

The Macroeconomics of Health Savings Accounts (HSAs) or Medical Savings Accounts (MSAs)

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Abstract

We use an OLG model with heterogeneous agents who choose how much to spend on their health under health uncertainty in order to study the effect of transitioning from a system with private health insurance for young agents and Medicare for old agents to a system with health savings accounts (HSAs) for young agents and Medicare for the old. We focus on possible cost savings, the effects on output, distributional issues and the effects on the government budget.

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1 Introduction

According to Feldstein (2006), a desirable system to finance health care has to have three objectives: *(i)* prevent the deprivation of care because of patient's inability to pay, *(ii)* avoid wasteful spending and *(iii)* allow health care to reflect different tastes of individuals. He uses these objectives to analyze health savings accounts (HSA) that were enacted as part of the 2003 Medicare legislation and concludes that they are promising.

A HSA is similar to an IRA or 401(k) in the sense that funds are deposited out of pretax income and can accumulate tax free. HSAs are combined with a high deductible but low premium catastrophic health insurance. The funds from health savings accounts can then be used to pay the deductible and also the premiums. In some instances the funds can also be withdrawn at a penalty for non-health care consumption after a certain threshold age.

1.1 Objectives of Medical Savings Account

Medical Savings Accounts (MSA) or Health Savings Accounts (HSA) have four broad objectives:

The first is to reduce health care costs by decreasing the demand for discretionary health care services. Since patients pay the deductibles from their own health savings

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accounts or out-of-pocket, they will consume (discretionary) health services more carefully, and hence circumvent the moral hazard problem of insurance contracts. MSAs therefore control low-cost routine expenses, something that managed care does not do very well according to Scandlen (2001). In addition, mismanagement and corruption are estimated to cost between 3% – 10% of the health budgets due to the complexity and intransparency of western health systems but also the lack of involvement of the patient (Dettling (2006)). Managed care in the U.S. has increased administrative costs considerably.

The cost savings function of HSAs is ambiguous though. Keeler et al. (1996) show that changes in health care expenditure after the introduction of MSAs range from a 1% increase to a 2% decrease whereas Ozanna (1996) found a decrease between 2% to 8%. Watanabe (2005) shows in a highly stylized partial equilibrium model that a MSA is a tax-preferred account that itself encourages health care consumption by lowering the effective price of health care. The cost-containment effect, on the other hand, comes from the high deductible of the attached catastrophic insurance plan.

The overall effect of the HSA program is ambiguous and depends on the relative strength on these opposing forces. Remler and Glied (2006) conclude that due to the already large amount of cost sharing that is present in today's health insurance policies the estimation results of older studies overpredict the potential cost savings of HSAs. Heffley and Miceli (1997) show that MSAs have the potential to induce socially efficient levels of health activities and preventive care, raising the expected wealth of consumers without reducing insurers' profits. Their model is a partial equilibrium model. Zabinski et al. (1999) use a microsimulation (MEDISIM) to show that a MSA combined with catastrophic health insurance will tend to crowd out comprehensive coverage due to the tax deductions offered for the funds that go into the health accounts. This results in premium spirals in the comprehensive coverage markets since the insurance pool of these markets erodes. These results are robust to a wide range of parameter assumptions. Aggregate effects from the reform might be positive although there's increased exposure to risk. This raises equity concerns since health care systems that are based on individual savings will naturally lead to less equity.

Zabinski et al. (1999) further show that poorer families and families with children lose the most from the reform. They find self selection by low-risk families into the MSA system which leaves the high-risk families with the choice of paying higher premiums in the comprehensive plans or joining the MSA system. In both cases high-risk families lose compared to their pre-reform coverage. Eichner, McClellan and Wise (1996) in their analysis of longitudinal health insurance claims data from a large firm (300,000 employees) over a three-year period (1989 – 1991) find that about 80% of retirees are left with at least 50% of total HSA contributions, whereas 5% have less than 20% of their contributions left. In their simulation the authors do not account for any behavioral responses of employees that can be expected due to alleviating moral hazard. Also, in their simulations they use data on individuals who were employed throughout their lifetime. Their data suggest that although health expenditures are persistent for a few years, in general high expenditures levels typically do not last for many years.

The second objective addresses population ageing. Since MSAs and HSAs are fully funded systems, they are less exposed to demographic trends since each generation pays for its own services directly. This goal requires a high coverage rate which makes implementation difficult. Singapore is the only country so far that has reached an almost universal coverage rate with MSAs.

The third goal is to build up capital stock via savings (compulsory savings in the case of MSAs) to achieve high economic growth rates. Especially China is interested in this aspect of MSAs.

Finally, MSAs put patients back in the center of health care decision making. Patients influence the entire process of their medical treatments, which can also reduce the risk of ex-post moral hazard. Supporters of MSAs claim that incentives for prevention are inherent in these accounts, although critics state the opposite. The notion that individuals will have an incentive to adopt healthier lifestyles in order to limit their health care expenses is unsupported by any evidence so far according to Laditka (2001). This objective is especially important in the U.S. discussion, since U.S. society values the freedom of the consumer more than other countries.

These four goals are implemented to various degrees in the four countries that have experimented with MSAs so far. Schreyogg (2002) presents a summary for Singapore, South Africa, China and the U.S. according to these goals.

1.2 Motivation

We see the following challenge. Rising health care expenditures make a reform of the current health care system in the U.S. inevitable. Demographic trends that already put the Social Security system under pressure, will pose an even greater threat to the sustainability of the current medical system. Health savings accounts have been proposed to curb the ever rising costs by centering on the patient's role of rational consumer of health care services. Research so far has focused on micro-simulations and partial equilibrium models to model moral hazard and adverse selection aspects of the insurance component of HSAs.

We find a lack of good economic models that incorporate macroeconomic implications of reforming one of the largest public programs. Since at this point there is no reliable data on HSAs available and the discussion about HSAs is increasingly polemic, we think there is need for economic analysis that is model based, allows for policy predictions and is supported by economic theory. Given the inconclusiveness of empirical evidence substantial insight can be gained from a carefully designed simulation.

In order for such a model to be convincing it must include an adequate representation of intertemporal consumption choice and major institutional features of HSAs. The institutional features in place as put forward in the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 are:

(i) HSA are tax free trust accounts to be used primarily for aping medical expenses, (ii) contributions are made with pre-tax dollars, (iii) interest earnings are not taxable, (iv) anyone under age 65 who has a qualified high deductible health insurance plan (a deductible of at least \$1,000 for an individual and \$2,000 for a family) is eligible to establish an HSA, (v) there's a penalty of 10% if funds are withdrawn to pay for non-medical expenditures before the age 65, (vi) after 65 funds can be withdrawn and spent for nonhealth purposes after paying normal income taxes.

We focus on the macroeconomic aspects of HSAs. With the exception of Watanabe (2006) we do not know of any model that concentrates on the macroeconomics of the introduction of health savings accounts. Since a possible reform of Medicare and Medicaid in favor of HSAs would affect the single largest public program we think it is useful to

analyze the impact of HSAs in various forms on existing programs and the effects on the government budget.

Imrohoroglu, Imrohoroglu and Joines (1998) model the savings effects of individual retirement accounts. Their framework is similar to ours in the sense that agents have two alternative savings mechanisms; tax favored savings with a penalty for early withdrawal and standard savings with a market interest return. Jeske and Kitao (2005) provide a mechanism to model the institutional details of private insurance and Medicare insurance in their work on health insurance choice. Palumbo (1999) estimates a health uncertainty model using U.S. data. In both these models health expenditures are exogenous. Suen (2006) uses a variant of a Grossman (1972) model with endogenous expenditure on medical treatments that increase the health capital of an agent. He investigates how growth in health expenditures is driven by technological factors and health accumulation. Khwaja (2002) and Khwaja (2006) provide estimates for a structural health uncertainty model with endogenous health expenditures. These two papers concentrate on the moral hazard of the Medicare program and finds that the introduction of Medicare increases health expenditures but does only minimally increase health damaging behavior like smoking, drinking alcohol and reduced exercising.

We use an OLG model with health uncertainty that is similar to Imrohoroglu, Imrohoroglu and Joines (1998), Jeske and Kitao (2005), and Suen (2006) and calibrate it to match the wealth distribution of the U.S.

Medical expenses are endogenous in our model and used to build up health capital. We then introduce HSAs and study the shift from employer provided private insurance to HSAs. Since the potential cost savings of HSA are ambiguous we conduct sensitivity analysis on various cost savings scenarios. In addition, we study the effect of HSAs on output and the wealth distribution. Finally, we study the effect of subjective health expectations using results from Jung (2006) (maybe?).

