instantaneous utility from consumption is defined as a CRRA form, $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, where σ is the coefficient of relative risk aversion.

3.5 Firms and production technology

A continuum of competitive firms operate a technology with constant returns to scale. Aggregate output is given by

$$F(K, L) = AK^{\alpha}L^{1-\alpha}, \tag{3}$$

where K and L are the aggregate capital and labor efficiency units employed by the firm's sector and A is the total factor productivity, which we assume is constant. Capital depreciates at rate δ every period.

As discussed above, if a firm offers employer-based health insurance benefits to its employees, a fraction $\psi \in [0, 1]$ of the insurance premium is paid at the firm level. The firm needs to adjust the wage to ensure the zero profit condition. The cost c_E is subtracted from the marginal product of labor, which is just enough to cover the total premium cost that the firm has to pay.[20] The

[19]Many old agents purchase various forms of supplementary insurance, but the fraction of health expenditures covered by such insurance is relatively small and it is only 15% of total health expenditures of individuals above age 65 (MEPS, 2001), and we choose to assume away the individual insurance market for the old, because the old generation is not the primary focus of our model. 97% of people above age 65 are enrolled in Medicare and the program covers 56% of their total health expenditures. For more on the health insurance of the old, see for example Cutler and Wise (2003).

[20]The assumption behind this wage setting rule is that a firm does not adjust salary according to individual states of a worker. A firm simply employs efficiency units optimally that consist of a mix of workers of different states according to their distribution. The employer-based insurance system with a competitive firm in essence implies a transfer of a subsidy from uninsured to insured workers. Our particular wage setting rule assumes the subsidy for each worker per efficiency unit is the same across agents in the firm.

An alternative is to assume that a firm adjusts the wage conditional on the purchase decision of group insurance by each agent or on some states. We made our choice in light of realism.

adjusted wage is given as

$$w_E = w - c_E, \tag{4}$$

where $w = F_L(K, L)$ and c_E, the employer's cost of health insurance per efficiency unit, is defined as

$$c_E = \mu_E^{ins} p \psi \frac{1}{\sum_{k=1}^{N_z} z_k \bar{p}_{Z,E}(k|i_E = 1)}, \tag{5}$$

where μ_E^{ins} is the fraction of workers that purchase health insurance, conditional on being offered such benefits, i.e. $i_E = 1$. $\bar{p}_{Z,E}(k|i_E = 1)$ is the stationary probability of drawing productivity z_k conditional on $i_E = 1$.[21]

3.6 The government

We impose government budget balance period by period. Social security and Medicare systems are self-financed by proportional taxes τ_{ss} and τ_{med} on labor income.

There is a "safety net" provided by the government, which we call social insurance. The government guarantees a minimum level of consumption $\bar{c}$ for every agent by supplementing the income in case the agent's disposable assets fall below $\bar{c}$, as in Hubbard, Skinner, and Zeldes (1995). The social insurance program stands in for social assistance and welfare programs such as Medicaid and Food Stamp Program.

The government levies tax on income and consumption to finance expenditures G and the social insurance program. Labor and capital income are taxed according to a progressive tax function $T(\cdot)$ and consumption is taxed at a proportional rate τ_c.

3.7 Households

The state for a young agent is summarized by a vector $s_y = (a, z, x, i_{HI}, i_E)$, where a denotes assets brought into the period, z the idiosyncratic shock to productivity, x the idiosyncratic health expenditure shock from the last period that has to be paid in the current period, and i_{HI} an indicator function that takes a value 1 if the agent purchased health insurance in the last period and 0 otherwise. The indicator function i_E signals the availability of employer-based health insurance benefits in the current period.

The timing of events is as follows. A young agent observes the state (a, z, x, i_{HI}, i_E) at the beginning of the period, then pays last period's health care bill x, makes the consumption and savings decision, pays taxes and receives transfers and also decides on whether to be covered by health insurance. After the agent has made all decisions, this period's health expenditure shock x' and next period's generation, i.e. whether he retires or not, and productivity and offer status

[21] It is easy to verify that this wage setting rule satisfies the zero profit condition of a firm that employs labor N: wN = (total salary) + (total insurance costs paid by the firm). Equilibrium conditions are satisfied in that both types of firms are indifferent between offering and not offering group health insurance to employees.

i'_E are revealed. Together with allocational decisions a' and i'_{HI} they form next period's state $s'_y = (a', z', x', i'_{HI}, i'_E)$. The agent makes the health insurance decision i'_{HI} after he or she finds out whether the employer offers group insurance but before the health expenditure shock for the current period x' is known. Also notice that agents pay an insurance premium one period before the expenditure payment occurs. Therefore the insurance company also earns interest on the premium revenues accrued during one period.

Since the arrangements for the health expenditure payment differ between young workers and retirees and agents pay their health care bills with a one-period lag, we have to distinguish between recently retired agents and the rest of the old agents. The former, which we call a 'recently retired agent', has to pay the health care bill of his last year, potentially covered by an insurance contract he purchased as a young agent, while an existing old person, which we call simply an 'old agent', is covered by Medicare. As a result, the state for recently retired agents is given as $s_r = (a, x, i_{HI})$ and for the other old agents $s_o = (a, x)$.

We write the maximization problem of all three generations of agents (young, recently retired and old) in a recursive form. In the value functions V_j, the subscript j denotes the generation of an agent, where y stands for young, r stands for recently retired and o refers to old agents:

Young agents' problem

$$V_y(s_y) = \max_{c,a',i'_{HI}} \left\{u(c) + \beta \left\{(1-\rho_o) E\left[V_y\left(s'_y\right)\right] + \rho_o E\left[V_r\left(s'_r\right)\right]\right\}\right\} \tag{6}$$

subject to

$$\begin{aligned} (1+\tau_c)c + a' + (1 - i_{HI} \cdot q(x))\, x &= \tilde{w}z - \tilde{p} + (1+r)(a+T_B) - Tax + T_{SI} \\ i'_{HI} &\in \{0,1\} \\ a' &\geq \underline{a} \end{aligned} \tag{7}$$

where

$$\tilde{w} = \begin{cases} (1-0.5(\tau_{med}+\tau_{ss}))\, w & \text{if } i_E = 0 \\ (1-0.5(\tau_{med}+\tau_{ss}))\,(w - c_E) & \text{if } i_E = 1 \end{cases} \tag{8}$$

$$\tilde{p} = \begin{cases} p \cdot (1-\psi) & \text{if } i'_{HI} = 1 \text{ and } i_E = 1 \\ p_m(x) & \text{if } i'_{HI} = 1 \text{ and } i_E = 0 \\ 0 & \text{if } i'_{HI} = 0 \end{cases} \tag{9}$$

$$Tax = T(y) + 0.5(\tau_{med}+\tau_{ss})(\tilde{w}z - i_E \cdot \tilde{p}) \tag{10}$$

$$y = \max\{\tilde{w}z + r(a+T_B) - i_E \cdot \tilde{p}, 0\} \tag{11}$$

$$T_{SI} = \max\{0, (1+\tau_c)\bar{c} + (1 - i_{HI} \cdot q(x))\, x + T(\tilde{y}) - \tilde{w}z - (1+r)(a+T_B)\} \tag{12}$$

$$\tilde{y} = \tilde{w}z + r(a+T_B)$$

Young agents' choice variables are (c, a', i'_{HI}), where c is consumption, a' is the riskless savings and i'_{HI} is the indicator variable for this period's health insurance which covers expenditures that show up in next period's budget constraint. Remember that the current state x is last period's expenditure shock while the current period's expenditure x' is not known when the agents makes the insurance coverage decision. Agents retire with probability ρ_o, in which case the agent's value function will be that of a recently retired old, $V_r(s'_o) = V_r(a', x', i'_{HI})$, as defined below.

Equation (7) is the flow budget constraint of a young agent. Consumption, saving, medical expenditures and payment for the insurance contract must be financed by labor income, saving from previous period and a lump sum bequest transfer plus accrued interest $(1 + r)(a + T_B)$, net of income and payroll taxes Tax plus social insurance transfer T_{SI} if applicable. a' cannot exceed the borrowing limit $\underline{a}$. $\tilde{w}$ is the wage per efficiency unit already adjusted by the employer's portion of payroll taxes and benefits cost as specified in equation (8). If the agent's employer does not offer health insurance benefits, it equals $(1 - 0.5(\tau_{med} + \tau_{ss}))\, w$, that is, the marginal product of labor net of employer payroll taxes. If the employer does offer insurance, the wage is reduced by both c_E, which is the health insurance cost paid by a firm as defined in equations (4) and (5), and the payroll tax. Consequently, one could interpret the $\tilde{w}z$ as the gross salary.

Payroll taxes are imposed on the wage income net of paid insurance premium if it is provided through an employer, as shown in the RHS of equation (10).[22] Equation (11) represents the income tax base; labor income paid to a worker plus accrued interest on savings and bequests less the insurance premium, again provided that the purchase is through the employer. The taxes are bounded below by zero.

The term T_{SI} in equation (12) is a government transfer that guarantees a minimum level $\bar{c}$ of consumption for each agent after receiving income, paying taxes and health care costs. The health insurance premium for a new contract is not covered under the government's transfer program.

The marginal cost of the insurance premium $\tilde{p}$ depends on the state i_E as given in equation (9).[23]

[22] To be precise, the payroll tax base at each of firm and individual levels is bounded below by zero, and we have

$$Tax = T(y) + 0.5(\tau_{med} + \tau_{ss}) \cdot \max\{\tilde{w}z - i_E \cdot \tilde{p}, 0\}.$$

For simplicity we present it as in equation (10), which is applicable when the zero boundary condition does not bind. The zero lower bound condition also applies for the employer portion of payroll taxes.

[23] Agents who are offered insurance by employers also have access to the individual insurance market and can purchase a contract at the market price, which depends on the individual health status. Given the same coverage ratios offered by each contract, agents choose to be insured at the lowest cost taking into account the tax break which can be applied only when they choose to purchase an employer-based contract. In our benchmark model, however, no one chooses to buy an individual contract in such a case since the fraction ψ paid by employers makes an employer-based contract more attractive. This holds even for agents with the best health condition, who could buy a contract in the market at the lowest price. Hence we write the premium as $\tilde{p} = p(1 - \psi)$, when $i_E = 1$ and $i'_{HI} = 1$.

Recently retired agents' problem

$$V_r(s_r) = \max_{c,a'} \{u(c) + \beta(1-\rho_d) E[V_o(s'_o)]\} \tag{13}$$

subject to

$$\begin{aligned}
(1+\tau_c)c + a' + (1 - i_{HI} \cdot q(x))\, x &= ss - p_{med} + (1+r)(a+T_B) - T(y) + T_{SI} && (14)\\
y &= r(a+T_B) && (15)\\
T_{SI} &= \max\{0, (1+\tau_c)\bar{c} + (1 - i_{HI} \cdot q(x))\, x \\
&\quad + p_{med} - ss - (1+r)(a+T_B) + T(y)\} && (16)\\
a' &\geq \underline{a}
\end{aligned}$$

Old agents' problem

$$V_o(s_o) = \max_{c,a'} \{u(c) + \beta(1-\rho_d) E[V_o(s'_o)]\} \tag{17}$$

subject to

$$\begin{aligned}
(1+\tau_c)c + a' + (1 - q_{med}(x))\, x &= ss - p_{med} + (1+r)(a+T_B) - T(y) + T_{SI} && (18)\\
y &= r(a+T_B) && (19)\\
T_{SI} &= \max\{0, (1+\tau_c)\bar{c} + (1 - q_{med}(x))\, x \\
&\quad + p_{med} - ss - (1+r)(a+T_B) + T(y)\} && (20)\\
a' &\geq \underline{a}
\end{aligned}$$

The choice variables of the two old generations are c, a'. The social security benefit payment is denoted by ss and p_{med} is the Medicare premium that each old agent pays. The only difference between the budget constraints of the two old generations is how health expenditures x are financed. The old agents are covered by Medicare for a fraction $q_{med}(x)$ of x and the recently retired agents are covered for $q(x)$ if they purchased an insurance contract in the previous period.

3.8 Stationary competitive equilibrium

At the beginning of the period, each young agent is characterized by a state vector $s_y = (a, z, x, i_{HI}, i_E)$, i.e. asset holdings a, labor productivity z, health care expenditure x, and indicator functions for insurance holding i_{HI}, and employer-based insurance benefits i_E. Old agent has the state vector $s_r = (a, x, i_{HI})$ or $s_o = (a, x)$, depending on whether the agent is recently retired or not. Let $a \in \mathbb{A} = \mathbb{R}_+$, $z \in \mathbb{Z}$, $x \in \mathbb{X}$, $i_{HI}, i_E \in \mathbb{I} = \{0, 1\}$ and $j \in \mathbb{J} = \{y, r, o\}$ and denote by $\mathbb{S} = \{\mathbb{J}\} \times \{\mathbb{S}_y, \mathbb{S}_r, \mathbb{S}_o\}$ the entire state space of the agents, where $\mathbb{S}_y = \mathbb{A} \times \mathbb{Z} \times \mathbb{X}_y \times \mathbb{I}^2$,

$\mathbb{S}_r = \mathbb{A} \times \mathbb{X}_o \times \mathbb{I}$ and $\mathbb{S}_o = \mathbb{A} \times \mathbb{X}_o$. Let $s \in \mathbb{S}$ denote a general state vector of an agent: $s \in \mathbb{S}_y$ if young, $s \in \mathbb{S}_r$ if recently retired and $s \in \mathbb{S}_o$ if old.

The equilibrium is given by interest rate r, wage rate w and adjusted wage w_E; allocation functions $\{c, a', i'_{HI}\}$ for young and $\{c, a'\}$ for old; government tax system given by income tax function $T(\cdot)$, consumption tax τ_c, Medicare, social security and social insurance program; accidental bequests transfer T_B; the individual health insurance contracts given as pairs of premium and coverage ratios $\{p, q\}$, $\{p_m(x), q\}$; a set of value functions $\{V_y(s_y)\}_{s_y \in \mathbb{S}_y}, \{V_r(s_r)\}_{s_r \in \mathbb{S}_r}$ and $\{V_o(s_o)\}_{s_o \in \mathbb{S}_o}$; and distribution of households over the state space $\mathbb{S}$ given by $\mu(s)$,

such that

1. Given the interest rate, the wage, the government tax system, Medicare, social security and social insurance program, and the individual health insurance contract, the allocations solve the maximization problem of each agent.

2. The interest rate r and wage rate w satisfy marginal productivity conditions, i.e. $r = F_K(K, L) - \delta$ and $w = F_L(K, L)$, where K and L are total capital and labor employed in the firm's sector.

3. A firm that offers employer-health insurance benefits pays the wage net of cost, given as $w_E = w - c_E$, where c_E is the cost of health insurance premium per efficiency unit paid by a firm, as defined in equation (5).

4. The accidental bequests transfer matches the remaining assets (net of health care expenditures) of the deceased.

$$T_B = \rho_d \int \left[a'(s) - \sum_{x'} p_o(x'|x) \{(1 - q_{med}(x'))\, x'\} \right] \mu(s|j = r, o) ds \tag{21}$$

5. The health insurance company is competitive, and satisfies conditions (1) and (2).

6. The government's primary budget is balanced.

$$G + \int T_{SI}(s)\, \mu(s) ds = \int [\tau_c c(s) + T(y(s))]\, \mu(s) ds \tag{22}$$

where $y(s)$ is the taxable income for an agent with a state vector s.

7. Social security system is self-financing.

$$ss \int \mu(s|j = r, o) ds = \tau_{ss} \int (\tilde{w} z - 0.5 i'_{HI} \cdot i_E \cdot p(1 - \psi))\, \mu(s|j = y) ds \tag{23}$$

8. Medicare program is self-financing.

$$\int q_{med}(x)\, x\mu(s|j = o)ds = \tau_{med}\int \left(\tilde{w}z - 0.5 i'_{HI}\cdot i_E \cdot p\,(1-\psi)\right)\mu(s|j = y)ds$$
$$+p_{med}\int \mu(s|j = r, o)ds \tag{24}$$

9. Capital and labor markets clear.

$$K = \int [a(s) + T_B]\,\mu(s)ds + \int i'_{HI}\left(i_E p + (1-i_E)\,p_m(x)\right)\mu(s|j = y)ds \tag{25}$$
$$L = \int z\mu(s|j = y)ds \tag{26}$$

10. The aggregate resource constraint of the economy is satisfied.

$$G + C + X = F(K, L) - \delta K, \tag{27}$$

where

$$C = \int c(s)\mu(s)ds \tag{28}$$
$$X = \int x(s)\mu(s)ds. \tag{29}$$

11. The law of motion for the distribution of agents over the state space $\mathbb{S}$ satisfies

$$\mu_{t+1} = R_{\mu}(\mu_t), \tag{30}$$

where R_{μ} is a one-period transition operator on the distribution.

4 Calibration

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

A model period corresponds to one year.

4.1 Endowment, health insurance and health expenditures

Data source: For a detailed description of the calibration process, please refer to Appendix A. For endowment, health expenditure shocks and health insurance, we use income and health data from one source, 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 expenditures and insurance. We drop the first three panels because one crucial variable that we need in determining the joint endowment and insurance offer process is missing in those panels.

To calibrate an income process, we consider wage income of all heads of households (both male and female), unlike many existing studies in the literature on stochastic income process (for example, Storesletten, et al, 2004, who use households to study earnings process, and Heathcote, et al, 2004, who use white male heads of households to estimate wage process). We choose heads instead of all individuals since many non-head individuals are covered by their spouses' health insurance. Our model also captures those with zero or very low level of assets, who would be eligible for public welfare assistance. Many households that fall in this category are headed by females, which is why we include both males and females. Most of the existing studies on the income process are focused on samples with strictly positive income, often above some threshold level and such treatment does not fit in our model, either. Moreover, we want to capture the heterogeneity in health insurance opportunities (group and individual) across the dimension of the income states, which is possible only by using a comprehensive database like MEPS.

Endowment: We calibrate the endowment process jointly with the stochastic probability of being offered employer-based health insurance. We specify the income distribution over the five income states so that in each year, an equal number of agents belong to each of the five bins of equal size. Then we determine for each individual in which bin he or she resides in the two consecutive years and thus construct the joint transition probabilities $p_{Z,E}(z, i_E; z', i'_E)$ of going from income bin z with insurance status i_E to income bin z' with i'_E. Recall i_E is an indicator function that takes a value 1 if employer-based health insurance is offered and 0 otherwise. The joint Markov process is defined over $N_z \times 2$ states with a transition matrix $\Pi_{Z,E}$ of size $(N_z \times 2) \times (N_z \times 2)$. We average the transition probabilities over the five panels weighted by the number of people in each panel. We display the transition matrix in Appendix A.

Finally, in order to get the grids for z, we compute the average income in each of the five bins in 2003 dollars. First we compute average income in 2003 dollars as \$32,768. The z relative to average income are

$$\mathbb{Z} = \{0.095, 0.484, 0.815, 1.238, 2.374\}$$

Notice that the income shocks look quite different from the ones normally used in the literature in that we include all heads of households, even those with zero income. This generates an extremely low income shock of about \$3,000 for a sizeable measure of the population. We assume that the agents cannot borrow, i.e. $\underline{a} = 0$. Given that the lowest possible income is quite small, the constraint is not very different from imposing a natural borrowing limit.

The stationary distribution over the $(N_z \times 2)$ grids is given as

z grid number	1	2	3	4	5	sum
GHI offered (%)	3.1	11.3	14.9	16.4	16.9	62.6
GHI not offered (%)	17.1	8.6	5.0	3.6	3.1	37.4

There is an asymmetry in the income distribution for the agents with a group insurance offer and those without such an offer. A high income is more likely to be associated with the group insurance offer.

Health expenditure shocks: In the same way as for the endowment process, we estimate the process of health expenditure shocks and the transition probabilities directly from the MEPS data. We use seven states for the expenditures and for each of the young and the old generations, we specify the bins of size $(20\% \times 4, 15\%, 4\%, 1\%)$. Young agents' expenditure grids are given as

$$\mathbb{X}_y = \{> 0.000, 0.005, 0.018, 0.047, 0.135, 0.397, 1.436\}$$

which are the mean expenditures in the seven bins in the first year of the last panel, that is, in the year 2002. The transition matrices for each young generation are displayed in Appendix A. The expenditures are normalized in terms of their ratios to the average labor income in 2003. This parametrization generates average expenditures of 6.6% of mean labor income in the young generation or $2,195 in year 2003 dollars.

Notice that an advantage of our procedure is that we can specify the bins ourselves. Average expenditures in the first and second bins are less than 1% of average labor income. In contrast, expenditures are substantial in the top bins. For example, the top 1% of the third generation have average expenditures of about 1.5 times the average income (over $48,000 in 2003 dollars). The next 4% have average expenditures of 40% of average income (over $13,000) while the following 15% spend about 14% of average income (about $4,600).

Likewise, using the same strategy for the old generation (common for $j = r$ and o) we obtain the expenditure grids

$$\mathbb{X}_o = \{0.005, 0.033, 0.077, 0.156, 0.397, 0.988, 2.209\}$$

and the transition matrix displayed in Appendix A, which generates unconditional expectation of x_o of 18.1% of mean income or $5,936 in year 2003 dollars.

In our baseline calibration, we assume the health expenditure shocks are independent of other states, in particular, the labor income z. We discuss the issue and the effects of incorporating the correlation on our experiment results in section 6.

4.2 Health insurance

The coverage ratios of health insurance contracts are calibrated using the same five MEPS panels. Given that the coverage depends on and increases in the health expenditures incurred by the insured, we estimate a polynomial $q(x)$, the coverage ratio as a function of expenditures x. More details on the estimation of this function are given in Appendix A.4.