The paper is structured as follows. The next section describes the model and contains the equilibrium definitions. In section 5 we conduct policy experiments. We conclude in section 6. The Appendix contains all detailed derivations of the steady state solutions.

2 The Model

We use a overlapping generations framework. Agents work for J_1 periods and then retire for $J - J_1$ periods. In each period there is an exogenous survival probability of cohort j which we denote π_j . Agents die for sure after J periods. Deceased agents leave an accidental bequest that is taxed and redistributed equally to all agents alive.¹ Population grows exogenously at net rate n . We assume stable demographic patterns so that similar to Huggett (1996) age j agents make up a constant fraction μ_j of the entire population at any point in time.

The fraction μ_j is recursively defined as

$$\mu_j = \frac{\pi_j}{(1+n)} \mu_{j-1}.$$

¹An alternative redistribution method is to redistribute the after tax bequests to newly born cohort or to working cohorts. It turns out that the results are not affected by the way the government redistributes bequests.

The fraction dying each period (conditional on survival up to the previous period) can be defined similarly as

$$\nu_j = \frac{1 - \pi_j}{(1 + n)} \mu_{j-1}.$$

2.0.1 Preferences

The consumer values consumption and health, so that her preferences are²³

$$u(c_j, h_j) = \frac{\left(c_j^{\eta_1} h_j^{\eta_2}\right)^{1-\sigma}}{1-\sigma},$$

where $\eta_1 + \eta_2 = 1$.

2.0.2 Production of Health

We use the idea of health capital as introduced in Grossman (1972). In this economy there are two commodities: a consumption good c and medical care m . The consumption good is produced via a neoclassical production function that is described later. Each unit of consumption good can be transformed into $\frac{1}{p_m}$ units of medical care. All medical care

²An alternative way of formulating this problem and reducing the state space would be to let total health expenditure m_j enter the utility function directly. Again total health expenditures of the household at age j are discretionary only. Depending on the realization of the health state ε_j the relative weight in the utility function of discretionary health expenditures m_j changes, so that

$$u(c_j, m_j, z_j) = \frac{\left(c_j^{\gamma_1} m_j^{\gamma_2(\varepsilon_j)}\right)^{1-\sigma}}{1-\sigma},$$

where $\gamma_2(\varepsilon_j)$ is a decreasing function in the health status variable ε_j . As the health state worsens, the consumer puts more weight on health expenditures in her utility function. Another way of thinking about this is health maintenance. If health deteriorates, the health maintenance costs are higher and therefore the consumer is willing to spend more on health care which establishes new relative rates of marginal utilities between consumption and health expenditures.

³Alternatively we could use a CES form

$$u(c_j, h_j) = \frac{\left[ac_j^\eta + bh_j^\eta\right]^{\frac{1}{\eta}}}{1-\sigma},$$

where if $\eta \rightarrow 0$ we get back to the Cobb-Douglas formulation, since

$$\lim_{\eta \rightarrow 0} \ln(ac^\eta + bh^\eta)^{\frac{1}{\eta}} = \lim_{\eta \rightarrow 0} \frac{\ln(ac^\eta + bh^\eta)}{\eta} = \frac{a}{b},$$

(if $a + b = 1$), so that using de Hospital and knowing that $\frac{\partial(x^a)}{\partial a} = x^a \ln x$ we get

$$\begin{aligned} \lim_{\eta \rightarrow 0} \frac{ac^\eta \ln c + bh^\eta \ln h}{ac^\eta + bh^\eta} &= \frac{a \ln c + b \ln h}{a + b}, \\ &= \left(\frac{a}{a+b}\right) \ln c + \left(\frac{b}{a+b}\right) \ln h, \\ &= c^{\left(\frac{a}{a+b}\right)} h^{1-\left(\frac{a}{a+b}\right)}, \\ &= c^{\eta_1} h^{1-\eta_2}, \end{aligned}$$

where $\eta_1 = \left(\frac{a}{a+b}\right)$.

is used to produce new units of health according to the following production function

$$i(m_j) = \phi m_j^\xi.$$

The accumulation process of health is given by

$$h_j = i(m_j) + (1 - \delta(h_j)) h_{j-1} + \varepsilon_j, \quad (1)$$

where h_j denotes the current health status, $\delta(h_j)$ is the health deterioration rate which depends on the current health status. This partly captures the 'immediacy' of health expenditures. The longer the agent waits to treat her health shock, the worse her health gets. Finally, ε_j is an age dependent health shock, where $\varepsilon_j \leq 0$.

The agent has to decide how much to spend out-of-pocket on medical care. We only model discretionary health expenditures m_j in this paper. Income will have a strong effect on total medical expenses since health expenditures are endogenous in our model. Our setup assumes that given the same magnitude of health shock ε_j a richer individual will outspend a poor individual by a great margin. This may be realistic in some circumstances. However, a large fraction of health expenditures are probably non-discretionary (e.g. health expenditures due to a catastrophic health event that requires surgery etc.). In such cases a poor individual could still incur large health care costs. We do not cover this case in the current model.⁴

2.0.3 Exogenous Process

The exogenous health shock ε_j can take on five different states, $\varepsilon_j = \{1, 2, 3, 4, 5\}$; 1. Poor, 2. Fair, 3. Good, 4. Very Good and 5. Excellent.⁵ The variable follows a Markov process with age dependent transition matrix P_j , where transition probabilities from one state to the next depend on past health status ε_j , age j and other household characteristics X_j so that an element of transition matrix P_j is denoted

$$P_j(\varepsilon_j, \varepsilon_{j-1}) = \Pr(\varepsilon_j | \varepsilon_{j-1}, j, X_j).$$

2.0.4 Human Capital

Effective human capital over the life-cycle evolves according to

$$e_j = g(h_j) e^{\beta_0 + \beta_1 j + \beta_2 j^2} \text{ for } j = \{1, \dots, J_1\},$$

where $\beta_0, \beta_2 < 0$ and $\beta_1 > 0$ and g is some increasing function in health h_j .

⁴One method would be to distinguish between discretionary and non-discretionary health expenditures. The consumer can freely decide on how much to spend on discretionary health expenditures m_j (e.g. preventive health check-ups, upgrades in hospitals, etc.) but incurs non-discretionary health expenditures $\bar{m}(\varepsilon_j)$ which are a function of her health shock ε_j (e.g. hospital visits due to serious health problems, emergency health care, etc.). The total out-of-pocket health expenditure would then be denoted

$$o(m_j) = \min [p_m \bar{m}(z_j) + p_m m_j, \rho + \alpha (p_m \bar{m}(z_j) + p_m m_j - \rho)].$$

⁵We use this classification because the data that we use to estimate the transition probabilities distinguishes these five health states.

2.0.5 Insurance, Health Savings Accounts and Out-of-Pocket Medical Expenses

When agents are young and working they can buy private health insurance. Insurance companies offer two policies, a low deductible policy with deductible ρ and copayment rate γ at a premium p_j and a high deductible policy with deductible ρ' and copayment γ' at a premium p'_j . These premia are tax deductible.⁶

Health savings accounts (HSAs) are tax sheltered accounts that can only be set up in combination with a high deductible health insurance. Funds in the HSA accumulate tax free at the market interest rate. Health expenses can be paid for with funds from the HSA without ever paying income tax. If funds are withdrawn to pay for other consumption expenses the forgone income tax has to be paid plus a tax penalty of τ^m . Also, at age 65 funds can be withdrawn and spent for nonhealth purposes after paying normal income taxes.

In order to be insured against a health shock, households have to buy insurance the period before their health shock is realized. Agents in their first period of life are thus not covered by any insurance. The household's out of pocket health expenditure when young and working is therefore denoted

$$o^W(m_j) = \begin{cases} \min [p_m m_j, \rho + \gamma (p_m m_j - \rho)], & \text{with the low deductible insurance} \\ \min [p_m m_j, \rho' + \gamma' (p_m m_j - \rho')], & \text{with the high deductible insurance} \end{cases}, \text{ if } j \leq J_1 + 1$$

where p_m is the relative price of health expenditures. The copayment rate γ is the fraction the household pays after the insurance company pays $(1 - \gamma)$ of the post deductible amount $m_j - \rho$. Since households have to buy insurance before health shocks are revealed, the generation that is in its first year of retirement at $J_1 + 1$ (the 'recently retired') is still insured under the private policy plan.