As mentioned before, there is a proportional operational cost incurred by insurance companies, which is passed through to the insurance premiums as a mark-up. Our choice for the mark-up is 11% based on the study in Kahn et al. (2005) and we assume that the same cost is added to the group and individual insurance contracts, i.e. $\phi_G = \phi_I$. [24] Notice that this parameter does not correspond to the total administrative cost in the health care sector, which is sometimes estimated to be as high as one third. For example, Woolhandler et al. (2003) estimate that in 1999, 31% of health expenditures were spent on administration, but most of these expenditures are on the provider side which are part of our calibrated cost of health care from MEPS already.

The group insurance premium p is determined in equilibrium to ensure zero profits for the insurance company in the group insurance market. The average annual premium of an employer-based health insurance was $2,051 in 1997 or about 7% of annual average labor income (Sommers, 2002). Model simulations yields a premium of 6.2% of average annual labor income.

A firm offering employer-based health insurance pays a fraction ψ of the premium. According to the MEPS, the average percentage of total premium paid by employees varies between 11% and 23% depending on the industry in 1997 (Sommers, 2002). Estimates in other studies lie in a similar range and we set the fraction $(1 - \psi)$ to 20%.[25]

With regards to individual health insurance, the insurance company sets $p_m(x)$ to satisfy the equation (2), that is, $p_m(x) = (1 + \phi_I)E\{q(x')\,x'|x\}/(1 + r)$. The expectation is with respect to the next period's expenditures x', and we compute the premium using the transition matrix Π_{x_y} as a function of last period's expenditures x. In the benchmark model, the premiums in the unit of average labor income are given as follows.

bin	1	2	3	4	5	6	7
$p_m(x)$	0.0156	0.0245	0.0488	0.0860	0.1221	0.2358	0.4905

4.3 Demographics, preferences and technology

We define the generations as follows. Young agents are between the ages of 20 and 64, and old agents are 65 and over. Young agents' probability of aging ρ_o is set at 1/45 so that they stay for

[24] The figure quoted in Kahn et al. (2005) is 9.9%, but this is overhead divided by the total premium, i.e., in the context of our paper where the ϕ are overhead relative to expenditures only, we solve $\phi_I/(1 + \phi_I) = 0.099$ and find $\phi_I = 0.11$.

[25] 15.1% by National Employer Health Insurance Survey of the National Center for Health Statistics in 1993 and 16% by Employer Health Benefits Survey of the Kaiser Family Foundation in 1999.

an average of 45 years in the labor force before retirement. The death probability ρ_d is calibrated so that the old agents above age 65 constitute 20% of the population, based on the panel data set we discuss below. This is a slight deviation from the fraction of 17.4% in the Census because our model unit is a head of a household. We abstract from the population growth and the demographic structure remains the same across periods. Every period a measure $\frac{\rho_d \rho_o}{\rho_d + \rho_o}$ of young agents enter the economy to replace the deceased old agents.

We calibrate the annual discount factor β to achieve an aggregate capital output ratio $K/Y = 3.0$. We choose a risk aversion parameter of $\sigma = 3$ and conduct sensitivity analysis over the value of σ in section 6.

Total factor productivity A is normalized so that the average labor income equals one in the benchmark. The capital share α is set at 0.33 and the depreciation rate δ at 0.06.

4.4 Government

Expenditures and taxation: The value for G, that is, the part of government spending not dedicated to social insurance transfers, is exogenously given and it is fixed across all policy experiments. We calibrate it to 18% of GDP in the benchmark economy in order to match the share of government consumption and gross investment excluding transfers, at the federal, state and local levels (The Economic Report of the President, 2004). We set the consumption tax rate τ_c at 5.67%, based on Mendoza, Razin, and Tesar (1994).[26]

The income tax function consists of two parts, a non-linear progressive income tax and proportional income tax. The progressive part mimics the actual income tax schedule in the U.S. following the functional form studied by Gouveia and Strauss (1994), while the proportional part stands in for all other taxes, that is, non-income and non-consumption taxes, which for simplicity we lump together into a single proportional tax τ_y levied on income. The functional form is given as

$$T(y) = a_0 \left\{ y - (y^{-a_1} + a_2)^{-1/a_1} \right\} + \tau_y y. \tag{31}$$

Parameter a_0 is the limit of marginal taxes in the progressive part as income goes to infinity, a_1 determines the curvature of marginal taxes and a_2 is a scaling parameter. To preserve the shape of the tax function estimated by Gouveia and Strauss, we use their parameter estimates $\{a_{0,} a_1\} = \{0.258, 0.768\}$ and choose the scaling parameter a_2 such that the share of government expenditures raised by the progressive part of the tax function $a_0 \left\{ y - (y^{-a_1} + a_2)^{-1/a_1} \right\}$ equals 65%. This matches the fraction of total revenues financed by income tax (OECD Revenue Statistics). The parameter a_2 is calibrated within the model because it depends on other endogenous

[26]The consumption tax rate is the average over the years 1965-1996. The original paper contains data for the period 1965-1988 and we use an unpublished extension for 1989-1996 for recent data available on Mendoza's webpage.

variables. The parameter τ_y in the proportional term is chosen to balance the overall government budget and determined in the model's equilibrium.

Social insurance program: The minimum consumption floor $\bar{c}$ is calibrated so that the model achieves the target share of households with a low level of assets. Households with net worth of less than \$5,000 constitute 20.0% (taken from Kennickell, 2003, averaged over 1989-2001 SCF data) and we use this fraction as a target to match in the benchmark equilibrium.

Social security system: We set the replacement ratio at 45% based on the study by Whitehouse (2003). In equilibrium, the total benefit payment equals the total social security tax revenues. The social security tax rate is pinned down in the model given that the system is self-financed. We obtain the social security tax rate $\tau_{ss} = 10.61\%$, which (endogenously) matches the current Old-Age and Survivors Insurance (OASI) part of the social security tax rate, 10.6%.

Medicare: We assume every old agent is enrolled in Medicare Part A and Part B. We use the MEPS data to calculate the coverage ratio of Medicare in the five expenditure bins $x_o \in \mathbb{X}_o$.

bin	1	2	3	4	5	6	7
$q_{med}(x)$	0.228	0.285	0.342	0.406	0.511	0.637	0.768

The Medicare premium for Part B was \$799.20 annually in the year 2004 or about 2.11% of annual GDP (\$37,800 per person in 2004) which is the ratio that we use in the simulations. The Medicare tax rate τ_{med} is determined within the model so that the Medicare system is self-financed. The model generates expenditures and revenues equal to 1.51% of labor income.[27]

5 Numerical results

5.1 Benchmark model

Although we don't calibrate the model to directly target and generate the patterns of health insurance across the dimension of individual states, our model succeeds in matching them fairly well not only qualitatively but in most cases even quantitatively. We measure the model's success by comparing the take-up ratio, defined as the share of households holding health insurance, in the model versus data. The overall take-up ratio is 75.6% (73.1% in the data) among all young agents and 35.5% among those not offered group health insurance (34.8% in the data).

[27]This figure is lower than in reality (Medicare tax rate 2.9% with its expenditures of about 2.3% of GDP) for two reasons. First, in our model Medicare is reserved exclusively for the old generation while the actual Medicare system pays for certain expenditures even for young agents. Second, payroll taxes apply to all of labor income while in reality there is a threshold level (\$97,500 as of 2007) above which the marginal payroll tax is zero.

Figure 1 displays the take-up ratios of the model over the labor income together with the same statistics from the MEPS data.[28] Both in the data and model, the take-up ratios increase in income. If agents are offered group insurance, the take-up ratios are very high since they receive the subsidy from the firm and the tax benefit. As we saw in the calibration section, agents with higher income are more likely to be offered group insurance and very few agents in the lowest income grid receive such a benefit, which contributes to the lower take-up ratio of low-income agents. Also recall that we do not impose any income threshold and capture agents with zero or very low labor income and. Many of them have a very low level of assets and are likely to be eligible for the social insurance. In case the agents face a high expenditure shock and can only purchase individual health insurance at a high premium, they may choose to remain uninsured in the hope of receiving the social insurance and having the health cost be covered by the government.

Figure 2 displays the take-up ratios over the health expenditures. The data show a fairly flat take-up ratio between 70 and 80% except for the agents with very low expenditures. Our model also generates a flat pattern of take-up ratios, although we are a bit off at the very low end, where the data exhibit a drop in the coverage. One possible reason is our assumption that all the employers pay 80% of the premium at the firm level, which is based on the average subsidy ratio in the data. In practice, however, different firms cover a varying fraction of the premium and the data may capture some of those agents with a less generous employer subsidy. The healthiest agents with a relatively low expected expenditure may choose not to be insured if the employer subsidy is sufficiently low.

Figures 3 and 4 plot take-up ratios over income and expenditures for those agents offered GHI. The model overstates the health insurance demand somewhat, especially at the low end of the income and expenditure distributions. It is likely that in the data individuals with relatively low income, say in income bin 1, could work for employers with a less generous subsidy than the average $\psi = 0.80$. As mentioned before, heterogeneity across the employer subsidy may solve this problem. We leave this to future and ongoing research. Most of the mass in the income distribution, of course, is concentrated among the higher bins where the fit is much better.

Finally, Figures 5 and 6 plot take-up ratios for those not offered GHI. Both over income and expenditure the model replicates the empirical take-up ratios fairly well, most of the time within 10 percentage points.

5.2 Policy experiments

We now conduct experiments to determine the effect of changes in the tax treatment of health insurance. In the experiments, we treat changes in the government revenue as follows: expen-

[28] We estimate the empirical take-up ratios over income via a probit model on three regressors: a constant, log of income and the squared log income. Likewise for the plots over expenditures (see below) we use the log of expenditures and squared log expenditures.

ditures G, consumption tax rate τ_c and the progressive part of the income tax function remain unchanged from the benchmark. We adjust the proportional tax rate τ_y to balance the government budget. Medicare and social security systems remain self-financed and the revenue will also be affected because the labor income, which is the payroll tax base, changes across experiments. We keep the Medicare premium p_{med} at the benchmark level and adjust the tax rate τ_{med} to maintain the balance. For the social security system, we keep the replacement ratio at 45% and adjust the retirement benefit ss to account for the changes in the average labor income and the tax rate τ_{ss} to balance the program's budget.

In each experiment, we first compute a steady state outcome under the stationary equilibrium and then the transition dynamics. In the latter, we assume that in period 0, the economy is in the steady state of the benchmark economy. In period 1, an unanticipated change of the policy is announced and implemented and the economy starts to make a transition to the new steady state. Throughout the transition, the proportional tax rate τ_y as well as payroll taxes τ_{ss} and τ_{med} are adjusted to balance the overall budget of the government, social security and the Medicare systems respectively. The group health insurance premium also changes as the insurance demand evolves over time.

In order to assess the welfare effect of a reform, once we solve for the transition dynamics, we compute the consumption equivalent variation ("*CEV*"). It measures a constant increment in percentage of consumption in every state of the world that has to be given to the agent so that he is indifferent between remaining in the benchmark and moving to another economy which is about to make a transition to the new steady state implied by an alternative policy.

5.2.1 Abolishing tax deductibility of group premium costs

In order to understand the economic and welfare effects of the current tax policy about health insurance, we ask what the agents would do if there was no such policy. The experiment (experiment A) invokes a radical change - the government abolishes the entire deductibility of the group insurance premium for both income and payroll tax purposes. Taxes are now collected on the entire portion of the premium and the taxable income is given as

$$y = \tilde{w}z + r(a + T_B) + i_E i'_{HI} \psi p.$$

Note that not only is the employee-paid portion no longer tax-deductible, but also the portion paid by the employer is subject to taxation and considered as part of the taxable income of an individual.

We allow supply side effects as a result of policy changes, both on the extensive and intensive margin, i.e. the probability of GHI offers and generosity in terms of the subsidy rate. On the intensive margin we assume that the employer subsidy to GHI adjusts when the premium changes. Specifically, we assume that employers pay ψ^m for every dollar of premium above the benchmark value of p^{bench}. In other words, employers pay a total subsidy worth $\psi p = \psi^{bench} p^{bench} + \psi^m \left(p - p^{bench}\right)$. This specification is motivated by the observation that at the margin employers tend to carry a much smaller share of the GHI premium, i.e., $\psi^m < \psi^{bench}$. This fact has been documented in the literature. For example, Gruber and McKnight (2003), argue that "the key dimension along which employers appear to be adjusting their health insurance spending is through the generosity of what they contribute." Sommers (2005) argues that wage stickiness prevents firms from reducing wages when the premium increases. Simon (2005) estimates that the employers pass 75% of the premium hike as increased employee contributions (i.e. only 25% paid by employers), but we regard this estimate of employer contribution is too low given that he looked at small firms only who tend to be less generous with their group insurance subsidy as pointed out by Gruber and Lettau (2004). Hence we set ψ^m at 50%.

For the extensive margin, to gauge the effect on the offer probability we rely on work by Gruber and Lettau (2004) who run a probit model of GHI offers on the tax-price of health insurance, which is defined as the after tax price of one dollar worth of insurance. They estimate that taking away the income and payroll tax subsidy, thereby increasing the tax-price of health insurance to unity, is going to reduce the share of workers that are offered GHI by 15.5%. To account for lower offer rates, we adjust the transition matrix $\Pi_{Z,E}$. Specifically, we target a new stationary distribution p_{sd} such that

$$\begin{aligned} p_{sd}\left(x, i_E = 1\right) &= 0.845 * p_{sd}^{bench}\left(x, i_E = 1\right) \\ p_{sd}\left(x, i_E = 0\right) &= 0.155 * p_{sd}^{bench}\left(x, i_E = 1\right) + p_{sd}\left(x, i_E = 0\right) \end{aligned}$$

where p_{sd}^{bench} is the stationary distribution from the benchmark.[29] This yields the following probabilities (in percentage) of being offered insurance

z grid number	1	2	3	4	5	sum
GHI offered: benchmark	3.2	11.2	15.1	16.4	17.3	62.6
GHI offered: no tax subsidy	2.7	9.5	12.8	13.8	14.6	52.9
Change	-15.5%	-15.5%	-15.5%	-15.5%	-15.5%	-15.5%

This ensures that the total share of agents offered group insurance is 15.5% lower than in the benchmark, but the distribution of labor productivity is unchanged. We conduct sensitivity analysis of our results under alternative assumptions about the supply side reactions. Specifically, we check how results change if we disregard the supply side effect on the intensive or extensive margins, or both. See section 6 for details.

Experiment results are summarized in Table 2. The top section displays some statistics on

[29] Appendix A.5 has more details on how we construct the new $\Pi_{Z,E}$ matrix.

health insurance: the premium of group insurance p, the overall take-up ratio TUR_{all}, the take-up ratio conditional on not being offered group insurance TUR_{noG} and offered group insurance TUR_G. The next two rows *Group* and *Individual* show the break-down of TUR_G, i.e. the fraction of agents who bought group insurance (*Group*) or individual insurance (*Individual*) conditional on being offered group insurance. The second section displays aggregate variables including the proportional tax rate τ_y on income that balances the government budget and the third section shows 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 policy is implemented.

Removing the tax subsidy leads to a partial collapse of the group insurance market. The take-up ratio conditional on being offered group insurance falls from 99.0% in the benchmark to 57.4%. About two-thirds of those who remain insured opt out of the group insurance market and purchase a contract in the individual market. Those are the agents in a better health condition who face a lower premium in the individual insurance market. The exit of these agents out of the group insurance market significantly deteriorates the health quality in the pool of the insured and the price of the group insurance premium p jumps up to $5,316 from the benchmark price of $2,018. The overall coverage ratio falls by as much as 27.3%. An increased exposure to the health expenditure shocks raises the precautionary savings demand and the aggregate capital increases by 0.8%. The magnitude of the drop is relatively small given the size of the decrease in the coverage, since many agents who become uninsured by declining the group insurance offer are healthy and less concerned about expenditure shocks in the immediate future. The firm's cost of providing the benefit is lower despite the price increase, since much fewer workers take the offer.

Although the wage rate is higher and the proportional tax rate τ_y and the social security tax rate τ_{ss} are lower than in the benchmark due to the increased tax base, it is not enough to compensate for the welfare loss due to the lower insurance coverage and increased exposure to health expenditure shocks. Agents without the offer will also face a welfare loss since the group insurance offer they may receive in future is not so attractive any more and they are exposed to more expenditure risks ask well. As shown in *% w/ CEV > 0*, only 20% of agents would experience a welfare gain from such a reform, and the average welfare effect (in CEV) is negative, in the order of 0.34% in terms of consumption in every state.

5.2.2 Other experiments

Experiment B. fixing regressiveness: In this experiment, we let the government continue to provide a subsidy for the group insurance, but correct for regressiveness associated with the deduction from the progressive income tax system. More precisely, the government abolishes the premium deductibility for the income tax purpose and in exchange returns a lump-sum subsidy for the purchase of group insurance. The subsidy is determined so that the government maintains the budget balance while keeping the income tax rate τ_y unchanged.

Compared to the benchmark, this policy is intended to be more beneficial if the agent with a group insurance offer belongs to a lower income group, because under the benchmark the deduction was based on their lower marginal tax rate. The subsidy based on the average tax rate under this policy is common across agents and higher than the benefit deduction from the lower tax bracket. As shown in the Table 3, the coverage goes up by most among the lowest income people and the welfare is improved, although the magnitude is relatively small.

Experiment C. extending tax deductibility to the non-group insurance market: In the next policy experiment, the government keeps the current tax deductibility for the group insurance premium untouched and aims to correct for the horizontal equity by providing some benefit for the individual insurance market. One way to do it is to extend the same tax advantage to everyone, i.e. agents who purchase a contract in the individual market can also deduct the premium cost from their income and payroll tax bases. As shown in the top section of Table 3, the policy would increase the insurance coverage among the people without an access to the group insurance market by more than 38% and the overall coverage by 14%. An increased cost of providing deduction is reflected in the higher proportional tax rate τ_y and social security tax rate τ_{ss}. The higher coverage across the different health status reduces the precautionary savings and the aggregate capital falls by about 0.7%.

In terms of welfare, the policy brings a relatively large welfare gain for those without an insurance offer from the employer, 0.38% in terms of the consumption equivalence. Despite the decrease in the aggregate consumption in the final steady state, the reform will enable agents to smooth consumption across the states and enhances the overall welfare. The number of agents who are eligible for the social insurance goes down by 1.5%, since agents are better insured and less exposed to a catastrophic health shock that would bring their disposable assets down to hit the minimum consumption level $\bar{c}$.

Experiment D. providing credit to the non-group insurance market: In experiments D-1 and D-2, the government offers a refundable credit of $1,000 to supplement for the purchase of individual insurance, if the person is not offered group insurance. In D-2, the provision of the subsidy is subject to the income threshold of $30,000, above which the subsidy phases out. As shown in Table 3, there is a significant effect on the insurance coverage among those without an access to group insurance. The conditional take-up ratio increases from 36% to 87% and 76% in D-1 and D-2, respectively.

The comparison of the results in experiments D-1 and D-2 reveals the tradeoff between the cost and efficiency in targeting beneficiaries. By restricting the eligibility to the lower income households in D-2, the required increase in the proportional tax rate τ_y is 0.42% as opposed to

0.65% in D-1. The policy increases the overall TUR by 15% and 19%. It becomes more costly to provide an incentive to be insured if the agent's income is higher. Wealthy households with more assets are better insured by their accumulated savings and the marginal price that makes them indifferent between buying a contract and not buying is higher.

At the bottom of Table 3, we display the take-up ratios across income shocks z and health expenditure shocks x. In D-1, compared to C, there is much larger increase of the take-up ratios among lower-income households. Providing a refundable credit as in D-1 and D-2 is more effective than a tax deduction because low-income agents do not pay much tax. Therefore, they receive only small benefits from the deduction policy. The credit policy D-2 is also effective in increasing the coverage among the poor, while the coverage among the rich changes little due to the phase-out of the benefit at a high income level. As shown in the take-up ratios over the expenditure shocks x, both credit policies encourage the purchase among healthier agents, since they face a lower premium cost, the large part of which can be covered by the subsidy.

Increased risk-sharing together with the higher tax rate reduce the saving motive and the aggregate capital and output are lower in both D-1 and D-2. Despite the increased tax burden and the relatively large fall in the aggregate level of consumption, the gain from the better insurance coverage and an increased protection against expenditure shocks dominate the negative effects and the welfare effect among young agents is positive on average with a CEV of 0.58% and 0.55% in the two experiments. The number of agents eligible for the social insurance is about 3%. The vast majority of the agents would support such reform proposals.

6 Extensions and discussions of the model

Supply side response: In experiment A, where the tax policy is completely eliminated, we allowed the firms to react in both extensive and intensive margins based on empirical studies. In this section, we present results under alternative assumptions about the supply side reactions.

Instead of using the exogenous assumptions about the GHI offers, one could model the demand and supply decisions of workers and firms jointly. Dey and Flinn (2005) build and estimate a model using a search, matching and bargaining environment and study how employer-based health insurance affects job mobility. There is a clear tradeoff between the richness of the model and the tractability. The structural model of Dey and Flinn, for example, while richer in the labor market frictions, assumes an exogenous health insurance premium and abstracts from a market for individual health insurance or decisions about savings as an alternative insurance device. Therefore it is not suitable for the policy analysis we have in mind, i.e. to understand how the agents decide to choose a particular insurance over alternatives, when the relative price is affected by a policy change. We choose to focus on the details on the demand side and abstract from the supply side decisions. Our main results, however, that the current policy enhances the pooling of the group insurance and improves the welfare is found to be robust to the plausible variations of the supply side reactions.