In addition, household can save a_j^m in HSAs tax free at the market interest rate if they bought a high deductible insurance. Agents can only contribute to their HSAs when they are young. Agents who have to pay $o(m_j)$ out-of-pocket medical expenses can pay this directly with savings from their HSAs. If they oversave in HSAs they can roll over the account balance into the next period. Savings accumulate tax free. If agents decide to use the savings account funds to pay for non-health related expenses, then they have to pay a tax penalty at rate τ^m . This acts as a punishment for spending money on non-health related expenses as it is introduced in the regulations of health savings accounts. This penalty only applies to agents younger than 65 years. Agents older than 65 can use the money in the health savings accounts for non-health related expenses without having to pay the tax penalty τ^m . They have to pay income taxes though on income spent in this way.

If they undersave and the funds in the HSAs do not cover medical expenses, then the household uses standard savings income to pay for the residual medical expenses and consumption at old age.

In addition, there is a savings upper limit for health savings accounts. According to

⁶Cutler and Wise (2003) report that about two thirds of the population younger than 65 is covered by some form of private insurance. The majority of these contracts is offered via employment contracts and premiums paid are thus tax deductible. Only 10% of these contracts are bought directly from insurance companies by the households. Premiums for these contracts are not tax deductible. For simplicity we assume that all private insurance contracts offered to the young population are offered via their employer and are thus tax deductible. Jeske and Kitao (2005) present a model where this is modelled specifically. We abstract from this detail in this paper.

the Medicare Modernization Act of 2003 the maximum that can be contributed is the lesser of the amount of the high deductible ρ' or the upper limit $\bar{\rho}$, so that the maximum contribution \bar{a}^m is

$$\bar{a}^m = \min [\rho', \bar{\rho}].$$

After retirement all agents are covered by Medicare. Each agent pays a fixed premium p^{Med} every period for Medicare. Medicare then pays a fixed fraction $(1 - \gamma^{Med})$ of the health expenditures that exceed the amount of the deductible δ^{Med} . The total out of pocket expenditures of a retiree are

$$o^R(m_j) = \min \left[p_m m_j, \rho^{Med} + \gamma^{Med} (p_m m_j - \rho^{Med}) \right], \text{ if } j > J_1 + 1.$$

Agent's out of pocket expenses when retired can still be paid with funds from the HSAs. The Medicare premium also qualifies for penalty free deductions from the HSAs. In addition Medicare is financed by a payroll tax τ^{Med} . We assume that old agents $j > J_1 + 1$ do not purchase private health insurance and that their health costs are covered by Medicare and their own resources, plus social insurance (e.g. Medicaid) if applicable.⁷

2.0.6 The Household Problem

The state vector of a household not counting age j is $x = (a, a^m, h, in, \varepsilon) \in S \times Z$ where $S \subset R_+$, $Z = \{\varepsilon_1, \varepsilon_2, \varepsilon_3\}$ for 3 different health shocks. For each $(x) \in D(x)$ let $\Lambda_j(x)$ denote the measure of age- j agents with $(x) \in D$. The fraction $\mu_j \Lambda_j(x)$ then denotes the measure of age- j agents with $x \in D$ with respect to the entire population of agents in the economy.

With HSAs we have to distinguish between agents that contribute to HSAs and those that take funds out of HSA. Among those who do not contribute, we again have to distinguish between those that use these funds for health related expenditures and those that use them for consumption. The latter have to pay a penalty tax when they are younger than 65 years old.

Young Agents (Younger than 65)

The household problem for young agents $j = \{1, \dots, J_1\}$ can be formulated recursively as

$$V(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = \max_{\{c_j, m_j, a_j, a_j^m, in_j\}} \{u(c_j, h_j) + \beta \pi_j E_\varepsilon [V(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}) | \varepsilon_j]\} \\ s.t.$$

(i) **Net Contributor** (automatically not using HSA funds for non-health related ex-

⁷According to Jeske and Kitao (2005) many old agents purchase various forms of supplementary insurance. The fraction of health expenditures covered by such insurances is small. According to the Medical Expenditure Panel Survey (MEPS) 2001, only 15% of total health expenditures of individuals older than 65 is covered by supplementary insurances. Cutler and Wise (2003) report that 97% of people above age 65 are enrolled in Medicare which covers 56% of their total health expenditures. Medicare Plan B requires the payment of a monthly premium and a yearly deductible. See *Medicare and You* (2007) for a brief summary of Medicare.

penditures):

$$\begin{aligned} c_j + a_j + a_j^m + o^W(m_j) + in_j p_j' &= \tilde{w}_j + R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m - Tax_j + T_j^{SI}, \\ 0 &\leq NI_j \leq \bar{a}^m, \\ 0 &\leq a_j, a_j^m, \end{aligned}$$

where

$$\begin{aligned} NW_j &= R^m a_{j-1}^m - o^W(m_j) - in_j p_j', \\ NI_j &= a_j^m - \max[0, NW_j], \\ o^W(m_j) &= \begin{cases} \min[p_m m_j, \rho' + \gamma'(p_m m_j - \rho')] & \text{if } in_{j-1} = 1, \\ p_m m & \text{if } in_{j-1} = 0, \end{cases} \\ \tilde{w}_j &= (1 - 0.5\tau^{Soc} - 0.5\tau^{Med}) w e_j, \\ h_j &= i(m_j) - (1 - \delta(m_j)) h_{j-1} - \varepsilon_j, \\ e_j &= g(e_{j-1}, h_{j-1}), \\ Tax_j &= \tilde{\tau}(\tilde{y}_j^W) + 0.5(\tau^{Soc} + \tau^{Med})(\tilde{w}(\varepsilon_j) - p_j'), \\ \tilde{y}_j^W &= \tilde{w}_j + r(a_{j-1} + T_j^{Beq}) - NI_j, \\ T_j^{SI} &= \max[0, \underline{c} + Tax_j - \tilde{w}_j - R(a_{j-1} + T_j^{Beq}) - (R^m a_{j-1}^m - o^W(m_j))], \\ \tilde{T}_p &= \tilde{w}_j + R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m - o^W(m_j) - Tax_j, \\ in_j &= \begin{cases} 1 & \text{if } I_{\{p' < \tilde{T}_p\}} = 1 \text{ and agent decides to buy insurance} \\ 0 & \text{otherwise,} \end{cases} \end{aligned}$$

(ii) **Net Non-Contributor** (automatically using *HSA* funds for non-health expenditures):

Remark 1 *Note to self: Question, do first order and envelope conditions have to include the T^{SI} term? Answer, yes. But the first order conditions won't be affected, since we automatically know that $a = a^m = p_j = 0$ and we don't have to search for this solution. Also the envelope condition are not used for this case (I think) as we can simply fill in the $V_k = (\underline{c}) \times \dots$. Think about this some more!!! In any case the first order conditions that we derive in the appendix are for the case where a and a^m are greater than zero and $T^{SI} = 0$, so that the FOCs and Envelope conditions are just fine. Since they would use the 0 part of $T_j^{SI} = \max(0, \text{whatever})$.*

$$\begin{aligned} NI_j &< 0, \\ Tax_j &= \tilde{\tau}(\tilde{y}_j^W) + 0.5(\tau^{Soc} + \tau^{Med})(\tilde{w}(\varepsilon_j) - p_j) - \tau^m NI_j, \end{aligned}$$

and all other definitions hold for both cases (i) and (ii). Variable c_j is consumption, a_j is savings into next period, a_j^m is savings in HSAs into next period, a^m is the maximum contribution into HSAs per period, $o^W(m_j)$ is out-of-pocket health expenditure, m_j is total health expenditure, p_j is the health insurance premium (that is only paid when the agent has at least \tilde{T}_p income after health shock and taxes, where $p < \tilde{T}_p$, otherwise

the agent cannot afford insurance in the private market)⁸, \tilde{w}_j is wage income net of the employer contribution to Social Security and Medicare, R is the gross interest rate paid on last periods savings a_{j-1} and accidental bequests T_j^{Beq} , Tax_j is total taxes paid and T_j^{SI} is Social Insurance (e.g. Medicaid and food stamp programs). The fact that we use \tilde{w}_j in the tax base for income tax $\tilde{\tau}(\tilde{y}_j^W)$ leads to a double taxation of a portion of wage income due to the flat payroll tax $0.5(\tau^{Soc} + \tau^{Med})(\tilde{w}_j - p_j)$ that is added. This mimics the institutional feature of income and payroll taxes (Social Security Tax Reform (Art#3)).