Table 4 summarizes the results. In the first experiment *(i) no adj.*, we make an assumption at one extreme that firms do not respond at all to the policy change. They continue to pay 80% of the premium as a subsidy no matter how high the price is and the offer probability is not affected. In experiments *(ii) ext.* and *(iii) int.*, firms adjust only one margin (extensive or intensive) at one time.

As shown in Table 4, the elimination of the policy always triggers a partial collapse of the group health insurance market, making the healthy agents leave the pool. The adjustment of the intensive margin is shown to reduce the conditional take-up ratios among those offered group insurance more significantly, since the adjustment directly raises the marginal price of the contract. The negative welfare effect of the policy change is robust across experiments under alternative specifications and it is sizeable even under an extreme assumption of no adjustment at all.

Correlation between health expenditures and labor income: In the baseline model, we imposed an assumption that health expenditure and income processes are independent. It is conceivable, however, that poor health may negatively affect labor productivity. Looking at the panel data we found that overall there is only a small negative correlation between the two variables. Closer inspection, however, reveals that this small number disguises the fact that it is mainly a small share of individuals with very high expenditures who have significantly lower income. We found that the average income in expenditure bins x_6 and x_7 is lower than the unconditional mean by 12 and 31 percent, respectively. In contrast, income in the first five bins is marginally higher than the aggregate, by only 0.8 percent.

As a robustness check we introduce a negative correlation between expenditure and income shocks by scaling up or down the labor income based on the current health expenditure shock.[30] We recalibrate the model with the correlated process of income and expenditures and present the results of the benchmark and the main experiment of eliminating the tax policy in Table 5. We find a stronger demand for health insurance than in the baseline model with no such correlation. Health insurance has more value since it pays out more when agents face negative income shocks associated with very high health expenditures. Implicitly, it provides insurance against income shocks as well, although the price does not reflect the value.

Effects of the policy experiment are similar, qualitatively and quantitatively in most cases. The loss of subsidy will trigger the partial collapse of the group insurance market as in the baseline model, but the effect is less severe since more people choose to remain insured despite

[30]Specifically, we assume that an agent with labor productivity shock i and health expenditure shock j has $z_i \cdot \xi_j$ efficiency units of labor available, where the scaling ξ_j is such that ξ_j=1.0085 for $j = 1, ..., 5$, ξ_6=0.8773 and $\xi_7 = 0.6879$. Notice that we choose the ξ such that their average (weighted by the stationary distribution of expenditures) is one.

the increase in the marginal price because of the additional value of the insurance contract.

Risk aversion: We assess the effects of the tax policy in a model with an alternative level of risk aversion, namely with the relative risk aversion coefficient σ of 2 and 4 as opposed to 3 in the baseline calibration. As we show in Table 5, the demand for insurance increases with the degree of risk aversion and the overall insurance coverage is 68%, 76% and 83%, when σ is set at 2, 3 (benchmark) and 4, respectively. This is intuitive: with higher risk aversion agents are more willing to stay in the insurance contract despite higher prices.

We also find that with $\sigma = 4$ the share of agents eligible for the social insurance coverage decreases after eliminating the tax subsidy. We explain this with a large increase in precautionary savings evident in the increase of more than 1 percent in the aggregate capital stock. Being more self-insured, fewer agents are eligible for the social insurance coverage.

As shown in Table 5, the policy elimination will cause a significant welfare loss in a very similar magnitude across the wide range of the risk aversion we consider. With a low risk aversion, although the agents value the insurance less, the coverage declines more significantly and they are exposed to much larger risk ex-post. With a high risk aversion, the relatively small drop in the coverage causes large welfare effects in terms of welfare since they care more about smoothing consumption.

Premium mark-up of group and individual insurance: We assumed that the same mark-up is added to the insurance premium for both group and individual contracts. In this experiment, we consider a case where there is a difference in the markup, in particular, administering individual contracts incur more overhead costs and the mark-up is 50% above that of the group insurance. We set the mark-ups at 13.2% and 8.8% for individual and group contracts so that it is 11% on average.

The last columns in Table 5 show the results. In the benchmark, the coverage among the agents who have no access to group insurance goes down, from 35.5% with the baseline calibration to 28.3% with the higher mark-up. Eliminating the deduction will cause a collapse of the group insurance market in a similar magnitude, although the demand for the individual insurance is somewhat lower due to the higher marginal cost. The welfare effects are more negative since many agents now only have the access to the individual contracts that are more expensive.

Exogenous health expenditures and moral hazard: We treat health expenditures as an exogenous shock that follows a Markov process. A challenging, yet interesting extension of our work would be to endogenize medical expenditures.[31] In terms of the results of our main

[31]For example, one could model health expenditures that directly affects the utility or introduce an interaction between the expenditures and mortalities. See for example Bajari, Hong, and Khwaja (2006) and Hall and Jones (2007).

experiment, adding endogenous health expenditures would have two major effects. Taking away the tax deductibility will reduce over-investment in health, at least for those who drop out of the group insurance market and do not sign up for an individual coverage. This first effect could improve the social welfare given the better allocation of available resources.

Bajari, Hong, and Khwaja (2006) also show that moral hazard is concentrated among relatively healthy individuals, i.e. their demand for medical services is more elastic to the price change than unhealthy individuals.[32] It implies that in response to eliminating the tax deductibility on group insurance, healthy agents will respond more elastically, by opting out of the group insurance contract faced with a higher marginal price and reduce the consumption of medical services. Those left in the group insurance pool will face a more significant increase of the premium than we saw in a model without moral hazard since the pool will lose a larger number of healthy agents. Therefore, the mechanism of the collapse of the group insurance market that we emphasized will remain in place and we suspect that welfare cost of losing risk-sharing opportunities more severely will be large, although the exact magnitude is unknown until we build and simulate a model.

Self-selection into GHI jobs: We assume that agents take the GHI offer as exogenously given. Another major extension of our model would be to allow for the self-selection of individuals into jobs that do or do not offer group health insurance plans.

We conjecture that endogenizing the mobility decision in what sector (GHI or non-GHI) to work in, will make our results even stronger. This is because of the response of healthy agents in the GHI firm to the removal of the tax subsidy. In our baseline economy, healthy individuals continued to cross-subsidize the agents with high expenditures in their firm, even after they dropped out of the GHI contract: the wage of all workers in the GHI firm, even those who don't sign up, is scaled down to cover the employer share of the GHI premium. In an alternative model with a sector choice, however, healthy agents who no longer want to sign up for GHI can escape that disadvantageous cross-subsidization and simply work in the non-GHI sector that offers a high wage. This would diminish pooling in the group contract even more than in our baseline, exacerbating the welfare losses after the removal of the GHI tax subsidy. Of course, the extent of such mobility is an empirical issue that must take into account the various labor market frictions, which certainly goes beyond the scope of our paper, but if such an effect exists, the welfare losses in our economy can be viewed as a lower bound.

[32]Specifically, they show that the expenditures of healthy agents respond more strongly to insurance by measuring the elasticity of medical expenditures with respect to the derivative of the co-payment function. The coefficient on the dummy variable for excellent health is much larger in absolute value than for that for fair health. In plain words, households have a lot of discretion to skip the doctor's visit for the common cold, but for the acute and very expensive medical conditions like heart attack and stroke, they will likely have no or limited room to adjust the scope of the medical procedures. Two heart attack patients in the emergency room, one with and one without health insurance, are likely to receive a treatment of a similar cost.

7 Conclusion

We study the tax policy associated with employer-provided health insurance in a general equilibrium model. Our main innovation is that we endogenize the health insurance decision and generate adverse selection in the group health insurance market. The model captures various institutions surrounding the different types of health insurance in a parsimonious way, yet it is rich enough to generate insurance demand that closely resembles that observed in the data. We examine the effects of several tax reforms and in each case we compute the transition dynamics from the benchmark economy to a new equilibrium under an alternative policy.

The experiments indicate that despite some issues entailed in the current tax system, providing some form of subsidy and an incentive for the group insurance coverage has a merit. Employer-provided group insurance has the feature that everyone can purchase a contract at the same premium irrespective of any individual characteristics - most importantly it is independent of current health status. Relatively healthy agents would have an incentive to opt out of this contract and either self-insure or find a cheaper insurance contract in the individual market. A subsidy on group insurance can therefore encourage even healthy agents to sign up, maintain the diverse health quality of the insurance pool and alleviate the adverse selection problem that could plague the group insurance contract. We conduct an experiment that confirms this intuition by showing that a complete removal of the subsidy would result in a deterioration of health quality in the group insurance market, a rise in the group insurance premium, a significant reduction in the insurance coverage, which put together reduces the welfare.

Our results are robust across a wide variety of alternative assumptions and parameterizations. For example, different assumptions about how the supply of group health insurance offer responds to the elimination of the tax subsidy all yield substantial welfare losses. Likewise, different values for the risk aversion parameter or the markups for group versus individual insurance yield results very similar to the baseline economy.

Our work complements the existing studies on the health policy and insurance by highlighting the additional insights one would only obtain by employing a general equilibrium framework. Equilibrium prices and aggregate variables are affected by changes in policy. For example, changing the tax treatment of the health insurance premium affects the composition of agents that sign up and therefore the equilibrium insurance premium. Altering the attractiveness of health insurance also affects precautionary demand for savings, which in turn affects the level of consumption and factor prices. We have also shown that it is important to capture fiscal consequences of a reform because providing the subsidy will affect the magnitude of distortionary taxation that must be levied on other sources. Moreover, the changes in insurance demand are shown to affect other government sponsored welfare programs such as Medicaid.

We also find that there is room for significantly increasing the insurance coverage and improving welfare by restructuring the current subsidy system. Extending the benefit to the individual insurance market to restore horizontal equity is more effective if the subsidy is refundable. Extending the deductions to the individual insurance is less effective since low income households will receive less benefit from such a reform. The refundable credit policy is shown to raise the coverage by about 20% and enhance the welfare despite the increase in the fiscal burden and the lower level of aggregate output and consumption due to the lower precautionary saving motives.

Since our focus is on the effect of the tax policy, we chose not to alter other institutions and features of the model along the transition. An interesting extension of the current paper will be to ask how agents' insurance and saving decisions as well as the government's fiscal balance will be affected in response to the future changes in those environment, in particular, the rapidly rising health costs and changing demographics. We also conjectured that other extensions, not yet explicitly modeled, such as endogenous health expenditures or self-selection of individuals into jobs with health insurance offer, are unlikely to overturn our results. Also, a radical policy reform would be the introduction of a national health system. We address these issues in future and ongoing research.

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Appendix

A Data and calibration details

We discuss additional details regarding the calibration of endowment, health insurance and expenditure processes.

A.1 Selection of individuals

The MEPS database does not explicitly identify a head of household, but rather one reference person per dwelling unit, usually the owner or renter. If more than one person owns/rents the unit then the interviewer picks *exactly* one of them. Unfortunately, the definition of one household in the model as one dwelling unit in the data is inappropriate for our purposes. This is because if multiple households live in one single dwelling unit we may miss a large fraction of the population. This happens if roommates share a unit, in which case we want to capture each person as a separate economic unit. Another example would be adult children living with their parents, where we want to capture the parents and the child as separate economic units.

Our definition of a household, therefore, is based on the Health Insurance Eligibility Unit (HIEU) defined in the MEPS database. A HIEU is a unit that includes adults and other family members who are eligible for coverage under family insurance plans. Thus, each dwelling unit is composed of potentially multiple HIEUs. A HIEU includes spouses, unmarried natural or adoptive children of age 18 or under and children under 24 who are full-time students. The definition of a head is the single adult member in case of an unmarried couple. For a household with a married couple, we choose the one with a higher income as the head of the households. We tried other definitions as head of households, for example the older adult, but the calibration results did not change materially.

MEPS also provides the longitudinal weight for each individual which we use to compute all of the statistics in our calibration, i.e., all moments are weighted by the MEPS weight. Finally, we call agents aged 20-64 'young' and those age 65+ 'old'.

Next, we stack individuals in the five different panels into one large data set, of course converting all nominal values into dollars of the base year 2003. Ho do we handle the longitudinal weights? For each panel we rescale the weights such that sum of the weights in that panel is equal to the number of heads of households age 20 and older. That way within each panel people get a weight proportional to their longitudinal weights, and each panel gets a weight proportional to the number of heads of household in the age groups we consider. The number of observations in each panel is as follows.

Panel	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004	Total
Individuals	6,099	4,839	9,863	7,381	7,612	35,794

A.2 Transition matrices

A.2.1 Income and health insurance offer

MEPS records annual wage income, for example, variable WAGEPyyX stands for income in the year yy$\in \{99, 00, 01, 02, 03, 04\}$. We keep all individuals in the sample, regardless of income. Specifically, even those with zero income stay in our sample and account for almost 9 percent of our samples. MEPS also records whether a person is offered health insurance at the workplace (variables OFFER31X, OFFER42X and OFFER53X). The three variables refer to three subperiods each year in which interviews were conducted. We assume that an individual was offered insurance if he or she got an offer in at least one subperiod.

Constructing the transition matrix is then simply summing up the longitudinal weights of individuals that jump from one of the $N_z \times 2$ bins in the first year into the $N_z \times 2$ bins in the second year. We also compute stationary distributions as well as the average income in each of the N_z bins to use it as the income grid point of our Markov process.

The transition matrix for the income z and group insurance offer status i_E is as follows. Entries 1 to 5 from the top are the income bins 1 to 5 with employer-based insurance and entries 6 to 10 are the five income groups without insurance offered. For example, $\Pi_{Z,E}(7,3) = 0.038$ implies that given the agent has income $z = 2$ and no group insurance offer this period, the probability of having income $z = 3$ and a group insurance offer in the next period is 3.8%, conditional on not aging tomorrow.

$$\Pi_{Z,E} = \left[\begin{array}{ccccc|ccccc}
0.201 & 0.312 & 0.110 & 0.065 & 0.046 & 0.165 & 0.074 & 0.019 & 0.005 & 0.002 \\
0.068 & 0.439 & 0.252 & 0.079 & 0.018 & 0.051 & 0.065 & 0.022 & 0.008 & 0.002 \\
0.024 & 0.122 & 0.489 & 0.240 & 0.052 & 0.015 & 0.019 & 0.024 & 0.013 & 0.002 \\
0.012 & 0.060 & 0.152 & 0.527 & 0.187 & 0.011 & 0.008 & 0.010 & 0.022 & 0.011 \\
0.009 & 0.025 & 0.048 & 0.134 & 0.724 & 0.009 & 0.004 & 0.008 & 0.008 & 0.030 \\
\hline
0.042 & 0.045 & 0.013 & 0.007 & 0.003 & 0.715 & 0.124 & 0.033 & 0.013 & 0.005 \\
0.025 & 0.119 & 0.038 & 0.022 & 0.004 & 0.219 & 0.373 & 0.136 & 0.040 & 0.025 \\
0.010 & 0.044 & 0.098 & 0.035 & 0.014 & 0.140 & 0.202 & 0.286 & 0.126 & 0.046 \\
0.008 & 0.018 & 0.034 & 0.075 & 0.029 & 0.099 & 0.137 & 0.158 & 0.306 & 0.136 \\
0.010 & 0.017 & 0.008 & 0.013 & 0.070 & 0.088 & 0.100 & 0.094 & 0.170 & 0.430
\end{array}\right]$$

A.2.2 Health Expenditure Shocks

MEPS reports total health expenditures as well as a breakdown into different sources of payment. Expenditures refer to the amount actually *paid* as opposed to the amount *charged* by providers. See AHRQ (2003), p. C-101, for details. We disregard medical expenditures paid for by Veteran's Affairs (TOTVAyy), Workman's Compensation (TOTWCPyy) and other sources (TOTOSRyy). Summing up the remaining categories gives us the total medical expenditures considered in our model.

As before, we assign expenditures in both years into their respective percentiles and sum up the weights of agents that move from one of the N_x bins in the first year into the N_x bins in the second year. The transition matrices for the health expenditures shocks x_y for young and x_o for old are given as follows.

$$\Pi_{x_y} = \begin{bmatrix} 0.542 & 0.243 & 0.113 & 0.061 & 0.032 & 0.007 & 0.002 \\ 0.243 & 0.330 & 0.242 & 0.117 & 0.056 & 0.011 & 0.001 \\ 0.119 & 0.224 & 0.296 & 0.232 & 0.098 & 0.025 & 0.006 \\ 0.058 & 0.130 & 0.225 & 0.347 & 0.201 & 0.035 & 0.005 \\ 0.043 & 0.079 & 0.140 & 0.263 & 0.371 & 0.090 & 0.014 \\ 0.030 & 0.063 & 0.080 & 0.203 & 0.359 & 0.200 & 0.065 \\ 0.008 & 0.024 & 0.073 & 0.106 & 0.269 & 0.286 & 0.233 \end{bmatrix}$$

$$\Pi_{x_o} = \begin{bmatrix} 0.654 & 0.165 & 0.075 & 0.055 & 0.042 & 0.009 & 0.001 \\ 0.191 & 0.385 & 0.199 & 0.126 & 0.075 & 0.021 & 0.003 \\ 0.071 & 0.222 & 0.323 & 0.217 & 0.135 & 0.026 & 0.005 \\ 0.057 & 0.146 & 0.249 & 0.311 & 0.184 & 0.041 & 0.013 \\ 0.027 & 0.084 & 0.173 & 0.318 & 0.292 & 0.083 & 0.024 \\ 0.026 & 0.090 & 0.102 & 0.216 & 0.375 & 0.137 & 0.054 \\ 0.044 & 0.027 & 0.047 & 0.217 & 0.391 & 0.264 & 0.010 \end{bmatrix}$$

A.3 Takeup ratios

MEPS records whether an individual who offered group insurance through the workplace actually signs up for it (variables HELD31X, HELD42X and HELD53X). As with the offer variables we assume that a person signed up he or she did so in at least one subperiod. We also have data on whether an individual had any kind of private insurance (GHI or IHI) during the year (variable PRVEVyy=1, where yy$\in \{99, 00, 01, 02, 03, 04\}$). We assume those who were not offered GHI but who hold private insurance, are in the IHI contract. If a person is offered GHI, did not accept it, but still holds private insurance, we assume that he or she is covered by IHI.

A.4 Calibration of the health insurance coverage ratio $q(x)$

We compute the coverage ratios of private insurance for young agents and Medicare for old agents. We use a polynomial of the following form:

$$q = \beta_0 + \beta_1 \log(x) + \beta_2 (\log x)^2,$$

where x is the total health expenditures in US dollars and q corresponds to the coverage ratio of private health insurance for young agents and Medicare coverage ratio for old agents. We consider only agents with positive expenditures in this regression. For the young generation we also restrict our attention to those that actually have private insurance (variable PRVEVyy=1). We use weighted least squares to find the following estimates, where the standard errors in brackets and all coefficient estimates are significant at the 1 percent level:

	q	q_{med}
β_0	0.3410	0.5749
	(0.0207)	(0.0230)
β_1	0.0291	-0.1392
	(0.0062)	(0.0061)
β_2	0.0016	0.0139
	(0.0005)	(0.0004)
R^2	0.2510	0.3946

We plug in the N_x grid points to attain the coverage ratio for each bin. We find the following coverage ratios for each expenditure grid.

bin	1	2	3	4	5	6	7
$q(x)$	0.341	0.532	0.594	0.645	0.702	0.765	0.845
$q_{med}(x)$	0.228	0.285	0.342	0.406	0.511	0.637	0.768

A.5 Constructing the $\Pi_{Z,E}$ matrix to achieve lower GHI offer rates

We construct a new $\Pi_{Z,E}$ matrix such that there is a 15.5 percent lower chance of receiving a GHI offer. Recall from Appendix Section A.2.1 that the benchmark transition matrix had the structure

$$\Pi_{Z,E} = \begin{bmatrix} \Pi_{Z,E}^{11} & \Pi_{Z,E}^{10} \\ \Pi_{Z,E}^{01} & \Pi_{Z,E}^{00} \end{bmatrix}$$

where upper left block $\Pi_{Z,E}^{11}$ is the income transition probabilities of agents who have a GHI offer in the current year and keep it, $\Pi_{Z,E}^{10}$ is the income transition probabilities of agents who have GHI but lose it, etc.

In the experiment with the supply side effect we assume that those agents who lose the GHI offer retain the same income transition matrix as those agents with GHI. We thus use a 15×15 transition matrix

$$\Pi_{Z,E}^{exp} = \begin{bmatrix} 0.845\Pi_{Z,E}^{11} & 0.155\Pi_{Z,E}^{11} & \Pi_{Z,E}^{10} \\ 0.845\Pi_{Z,E}^{11} & 0.155\Pi_{Z,E}^{11} & \Pi_{Z,E}^{10} \\ 0.845\Pi_{Z,E}^{01} & 0.155\Pi_{Z,E}^{01} & \Pi_{Z,E}^{00} \end{bmatrix}$$

One can think of this as introducing an additional i_E state for people without GHI who have the income transition matrix as those with the GHI offer. If we instead assume that agents who lost their GHI are subject to the income transition matrix $\Pi_{Z,E}^{00}$, the welfare effects of eliminating the policy is even more negative by an order of magnitude. This welfare effect, however, does not come from agents losing GHI, but rather from falling into the income process of those agents who were without GHI in the benchmark, which has a significantly lower average income.

Also notice that this transition matrix implicitly assumes the GHI loss due to the supply side effect of the tax policy change is a) equally distributed among income groups and b) iid across time. Both assumptions will give the policy change the possible chance to improve welfare, because according to Gruber and Lettau (2004), the GHI losses will occur disproportionately among lower income agents. Moreover, the GHI losses will likely be persistent rather than than iid. One can thus interpret the welfare loss we found in the experiment as a lower bound.