NW_j is net wealth in the health savings account after subtracting out-of-pocket health expenses and insurance premiums, NI_j is net investment in the HSA, we_j is the effective wage income.

Function measures $\tilde{\tau}(\tilde{y}_j^W)$ progressive income tax, $0.5(\tau^{Soc} + \tau^{Med})(\tilde{w}_j - p_j)$ is the payroll tax that the household pays for Social Security and Medicare, and $\tau^m NI_j$ is the penalty tax for non-qualified withdrawals from the HSA, \tilde{y}_j^W is the tax base for the income tax composed of wage income and interest income on savings and accidental bequests and the net contributions to HSAs are tax deductible. Since in this case the agent does not make contributions so that $NI_j < 0$, the agent actually has to pay income taxes on these non-qualified deductions.

For (i) net contributors it has to hold that $NI_j \geq 0$, that is next periods funds in the HSA a_j^m have to be larger than the funds at the beginning of the period minus the allowed health related expenditures (e.g. out-of-pocket health expenses o^W and insurance premia p_j that can be financed with HSA funds).

(ii) Net non-contributors draw funds from HSAs beyond what is allowed so that $NI_j < 0$ and therefore pay the penalty tax τ^m on the part spent on non-health related expenditures $\tau^m NI_j$.

The social insurance kicks in when all funds, returns on a_{j-1} and a_{j-1}^m are depleted, therefore these terms do not show up in the definition of T_j^{SI} . The Social Insurance program T_j^{SI} guarantees a minimum consumption level \underline{c} . If Social Insurance is paid out then automatically $a_j = a_j^m = 0$ and $in_j = 3$ (the no insurance state) so that Social Insurance cannot be used to finance savings, savings into HSAs and private health insurance.

Recently Retired Agents

Again recently retired agents $j = J_1 + 1$, are still insured under the private insurance regime with the high deductible insurance. Retirees in general, that is all agents with age $j > J_1$, are not allowed to make tax exempt contributions to HSAs anymore (that is agents older than 65). So they are all classified as net non-contributors. In addition, the tax penalty τ^m for non-health expenditures of HSA funds does not apply anymore. The individual has to pay income tax though, if she uses HSA funds for non-health related expenditures.

The household problem for recently retired agents $j = J_1 + 1$ is can be formulated

⁸We assume that private health insurance is offered by the employers; the premia are therefore tax deductible.

recursively as

$$V(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = \max_{\{c_j, m_j, a_j, a_j^m\}} \{u(c_j, h_j) + \beta \pi_j E_\varepsilon [V(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}) | \varepsilon_j]\} \\ s.t.$$

(i) **Non-Contributor, no Penalty:** using HSA funds only for health related expenditures:

$$c_j + a_j + a_j^m + o^W(m_j) + p_j^{Med} = R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m - Tax_j + T_j^{Soc} + T_j^{SI}, \\ NI_j = 0, \\ 0 \leq a_j, a_j^m,$$

where

$$o^R(m_j) = \begin{cases} \min[p_m m_j, \rho + \gamma(p_m m_j - \rho)] & \text{if } in_{j-1} = 1, \\ p_m m & \text{if } in_{j-1} = 0, \end{cases} \\ NW_j = R^m a_{j-1}^m - o^W(m_j) - p_j^{Med}, \\ NI_j = a_j^m - \max[0, NW_j], \\ h_j = i(m_j) - (1 - \delta(m_j)) h_{j-1} - \varepsilon_j, \\ Tax_j = \tilde{\tau}(\tilde{y}_j^R), \\ \tilde{y}_j^R = r(a_{j-1} + T_j^{Beq}) - NI_j, \\ T_j^{SI} = \max[0, \underline{c} + o^W(m_j) + Tax_j + p_j^{Med} - R(a_{j-1} + T_j^{Beq}) - R^m a_{j-1}^m - T_j^{Soc}], \\ in_j = 1.$$

(ii) **Non-Contributor** using HSA funds for non-health related expenses has to pay income tax on these funds (no penalty τ^m applies for agents older than 65):

$$NI_j < 0,$$

and all other conditions are the same as in the previous case.

Old Agents

Retirees $j > J_1 + 1$, have the same budget constraints as 'recently retired' agents. The only difference is that instead of o^W their out-of-pocket health expenditure is o^R , that is they have now Medicare as their health insurer.

2.0.7 Insurance companies

Insurance companies have a zero profit condition within each period (cross subsidizing across generations is allowed):

$$\sum_{j=2}^{J_1+1} \mu_j \int [in_j (1 - \gamma) (p_m m_j(x) - \rho)] d\Lambda_j(x) = \sum_{j=1}^{J_1} \mu_j \int (1 + r) in_j p_j(x) d\Lambda_j(x), \quad (3)$$

where $I_{m_j > \rho}$ is an indicator function equal to one whenever health expenditures are larger than the deductible $m_j > \rho$. Since agents have to buy their insurance one period prior

to the realization of the health shock, first period agents are not insured and insurance premiums accumulate interest from the last period.

2.0.8 Firms

Firms produce according to a general Cobb-Douglas production function and solve

$$\max_{\{K,L\}} \{AK^{\alpha_1}L^{\alpha_2} - qK - wL\}. \quad (4)$$

2.0.9 Government

The government taxes workers income (wages, interest income, interest on bequests) at a progressive tax rate $\tilde{\tau}(\tilde{y}_j)$ which is a function of taxable income \tilde{y} .

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

$$\sum_{j=1}^J \mu_j \int T_j^{Beq}(x) d\Lambda_j(x) = \sum_{j=1}^{J_1} \nu_j \int a_j(x) d\Lambda_j(x) + \sum_{j=J_1+1}^J \nu_j \int a_j(x) d\Lambda_j(x), \quad (5)$$

where ν_j denotes the deceased mass of agents aged j in time t . An equivalent notation applies for the surviving population of workers and retirees denoted μ_j .

The Social Security program is self-financing

$$\sum_{j=J_1+1}^J \mu_j \int T_j^{Soc}(x) d\Lambda_j(x) = \sum_{j=1}^{J_1} \mu_j \int 0.5\tau^{Soc}we_j(x) + 0.5\tau^{Soc}(\tilde{w}_j(x) - p_j(x)) d\Lambda_j(x). \quad (6)$$

The Medicare program is self-financing (and paid on a pay-as-you go basis so that the insurance premiums do not accumulate interest from last period)

$$\begin{aligned} & \sum_{j=J_1+1}^J \mu_j \int I_{m_j(x) > \rho^{Med}} (1 - \gamma^{Med}) (m_j(x) - \rho^{Med}) d\Lambda_j(x) \\ = & \sum_{j=1}^{J_1} \mu_j \int \left[0.5\tau^{Med}we_j(x) + 0.5\tau^{Med}\tilde{w}_j(x) - p_j(x) \right] d\Lambda_j(x) + \sum_{j=J_1+1}^J \mu_j \int p_j^{Med} d\Lambda_j(x). \end{aligned} \quad (7)$$

The government budget is balanced so that

$$G + \sum_{j=1}^J \mu_j \int T_j^{SI}(x) d\Lambda_j(x) = \sum_{j=1}^J \mu_j \int Tax_j(x) d\Lambda_j(x). \quad (8)$$

2.0.10 Equilibrium

Definition 2 Given the exogenous number of health shock realizations Z , transition probabilities $P_{Z \times Z}$, realizations of health shocks $\varepsilon_{1 \times M}$, the survival probabilities $\{\pi_j\}_{j=1}^J$ and the exogenous government policies $\{\tilde{\tau}(\tilde{y}_j(x)), \tau^K\}_{j=1}^J$, a competitive equilibrium **with health savings accounts** is a collection of sequences of distributions $\{\mu_j, \Lambda_j(x)\}_{j=1}^J$ of individual household-worker decisions $\{c_j(x), a_j(x), a_j^m(x), m_j(x), in_j(x)\}_{j=1}^J$, aggregate stocks of physical capital and labor $\{K, L\}$, factor prices $\{w, q, R, r\}$ such that

(a) $\{c_j(x), a_j(x), a_j^m(x), m_j(x), in_j(x)\}_{j=1}^J$ solves the consumer problem (2),

(b) the firm first order conditions hold

$$\begin{aligned} w &= \alpha_2 \frac{Y}{L}, \\ q &= \alpha_1 \frac{Y}{K} \\ R &= q + 1 - \delta, \\ r &= R - 1, \end{aligned}$$

(c) markets clear

$$\begin{aligned} K' &= S = \sum_{j=1}^J \mu_j \int (a_j(x) + a_j^m(x)) d\Lambda_j(x), \\ L &= \sum_{j=1}^{J_1} \mu_j \int e(j, \varepsilon_j(x)) d\Lambda_j(x), \end{aligned}$$

(d) the aggregate resource constraint holds

$$S + \sum_{j=1}^{J_1} \mu_j \int (c_j(x) + m_j(x)) d\Lambda_j(x) = Y + (1 - \delta) K,$$

(e) the government programs clear so that (5), (6), (7), (8) and hold,

(f) the zero profit condition of insurance companies (3) holds

(g) the distribution is stationary

$$\Lambda_j(x') = \int I_{\substack{a'=a(x) \\ a^m'=a^m(x) \\ m'=m(x)}} P(\varepsilon', \varepsilon) d\Lambda_{j-1}(x),$$

where I is an indicator function.

3 Solving the Model

We solve the model backwards discretizing a , a^m , and h . Choosing the optimal health level from a grid allows us to substitute out m_j of the optimization problem via the law of motion of health, expression (1). Instead of choosing how much to spend on health in period j , the consumer picks the new health level h_j directly. Health expenditure m_j is then the residual

$$m_j = \left[\frac{h_j - (1 - \delta(h_j)) h_{j-1} - \varepsilon_j}{\phi} \right]^{\frac{1}{\xi}}.$$

This method turns out to be simpler than picking m_j directly, since that would require an additional discretization over m_j . An alternative specification would be to let depreciation be a function of current health expenditures, $\delta(m_j)$. However, if the function $\delta(m_j)$ is nonlinear we cannot easily solve for m_j anymore which would increase the computational burden.

Solving the model we use a hybrid algorithm that combines Euler equation iteration with value function iteration. First order conditions of the optimization problem are used to find next periods optimal capital stock a' . The appendix contains the derivations of

the first order- and Envelope conditions for the penalty- and non-penalty paying workers and retirees. We then use a grid search over a^m and h that directly maximizes the value function.

4 Calibration

Table 1 contains parameters that we pick to solve the model.

4.1 Savings Limit in HSAs

In addition, there is a savings upper limit for health savings accounts. According to the Medicare Modernization Act of 2003 the maximum that can be contributed is the lesser of the amount of the high deductible ρ' or $\bar{\rho} = \$2,600$ for an individual and \$5,150 for a family. Since we optimize for an individual the maximum contribution \bar{a}^m is

$$\bar{a}^m = \min [\rho', \$2,600].$$

The tax penalty for withdrawing funds from HSAs before the age of 65 and using them on non-health related consumption is $\tau^m = 10\%$.

4.2 Taxes

Social security taxes are $\tau^{Soc} = 2 \times 6.2\%$ on earnings up to \$97,500 this contribution is made by both employee and employer. Medicare taxes are $\tau^{Med} = 2 \times 1.45\%$ on all earnings again split in employer and employee contributions (see *Social Security Update 2007* (2007)).

The simple functional form for the progressive income tax is

$$\tilde{\tau}(\tilde{y}_j) = \tilde{y}_j^2.$$

Alternatively, we also use a tax function estimated by Miguel and Strauss (1994). This functional form approximates the progressive structure of the U.S. income tax code as

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

where y is total income earned and $\tilde{\tau}(\tilde{y})$ represents total taxes paid. 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. We can then express the average and marginal tax rates as

$$\begin{aligned} \frac{\tilde{\tau}(\tilde{y})}{\tilde{y}} &= a_0 \left(1 - (1 + a_2 \tilde{y}^{a_1})^{-\frac{1}{a_1}} \right), \\ \tilde{\tau}'(\tilde{y}) &= a_0 \left(1 - (1 + a_2 \tilde{y}^{a_1})^{-\frac{1}{a_1} - 1} \right). \end{aligned}$$

respectively. This functional form is often used in calibrated life-cycle modelling (e.g. Smyth (2005), Jeske and Kitao (2005) and Conesa and Krueger (2005)). Miguel and Strauss (1994) estimate $\{a_0, a_1\} = \{0.258, 0.768\}$. We then use scaling parameter a_2 such that the share of government expenditures equals 65%. According to Jeske and Kitao

(2005) this matches the fraction of total revenues financed by income tax according to the OECD Revenue Statistics.

5 Policy Experiments

5.1 Model 1

In this model variant agents can only choose between one type of insurance.

We calculate three separate regimes: (1) Agents can buy a low deductible insurance, (2) agents can buy a high deductible insurance, and (3) agents can buy a high deductible insurance and start a HSA.

We compare the steady state results in table 4.

In the next step we compare two scenarios, one without HSAs and one with HSAs. We allow for variation in the deductible ρ and in the coinsurance rate γ in both scenarios. We report the results for the model without HSAs in tables 4 and 5. The results for the model with HSAs are reported in tables 8 and 9. Finally, we plot the results of the same exercise for aggregate variable Y , H , M , % of Workers insured, p and $Gini$ in figures 3, 4, 5, 6, 7, and 8.

5.2 Model 2

In this model agents can choose between a low deductible insurance and a high deductibles insurance. If they choose a they deductible insurance the agent can save into a HSA.

We calculate two separate regimes: (1) Agents can buy a low or high deductible insurance and (2) agents can buy a low deductible insurance or a high deductible insurance with or without a HSA.

We compare the steady state results in table 6.

In the next step we compare two scenarios, one without HSAs and one with HSAs. We allow for variation in the deductible ρ' and in the coinsurance rate γ' in both scenarios. We report the results for the model without HSAs in tables 6 and 7. The results for the model with HSAs are reported in tables 10 and 11. Finally, we plot the results of the same exercise for aggregate variable Y , H , M , % of Workers insured, p and $Gini$ in figures 9, 10, 11, 12, 13, and 14.

6 Conclusion

References

- Conesa, Juan C. and Dirk Krueger. 2005. "On the Optimal Progressivity of the Income Tax Code." NBER Working Papers 11044.
- Cutler, David and David Wise. 2003. "The U.S. Medical Care System for the Elderly." Harvard and NBER.
- Detting, Daniel. 2006. "Jedem seine Arztrechnung." *Die Zeit*.
- Eichner, Matthew, J., Mark B. McClellan and David A. Wise. 1996. "Insurance or Self-Insurance?: Variation, Persistence, and Individual HealthAccounts." NBER Working Paper 5640.

- Feldstein, Martin. 2006. "Balancing the Goals of Health Care Provision." NBER Working Paper 12279.
- Grossman, Michael. 1972. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy* 80:223–255.
- Heffley, Dennis and Thomas J. Miceli. 1997. "The Economics of INcentive-Based Health Care Plans." Working Paper 1997-05, University of Connecticut.
- Huggett, Mark. 1996. "Wealth Distribution in Life-Cycle Economies." *Journal of Monetary Economics* 38:469–494.
- Imrohorglu, Ayse, Selahattin Imrohorglu and Douglas H. Joines. 1998. "The Effect of Tax-Favored Retirement Accounts on Capital Accumulation." *American Economic Review* 88(4):749–768.
- Jeske, Karsten and Sagiri Kitao. 2005. "Health Insurance and Tax Policy." *Federal Reserve Bank of Atlanta* .
- Jung, Juergen. 2006. "Subjective Health Expectations." Indiana University.
- Keeler, Emmet B., Jesse D. Malkin, Dana P. Goldman and Joan L. Buchanan. 1996. "Can Medical Savings Accounts for the Nonelderly Reduce Health Care Costs?" *Journal of the American Medical Association* 275(21):1666–1671.
- Khwaja, Ahmed W. 2002. Health Insurance, Habits and Health Outcomes: Moral Hazard in a Dynamic Stochastic Model of Investment in Health. In *Proceedings of the 2002 North American Summer Meetings of the Econometric Society: Labor Economics and Applied Econometrics*, ed. David K. Levine and William Zame.
- Khwaja, Ahmed W. 2006. "A Life Cycle Analysis of the Effects of Medicare on Individual Health Incentives and Health Outcomes." *Journal of Econometrics* forthcoming.
- Laditka, James N. 2001. "Providing Behavioral Incentives for Improved Health in Aging and Medicare Cost Control: A Policy Proposal for Universal Medical Savings Accounts." *Journal of Health and Social Policy* 13(4):75–90.
- Medicare and You*. 2007. U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services.
- Miguel, Gouveia and Robert P. Strauss. 1994. "Effective Federal Individual Income Tax Functions: An Exploratory Empirical Analysis." *National Tax Journal* 47:317–339.
- Ozanna, Larry. 1996. "How will medical savings accounts affect medical spending?" *Inquiry* 33:225–236.
- Palumbo, Michael G. 1999. "Uncertain Medical Expenses and Precautionary Saving Near the End of the Life Cycle." *Review of Economic Studies* 66(2):395–421.
- Remler, Dahlia, K. and Sherry A. Glied. 2006. "How Much More Cost Sharing Will Health Savings Accounts Bring?" *Health Affairs* 25(4):1070–1078.
- Scandlen, Greg. 2001. "MSAs Can Be a Windfall for All." Policy Backgrounder No. 157, The National Center for Policy Analysis.