Table 1: Parameters of the model

Parameter	Description	Values
Preferences		
β	discount factor	0.934
σ	relative risk aversion	3.0
Technology and production		
α	capital share	0.33
δ	depreciation rate of capital	0.06
Government		
$\{a_0, a_1, a_2\}$	income tax parameters (progressive part)	{0.258,0.768,0.716}
τ_y	income tax parameter (proportional part)	4.456%
$\bar{c}$	social insurance minimum consumption	23.9% of average earnings
τ_{ss}	social security tax rate	10.61%
	Social security replacement ratio	45%
$q_{med}(x)$	Medicare coverage ratio	see text
τ_{med}	Medicare tax rate	1.51%
p_{med}	Medicare premium	2.11% of per capita output
Demographics		
ρ_o	aging probability	2.22%
ρ_d	death probability after retirement	8.89%
Health insurance		
$q(x)$	coverage ratio	see text
p	group insurance premium	6.2% of average earnigns ($2,018)
ψ	group insurance premium covered by a firm (%)	80%
ϕ_I, ϕ_G	premium mark-up	11%

Table 2: Experiment A: abolishing deductibility of group insurance premium from income and payroll income tax bases

	Benchmark	A
p	\$2,018	\$5,316
TUR_{all}	75.67%	48.35%
TUR_{noG}	35.54%	38.00%
TUR_G	99.04%	57.38%
Group	99.04%	17.56%
Individual	0.00%	39.82%
Agg. output	1.0000	1.0027
Agg. capital	1.0000	1.0081
Agg. consumption	1.0000	1.0038
Interest rate	4.993%	4.934%
Wage rate (w)	1.0000	1.0027
Offer cost (c_E)	1.0000	0.3585
Avg Labor Inc	1.0000	1.0236
τ_y	4.456%	3.742%
τ_{ss}	10.607%	10.531%
τ_{med}	1.505%	1.458%
Social ins. covered	1.0000	1.0328
CEV from transition		
all (young)	-	-0.335%
young w/ GHI offer	-	-0.462%
young w/o GHI offer	-	-0.118%
$\%w/CEV > 0$ (young)	-	19.20%

TUR by z		
z_1	32.34%	25.02%
z_2	70.74%	42.72%
z_3	88.44%	64.97%
z_4	93.60%	60.58%
z_5	94.62%	49.12%
TUR by x		
x_1	76.70%	50.88%
x_2	75.03%	45.40%
x_3	75.05%	44.69%
x_4	75.17%	46.13%
x_5	76.16%	53.09%
x_6	76.83%	58.45%
x_7	77.14%	63.14%

Table 3: Other experiments

	Benchmark	B	C	D-1	D-2
p	\$2,018	\$2,013	\$2,017	\$2,016	\$2,016
TUR_{all}	75.67%	75.98%	89.76%	94.52%	90.47%
TUR_{noG}	35.54%	35.44%	73.81%	86.74%	75.74%
TUR_G	99.04%	99.60%	99.04%	99.06%	99.06%
Group	99.04%	99.60%	99.04%	99.06%	99.06%
Individual	0.00%	0.00%	0.00%	0.00%	0.00%
Agg. output	1.0000	0.9991	0.9977	0.9941	0.9947
Agg. capital	1.0000	0.9971	0.9931	0.9823	0.9841
Agg. consumption	1.0000	0.9991	0.9973	0.9938	0.9949
Interest rate	4.993%	5.015%	5.045%	5.126%	5.112%
Wage rate (w)	1.0000	0.9991	0.9977	0.9941	0.9947
Offer cost (c_E)	1.0000	1.0029	0.9995	0.9990	0.9990
Avg Labor Inc	1.0000	0.9989	0.9972	0.9939	0.9945
τ_y	4.456%	4.456%	4.722%	5.106%	4.873%
τ_{ss}	10.607%	10.607%	10.680%	10.607%	10.607%
τ_{med}	1.505%	1.507%	1.521%	1.518%	1.517%
Social ins. covered	1.0000	1.0009	0.9854	0.9697	0.9713
CEV from transition					
all (young)	-	0.073%	0.241%	0.583%	0.554%
young w/ GHI offer	-	0.062%	0.159%	0.371%	0.387%
young w/o GHI offer	-	0.092%	0.381%	0.946%	0.840%
$\%w/CEV > 0$ (young)	-	79.90%	79.79%	99.25%	99.86%
TUR by z					
z_1	32.34%	33.95%	57.22%	77.41%	77.18%
z_2	70.74%	70.70%	93.47%	96.59%	92.78%
z_3	88.44%	88.43%	99.44%	99.39%	94.31%
z_4	93.60%	93.53%	99.88%	99.89%	93.79%
z_5	94.62%	94.64%	99.97%	99.98%	94.81%
TUR by x					
x_1	76.70%	77.03%	90.07%	97.57%	93.94%
x_2	75.03%	75.45%	90.24%	96.18%	91.94%
x_3	75.05%	75.44%	90.08%	94.58%	90.26%
x_4	75.17%	75.42%	89.70%	92.89%	88.57%
x_5	76.16%	76.31%	88.96%	91.37%	87.40%
x_6	76.83%	76.96%	87.88%	89.84%	86.53%
x_7	77.14%	77.25%	86.28%	87.74%	85.35%

B: abolish group insurance deductibility from income tax base and provide credit for group insurance at the average income tax rate
C: extend the same deduction for the purchase of individual insurance
D-1: provide credit of \$1,000 for the purchase of individual insurance if no access to group insurance
D-2: same as D-1 but the subsidy is subject to annual income < \$30,000

Table 4: Robustness analysis: supply side response

	Benchmark	A Baseline	(i) no adj.	(ii) ext.	(iii) int
p	\$2,018	\$5,316	\$3,029	\$3,028	\$5,317
TUR_{all}	75.67%	48.35%	60.90%	58.34%	48.58%
TUR_{noG}	35.54%	38.00%	35.78%	37.32%	36.08%
TUR_G	99.04%	57.38%	75.52%	76.69%	55.86%
Group	99.04%	17.56%	55.07%	55.01%	17.57%
Individual	0.00%	39.82%	20.46%	21.68%	39.29%
Agg. output	1.0000	1.0027	1.0017	1.0020	1.0026
Agg. capital	1.0000	1.0081	1.0053	1.0060	1.0078
Agg. consumption	1.0000	1.0038	1.0023	1.0027	1.0035
Interest rate	4.993%	4.934%	4.954%	4.950%	4.937%
Wage rate (w)	1.0000	1.0027	1.0018	1.0020	1.0026
Offer cost (c_E)	1.0000	0.3585	0.8345	0.8332	0.3585
Avg Labor Inc	1.0000	1.0236	1.0076	1.0115	1.0219
τ_y	4.456%	3.742%	3.752%	3.754%	3.741%
τ_{ss}	10.607%	10.531%	10.454%	10.473%	10.523%
τ_{med}	1.505%	1.458%	1.471%	1.468%	1.459%
Social ins. covered	1.0000	1.0328	1.0091	1.0203	1.0259
CEV from transition					
all (young)	-	-0.335%	-0.162%	-0.205%	-0.342%
young w/ GHI offer	-	-0.462%	-0.244%	-0.297%	-0.468%
young w/o GHI offer	-	-0.118%	-0.022%	-0.046%	-0.124%
$\%w/CEV > 0$ (young)	-	19.20%	23.93%	19.49%	19.20%

TUR by z					
z_1	32.34%	25.02%	28.58%	27.00%	26.09%
z_2	70.74%	42.72%	53.67%	51.23%	42.72%
z_3	88.44%	64.97%	74.79%	73.58%	63.75%
z_4	93.60%	60.58%	77.06%	73.56%	61.37%
z_5	94.62%	49.12%	71.32%	67.26%	49.60%
TUR by x					
x_1	76.70%	50.88%	52.84%	53.27%	50.52%
x_2	75.03%	45.40%	54.45%	53.05%	45.08%
x_3	75.05%	44.69%	60.91%	57.76%	44.55%
x_4	75.17%	46.13%	67.25%	62.73%	46.56%
x_5	76.16%	53.09%	70.10%	65.24%	54.93%
x_6	76.83%	58.45%	71.32%	67.50%	59.91%
x_7	77.14%	63.14%	72.32%	69.98%	63.52%

Table 5: Robustness analysis

	Baseline		$x-z$ correlation		RRA σ=2		RRA $\sigma=4$		Mark-up $\phi_I > \phi_G$	
	Bench.	Exp. A	Bench.	Exp. A	Bench.	Exp. A	Bench.	Exp. A	Bench.	Exp. A
p	\$2,018	\$5,316	\$2,018	\$5,292	\$2,017	\$5,300	\$2,017	\$5,318	\$1,978	\$5,210
TUR_{all}	75.67%	48.35%	77.87%	58.16%	67.72%	26.36%	82.84%	68.41%	73.02%	42.38%
TUR_{noG}	35.54%	38.00%	41.89%	45.23%	14.19%	14.17%	55.39%	59.26%	28.32%	31.77%
TUR_G	99.04%	57.38%	98.82%	69.45%	98.89%	37.00%	98.83%	76.39%	99.04%	51.64%
Group	99.04%	17.56%	98.82%	17.42%	98.89%	17.48%	98.83%	17.57%	99.04%	17.53%
Individual	0.00%	39.82%	0.00%	52.02%	0.00%	19.52%	0.00%	58.82%	0.00%	34.11%
Agg. output	1.0000	1.0027	1.0000	1.0014	1.0000	1.0014	1.0000	1.0036	1.0000	1.0026
Agg. capital	1.0000	1.0081	1.0000	1.0042	1.0000	1.0042	1.0000	1.0109	1.0000	1.0078
Agg. consumption	1.0000	1.0038	1.0000	1.0019	1.0000	1.0014	1.0000	1.0041	1.0000	1.0030
Interest rate	4.993%	4.934%	5.005%	4.973%	5.013%	4.978%	5.009%	4.928%	4.983%	4.926%
Wage rate (w)	1.0000	1.0027	1.0000	1.0014	1.0000	1.0016	1.0000	1.0036	1.0000	1.0026
Offer cost (c_E)	1.0000	0.3585	1.0000	0.2891	1.0000	0.2903	1.0000	0.2928	1.0000	0.2913
Avg Labor Inc	1.0000	1.0236	1.0000	1.0239	1.0000	1.0274	1.0000	1.0295	1.0000	1.0279
τ_y	4.456%	3.742%	4.457%	3.800%	4.343%	3.688%	4.513%	3.753%	4.452%	3.759%
τ_{ss}	10.607%	10.531%	10.607%	10.539%	10.607%	10.539%	10.607%	10.539%	10.606%	10.539%
τ_{med}	1.505%	1.458%	1.507%	1.461%	1.507%	1.461%	1.507%	1.457%	1.503%	1.456%
Social ins. covered	1.0000	1.0328	1.0000	1.0414	1.0000	1.0524	1.0000	0.9700	1.0000	1.0356
CEV from transition										
all (young)	-	-0.335%	-	-0.350%	-	-0.335%	-	-0.422%	-	-0.414%
young w/ GHI offer	-	-0.462%	-	-0.501%	-	-0.434%	-	-0.577%	-	-0.553%
young w/o GHI offer	-	-0.118%	-	-0.091%	-	-0.166%	-	-0.157%	-	-0.176%
$\%w/CEV > 0$ (young)	-	19.20%	-	19.75%	-	19.72%	-	14.68%	-	13.93%