- Schreyogg, Jonas. 2002. "Medical Savings Accounts - Eine internationale Bestandsaufnahme de Konzeptes der Gesundheitssparkonten." Technical University Berlin.
- Smyth, Seamus J. 2005. "A Bancing Act: Optimal Nonlinear Taxation in Overlapping Generations Models." Harvard University, Department of Economics.
- Social Security Update 2007*. 2007. SSA Publication No. 05-10003.
- Suen, Richard M. H. 2006. "Technological Advance and the Growth in Health Care Spending." *Economie D'Avant Garde*, Research Report No. 13. University of Rochester.
- Watanabe, Mashito. 2005. "When Do Health Savings Accounts Decrease Health Care Costs?".
- Watanabe, Mashito. 2006. "Health Savings Accounts: A Quantitative Analysis." Dissertation, Georgetown University.
- Zabinski, Daniel, Thomas M. Selden, John F. Moeller and Jessica S. Banthin. 1999. "Medical Savings Accounts: Microsimulation Results from a Model with Adverse Selection." *Journal of Health Economics* 18:195-218.

7 Appendix

7.1 Solving the Model

We assume the tax function is $\tilde{\tau}(x) = \tau_L x$, just a linear function and not progressive.

These are the interior cases, where $T^{SI} = 0$, otherwise we have $T^{SI} > 0$ and $a = a^m = p_j = 0$.

7.1.1 Workers

(i) **Net Contributor** (automatically not using HSA funds for non-health related expenditures): This holds for

$$\begin{aligned} 0 &\leq NI_j \leq \bar{a}^m, \\ NI_j &= a_j^m - \max[0, NW_j], \\ NW_j &= R^m a_{j-1}^m - o^W(m_j) - I_{p_j < \tilde{\tau} p_j}. \end{aligned}$$

$$\begin{aligned} &V(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) \\ = &\max_{\{c_j, m_j, a_j, a_j^m, in_j\}} \left\{ u \left(\left[\begin{array}{c} \tilde{w}_j + R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m \\ \tilde{w}_j + r(a_{j-1} + T_j^{Beq}) \\ - \left(a_j^m - \max[0, R^m a_{j-1}^m - o^W(m_j) - in_j p_j] \right) \\ + 0.5(\tau^{Soc} + \tau^{Med})(\tilde{w}_j - p_j) \\ - a_j - a_j^m - o^W(m_j) - in_j p_j \end{array} \right] \right), h_j \right\}, \\ &+ \beta \pi_j E_\varepsilon \left[V(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}) | \varepsilon_j \right] \end{aligned}$$

then the first order condition with respect to a_j is

$$a_j : u_c(t) = \beta \pi_j EV_{a_j}(t+1),$$

so that using $u_c(c_j, h_j) = c_j^{\eta_1(1-\sigma)-1} h_j^{\eta_2(1-\sigma)}$ we have

$$c_j^{\eta_1(1-\sigma)-1} h_j^{\eta_2(1-\sigma)} = \beta \pi_j EV_{a_j}(t+1),$$

and Envelope conditions are

$$a_{j-1} : V_{a_j}(t) = u_c(t) \left[R - \frac{\partial \tilde{\tau}(t)}{\partial a_{j-1}} \times r \right],$$

which results in

$$V_{a_j}(t) = c_j^{\eta_1(1-\sigma)-1} h_j^{\eta_2(1-\sigma)} (R - \tau^L r).$$

Then the solution is

Solution 3

Worker - Contributor; No Penalty

$$NI_j > 0,$$

$$a_j = \text{income}(a_j^m) + NW_j - a_j^m - \left[\frac{\beta \pi_j EV_{a_j}(t+1)}{h_j^{\eta_2(1-\sigma)}} \right]^{\frac{1}{\eta_1(1-\sigma)-1}},$$

$$V_{a_j}(t) = c_j^{\eta_1(1-\sigma)-1} h_j^{\eta_2(1-\sigma)} (R - \tau^L r),$$

where

$$\text{income}(a_j^m) = \tilde{w}_j + R(a_{j-1} + T_j^{Beq}) - Tax_j,$$

$$Tax_j(a_j^m) = \tilde{\tau} \left[\tilde{w}_j + r(a_{j-1} + T_j^{Beq}) - NI_j \right] + 0.5(\tau^{Soc} + \tau^{Med})(\tilde{w}_j - p_j),$$

$$NI_j(a_j^m) = a_j^m - \max[0, NW_j],$$

$$NW_j = R^m a_{j-1}^m - o^W(m_j) - in_j p_j.$$

(ii) **Net Non-Contributor** (automatically using *HSA* funds for non-health expenditures):

$$NI_j < 0,$$

$$NI_j = a_j^m - \max[0, NW_j],$$

$$NW_j = R^m a_{j-1}^m - o^W(m_j) - in_j p_j.$$

$$V(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = \max_{\{c_j, m_j, a_j, a_j^m, in_j\}} \left\{ u \left(\left[\begin{array}{l} \tilde{w}_j + R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m \\ \tilde{w}_j + r(a_{j-1} + T_j^{Beq}) \\ - \left(a_j^m - \max[0, R^m a_{j-1}^m - o^W(m_j) - I_{p_j < \tilde{T}_p} p_j \right) \\ + 0.5(\tau^{Soc} + \tau^{Med})(\tilde{w}_j - p_j) \\ - \left(a_j^m - \max[0, R^m a_{j-1}^m - o^W(m_j) - I_{p_j < \tilde{T}_p} p_j \right) \tau^m \\ - a_j - a_j^m - o^W(m_j) - I_{\{p_j < \tilde{T}_p\}} p_j \\ + \beta \pi_j E_\varepsilon \left[V(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}) | \varepsilon_j \right] \end{array} \right] , h_j \right) \right\}$$

then the first order condition for a_j is

$$a_j : u_c(t) = \beta \pi_j EV_{a_j}(t+1),$$

and Envelope conditions are

$$a_{j-1} : V_{a_j}(t) = u_c(t) \left[R - \frac{\partial \tilde{\tau}}{\partial a_j} \times r \right],$$

Solution 4

Worker Non-Contributor; pays Penalty

$$\begin{aligned} NI_j &< 0, \\ NW_j &> 0, \end{aligned}$$

$$a_j = \text{income}(a_j^m) + NW_j - a_j^m - \left[\frac{\beta\pi_j EV_{a_j}(t+1)}{h_j^{\eta_2(1-\sigma)}} \right]^{\frac{1}{\eta_1(1-\sigma)-1}},$$

$$V_{a_j}(t) = c_j^{\eta_1(1-\sigma)-1} h_j^{\eta_2(1-\sigma)} (R - \tau^L r),$$

where

$$\text{income}(a_j^m) = \tilde{w}_j + R(a_{j-1} + T_j^{Beq}) - Tax_j,$$

$$Tax_j(a_j^m) = \tilde{\tau} \left[\tilde{w}_j + r(a_{j-1} + T_j^{Beq}) - NI_j \right] + 0.5 \left(\tau^{Soc} + \tau^{Med} \right) (\tilde{w}_j - p_j) - \tau^m NI_j,$$

$$NI_j(a_j^m) = a_j^m - \max[0, NW_j],$$

$$NW_j = R^m a_{j-1}^m - o^W(m_j) - in_j p_j.$$

7.1.2 Retirees

(i) **Non-Contributor, No Penalty:** using HSA funds only for health related expenditures: This is the case if

$$NI_j = 0.$$

$$\begin{aligned} &V(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) \\ = &\max_{\{c_j, m_j, a_j, a_j^m\}} \left\{ u \left(\left[\begin{array}{c} R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m + T_j^{Soc} \\ r(a_{j-1} + T_j^{Beq}) \\ -\tilde{\tau} \left[-\left(a_j^m - \max \left[0, R^m a_{j-1}^m - o^W(m_j) - p_j^{Med} \right] \right) \right] \\ -a_j - a_j^m - o^W(m_j) - p_j^{Med} \\ +\beta\pi_j E_\varepsilon V(a_j, a_j^m, h_j, in_j = 1, \varepsilon_{j+1} | \varepsilon_j) \end{array} \right], h_j \right) \right\} \end{aligned}$$

then the first order conditions are

$$\partial a_j : u_c(t) = \beta\pi_j EV_{a_j}(t+1),$$

and Envelope conditions are

$$\partial a_{j-1} : V_{a_j}(t) = u_c(t) \left(R - \frac{\partial \tilde{\tau}(t)}{\partial a_j} r \right),$$