Figure 1: Take-up ratios over income z (model and data)

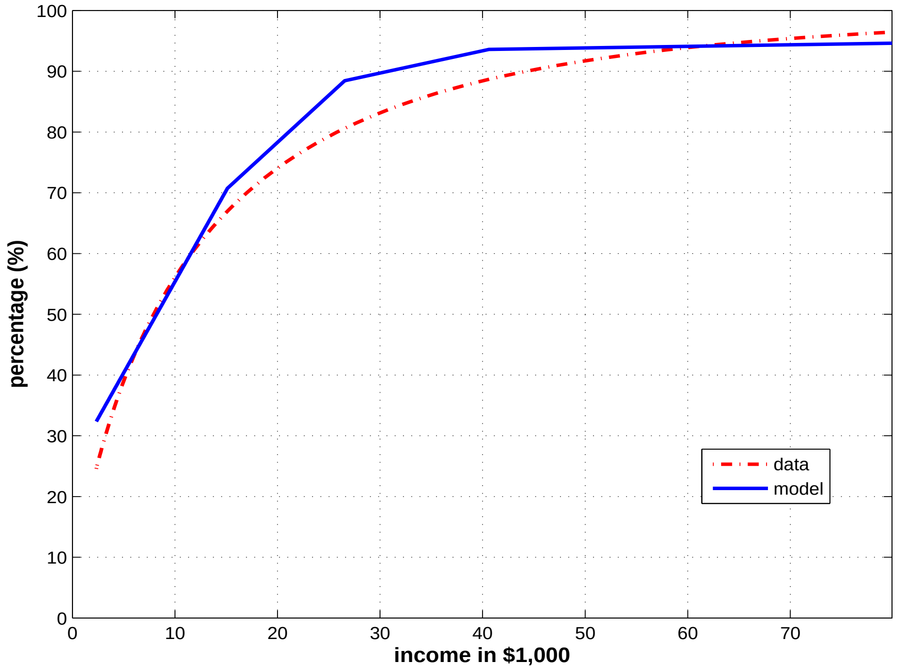

Figure 2: Take-up ratios over expenditures x_y (model and data)

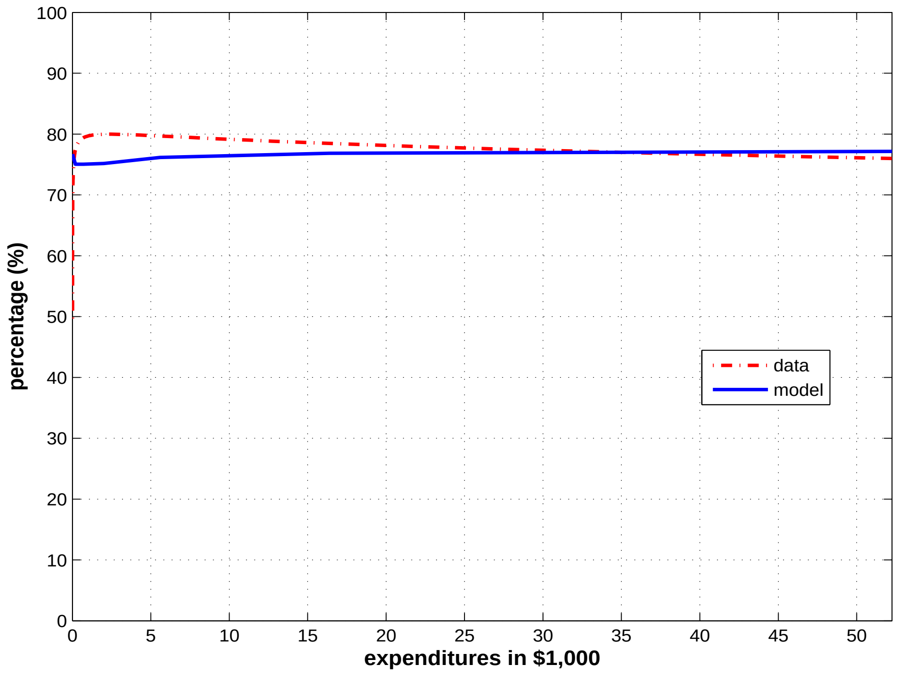

Figure 3: Take-up ratios over income z for agents with GHI offer (model and data)

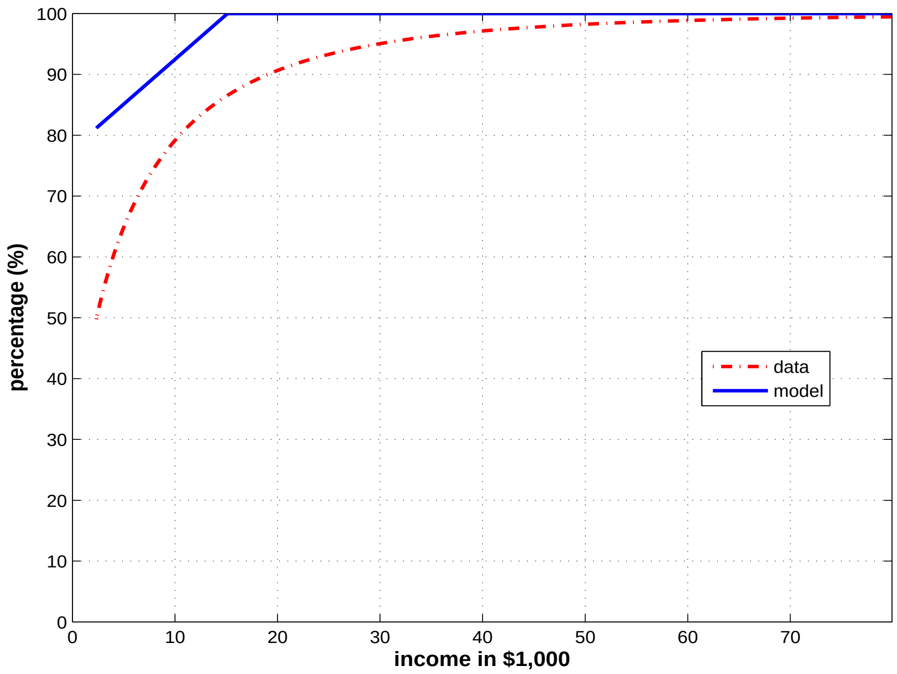

Figure 4: Take-up ratios over expenditures x_y for agents with GHI offer (model and data)

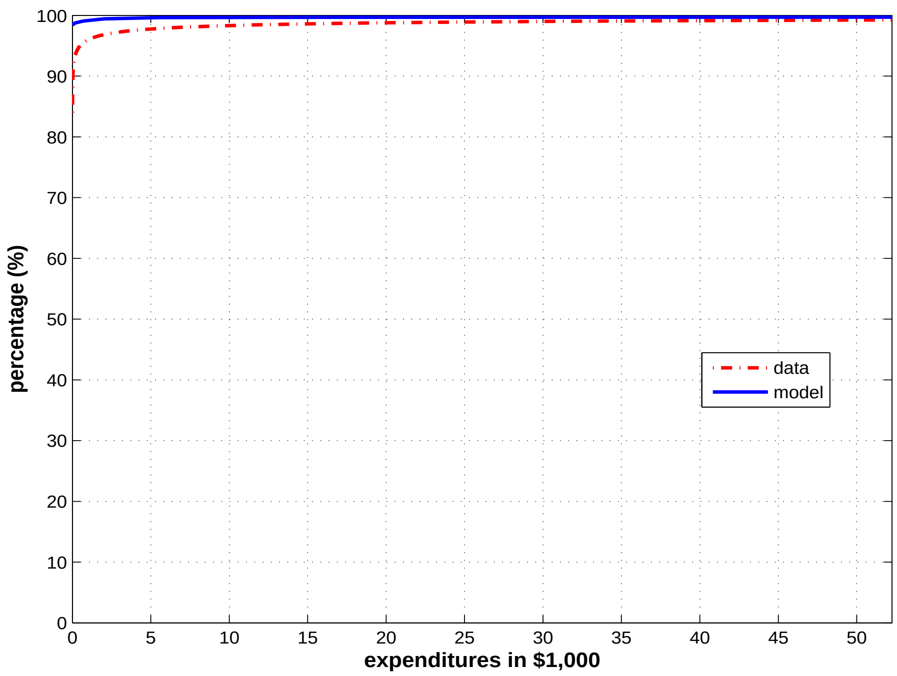

Figure 5: Take-up ratios over income z for agents without GHI offer (model and data)

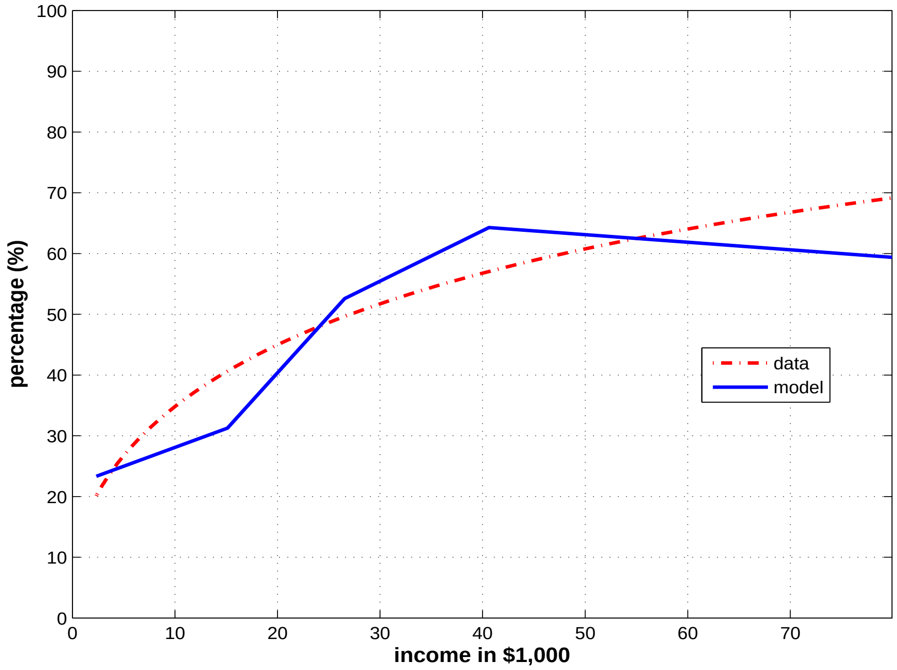

Figure 6: Take-up ratios over expenditures x_y for agents without GHI offer (model and data)