Solution 5

Retiree, No penalty

$$NI = 0,$$

$$a_j = \text{Income}(a_j^m) + NW_j - a_j^m - \left[\frac{\beta \pi_j EV_{a_j}(t+1)}{h_j^{\eta_2(1-\sigma)}} \right]^{\frac{1}{\eta_1(1-\sigma)-1}},$$

$$V_{a_j}(t) = c_j^{\eta_1(1-\sigma)-1} h_j^{\eta_2(1-\sigma)} (R - \tau^L r),$$

where

$$\text{Income}(a_j^m) = R(a_{j-1} + T_j^{Beq}) - \text{Tax}(a_j^m) + T_j^{Soc},$$

$$\text{Tax}(a_j^m) = \tilde{\tau} \left[r(a_{j-1} + T_j^{Beq}) - NI(a_j^m) \right],$$

$$NI(a_j^m) = a_j^m - \max[0, NW_j],$$

$$NW_j = R^m a_{j-1}^m - o^W(m_j) - p_j^{Med}.$$

(ii) **Non-Contributor, Penalty applies:** using HSA funds for non-health related expenses has to pay income tax on these funds (no penalty τ^m applies for agents older than 65): This is the case if

$$NI_j < 0.$$

$$V(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = \max_{\{c_j, m_j, a_j, a_j^m\}} \left\{ u \left(\left[\begin{array}{l} R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m + T_j^{Soc} \\ -\tilde{\tau} \left[r(a_{j-1} + T_j^{Beq}) - (a_j^m - \max[0, R^m a_{j-1}^m - o^W(m_j) - p_j^{Med}]) \right] \\ -a_j - a_j^m - o^W(m_j) - p_j^{Med} \\ +\beta \pi_j E_\varepsilon V(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1} | \varepsilon_j) \end{array} \right], h_j \right) \right\},$$

then the first order conditions are

$$a_j : u_c(t) = \beta \pi_j EV_{a_j}(t+1), ,$$

and Envelope conditions are

$$\partial a_{j-1} : V_{a_j}(t) = u_c(t) \left(R - \frac{\partial \tilde{\tau}(t)}{\partial a_j} r \right),$$

Solution 6

Retiree; pays penalty

$$\begin{aligned} NI_j &< 0, \\ NW &> 0, \end{aligned}$$

$$a_j = \text{Income}(a_j^m) + NW - a_j^m - \left[\frac{\beta \pi_j E V_{a_j}(t+1)}{h_j^{\eta_2(1-\sigma)}} \right]^{\frac{1}{\eta_1(1-\sigma)-1}},$$

$$V_{a_j}(t) = c_j^{\eta_1(1-\sigma)-1} h_j^{\eta_2(1-\sigma)} (R - \tau^L r),$$

where

$$\begin{aligned} \text{Income}(a_j^m) &= R(a_{j-1} + T_j^{\text{Beq}}) - \text{Tax}(a_j^m) + T_j^{\text{Soc}}, \\ \text{Tax}(a_j^m) &= \tilde{\tau} \left[r(a_{j-1} + T_j^{\text{Beq}}) - NI(a_j^m) \right], \\ NI(a_j^m) &= a_j^m - \max[0, NW_j], \\ NW_j &= R^m a_{j-1}^m - o^W(m_j) - p_j^{\text{Med}}. \end{aligned}$$

7.2 Welfare analysis

7.2.1 Compensating Consumption

We compare two regimes, the benchmark regime 0 with the new regime 1, the value function for the two regimes are:

$$\begin{aligned} V^0(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) &= u(c_j^0, h_j^0) + \beta \pi_j E_\varepsilon V^0(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1} | \varepsilon_j), \\ V^1(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) &= u(c_j^1, h_j^1) + \beta \pi_j E_\varepsilon V^1(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1} | \varepsilon_j), \end{aligned}$$

where c_j^0, h_j^0 and c_j^1, h_j^1 are the optimal consumption and health state choices for the j year old individual in regime 0 and regime 1. We then find the difference in consumption Δc_j that equates the value functions of the two regimes conditioning on the particular state, so that

$$V^0(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = u(c_j^1 + \Delta c_j, h_j^1) + \beta \pi_j E_\varepsilon V^1(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1} | \varepsilon_j),$$

where $\Delta c_j(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j)$ is a function of the state. So for each state we have the compensating consumption. We can then express this in terms of averages, e.g.

$$\Delta \bar{c}_j = \sum_{a \times a^m \times h \times in \times \varepsilon} \Delta c_j(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) \mu^w(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j)$$

is the total compensating consumption for the generation j . In other words, it is the total compensating consumption that makes generation j indifferent between regime 0 and regime 1. Furthermore, $\frac{1}{j} \Delta \bar{c}_j$ is the 'average' compensating consumption of a j year old agent. We express these compensating consumptions in terms of GDP or total consumption of generation j , e.g. $\frac{\Delta \bar{c}_j}{Y^0}$ or $\frac{\Delta \bar{c}_j}{c_j^0}$.

We next summarize the state vector as $\Theta_j = \{a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j\}$. We can

Parameters	
$J_1 = 4$	$\rho^{Med} = 0.03$
$J_2 = 2$	$\gamma^{Med} = 0.8$
$\sigma = 1.5$	$\rho = 0.01$
$\beta = .99$	$\gamma = 0.5$
$\eta_1 = 0.4$	$\rho' = 1.5$
$\eta_2 = 0.6$	$\gamma' = 0.5$
$\alpha = 0.36$	
$\delta = 1 - 0.97^{(60/J)}$	$\varepsilon = [0., 0.5, 1.]$
$\phi = 1$	$a_{Grid} = [0, \dots, 12]_{1 \times 12}$
$\xi = 0.4$	$a_{Grid}^m = [0, \dots, 3]_{1 \times 5}$
$\delta_h = 1 - 0.94^{(60/J)}$	$h_{jGrid} = [0.01, \dots, 1.5]_{1 \times 8}$
State Space	$6 \times 12 \times 5 \times 8 \times 8 \times 3 \times 2 =$

Table 1: Parameters for Calibration

then calculate compensating consumption as

$$V^0(\Theta_{j-1}) = \frac{\left((c_j^1 + \Delta c_j)^{\eta_1} (h_j^1)^{\eta_2} \right)^{1-\sigma}}{1-\sigma} + \beta \pi_j E_\varepsilon V^1(\Theta_j | \varepsilon_j),$$

so that

$$\Delta c_j(\Theta_{j-1}) = \left[\frac{[(1-\sigma)(V^0(\Theta_{j-1}) - \beta \pi_j E_\varepsilon V^1(\Theta_j | \varepsilon_j))]^{\frac{1}{1-\sigma}}}{(h_j^1)^{\eta_2}} \right]^{\frac{1}{\eta_1}} - c_j^1.$$

An alternative method is compensating income. Here agents could re-maximize their optimal decisions according to

$$V^0(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = \max_{\{c_j, h_j, a_j, a_j^m\}} \{u(c_j + \Delta c_j, h_j) + \beta \pi_j E_\varepsilon V^1(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1} | \varepsilon_j)\}$$

s.t.

$$c_j + s_j = I^1(\Theta) + \Delta I(\Theta),$$

7.3 Tables

	$\rho = 0.1$	$\rho = 1.5$	$\rho = 1.5$ -with-HSA		
Y	18.895	18.895	19.983	19.983	19.983
K	4.505	4.505	5.262	5.262	5.262
K/Y	2.043	2.043	2.257	2.257	2.257
a	4.512	4.512	4.149	4.149	4.149
a^m	0.000	0.000	1.122	1.122	1.122
$HealthCap$	3.759	3.759	3.759	3.759	3.759
$HealthCap/Y$	1.705	1.705	1.612	1.612	1.612
M	0.094	0.094	0.094	0.094	0.094
M/Y	0.005	0.005	0.005	0.005	0.005
C	8.054	8.054	8.336	8.336	8.336
C/Y	0.426	0.426	0.417	0.417	0.417
Hk	1.159	1.159	1.159	1.159	1.159
$R(J)$	2.294	2.294	2.151	2.151	2.151
R	1.109	1.109	1.100	1.100	1.100
w	10.433	10.433	11.034	11.034	11.034
τ^{Soc}	0.129	0.129	0.129	0.129	0.129
$Income - Tax$	2.230	2.230	2.272	2.272	2.272
TSi	0.000	0.000	0.000	0.000	0.000
$Worker - Insured$	0.000	0.000	0.689	0.689	0.689
$All - Insured$	0.182	0.182	0.746	0.746	0.746
p^{Ins}	0.000	0.000	0.000	0.000	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000
$TBeq$	0.022	0.022	0.026	0.026	0.026
G	2.230	2.230	2.272	2.272	2.272
$Gini$	0.387	0.387	0.400	0.400	0.400
$Error - in - \%$	0.017	0.017	0.018	0.018	0.018
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000

Table 2: 3 Regimes: [1] Benchmark, low deductible, no HSA, [2] High deductible, no HSA, [3] High deductible with HSA

	noHSA	HSA
Y	22.504	23.857
K	7.162	8.423
K/Y	3.183	3.531
a	7.160	6.678
a^m	0.000	1.749
$HealthCap$	5.514	5.514
$HealthCap/Y$	2.450	2.311
M	0.378	0.378
M/Y	0.017	0.016
C	12.000	12.757
C/Y	0.533	0.535
Hk	1.173	1.173
$R(J)$	1.869	1.757
R	1.065	1.058
w	12.274	13.012
τ^{Soc}	0.169	0.169
$Income - Tax$	2.989	3.055
T^{Si}	0.000	0.000
$\%low - deductible$	0.000	0.238
$\%high - deductible$	0.746	0.508
$Worker - Insured$	0.746	0.746
$All - Insured$	0.665	0.826
p^{Ins}	0.037	0.242
p'^{Ins}	0.002	0.003
p^{Med}	0.000	0.000
$TBeq$	0.036	0.043
G	2.989	3.055
$Gini$	0.313	0.324
$Error - in - \%$	0.008	0.011
$overrun - Iter2w$	0.000	0.000
$overrun - Iter2r$	0.000	0.000

Table 3: 3 Regimes: [1] Benchmark, no HSA and [2] HSA. Agents can choose between low and high deductible insurances. Only the high deductible insurance can be combined with a HSA.

NO HSA										
$\rho =$	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.5
Y	19.978	19.982	19.983	19.983	19.983	19.983	19.983	19.983	19.983	19.983
K	5.259	5.262	5.262	5.262	5.262	5.262	5.262	5.262	5.262	5.262
K/Y	2.256	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257
a	4.145	4.148	4.149	4.149	4.149	4.149	4.149	4.149	4.149	4.149
a^m	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122
$HealthCap$	3.759	3.759	3.759	3.759	3.759	3.759	3.759	3.759	3.759	3.759
$HealthCap/Y$	1.613	1.612	1.612	1.612	1.612	1.612	1.612	1.612	1.612	1.612
M	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
M/Y	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
C	8.334	8.336	8.336	8.336	8.336	8.336	8.336	8.336	8.336	8.336
C/Y	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
Hk	1.159	1.159	1.159	1.159	1.159	1.159	1.159	1.159	1.159	1.159
$R(J)$	2.151	2.151	2.151	2.151	2.151	2.151	2.151	2.151	2.151	2.151
R	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
w	11.031	11.034	11.034	11.034	11.034	11.034	11.034	11.034	11.034	11.034
τ^{Soc}	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
$Income - Tax$	2.273	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272
T^{Si}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$Worker - Insured$	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689
$All - Insured$	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746
p^{Ins}	0.054	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
T^{Beq}	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
G	2.273	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272
$Gini$	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
$Error - in - \%$	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4: No HSA, varying deductible: ρ given coinsurance rate = 0.5.

$\gamma =$	NO HSA				
	0	0.25	0.5	0.75	1
Y	18.895	18.895	18.895	18.895	18.895
K	4.505	4.505	4.505	4.505	4.505
K/Y	2.043	2.043	2.043	2.043	2.043
a	4.512	4.512	4.512	4.512	4.512
a^m	0.000	0.000	0.000	0.000	0.000
$HealthCap$	3.759	3.759	3.759	3.759	3.759
$HealthCap/Y$	1.705	1.705	1.705	1.705	1.705
M	0.094	0.094	0.094	0.094	0.094
M/Y	0.005	0.005	0.005	0.005	0.005
C	8.054	8.054	8.054	8.054	8.054
C/Y	0.426	0.426	0.426	0.426	0.426
Hk	1.159	1.159	1.159	1.159	1.159
$R(J)$	2.294	2.294	2.294	2.294	2.294
R	1.109	1.109	1.109	1.109	1.109
w	10.433	10.433	10.433	10.433	10.433
τ^{Soc}	0.129	0.129	0.129	0.129	0.129
$Income - Tax$	2.230	2.230	2.230	2.230	2.230
T^{Si}	0.000	0.000	0.000	0.000	0.000
$Worker - Insured$	0.000	0.000	0.000	0.000	0.000
$All - Insured$	0.182	0.182	0.182	0.182	0.182
p^{Ins}	0.000	0.000	0.000	0.000	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000
T^{Beq}	0.022	0.022	0.022	0.022	0.022
G	2.230	2.230	2.230	2.230	2.230
$Gini$	0.387	0.387	0.387	0.387	0.387
$Error - in - \%$	0.017	0.017	0.017	0.017	0.017
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000

Table 5: No HSA, varying coinsurance rate: γ given deductible: $\rho = 0.05$.

NO HSA										
$\rho' =$	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.5
Y	22.547	22.544	22.534	22.517	22.511	22.512	22.504	22.497	22.497	22.497
K	7.200	7.198	7.188	7.174	7.168	7.169	7.162	7.156	7.156	7.156
K/Y	3.193	3.193	3.190	3.186	3.184	3.185	3.183	3.181	3.181	3.181
a	7.203	7.199	7.187	7.175	7.167	7.162	7.160	7.160	7.160	7.160
a^m	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$HealthCap$	5.514	5.514	5.514	5.514	5.514	5.514	5.514	5.514	5.514	5.514
$HealthCap/Y$	2.446	2.446	2.447	2.449	2.450	2.450	2.450	2.451	2.451	2.451
M	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378
M/Y	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
C	12.086	12.072	12.058	12.035	12.015	12.002	12.000	12.001	12.001	12.001
C/Y	0.536	0.535	0.535	0.534	0.534	0.533	0.533	0.533	0.533	0.533
Hk	1.173	1.173	1.173	1.173	1.173	1.173	1.173	1.173	1.173	1.173
$R(J)$	1.865	1.865	1.866	1.867	1.868	1.868	1.869	1.869	1.869	1.869
R	1.064	1.064	1.064	1.064	1.064	1.064	1.065	1.065	1.065	1.065
w	12.298	12.296	12.290	12.282	12.278	12.279	12.274	12.271	12.271	12.271
τ^{Soc}	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169
$Income - Tax$	2.994	2.993	2.991	2.990	2.989	2.988	2.989	2.989	2.989	2.989
T^{Si}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\%low - deductible$	0.249	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\%high - deductible$	0.000	0.249	0.575	0.746	0.746	0.746	0.746	0.746	0.746	0.746
$Worker - Insured$	0.249	0.249	0.575	0.746	0.746	0.746	0.746	0.746	0.746	0.746
$All - Insured$	0.324	0.324	0.548	0.665	0.665	0.665	0.665	0.665	0.665	0.665
p^{Ins}	0.404	0.179	0.142	0.087	0.041	0.019	0.037	0.000	0.000	0.000
p'^{Ins}	0.204	0.334	0.139	0.095	0.073	0.041	0.002	0.000	0.000	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$TBeq$	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
G	2.994	2.993	2.991	2.990	2.989	2.988	2.989	2.989	2.989	2.989
$Gini$	0.312	0.312	0.313	0.313	0.314	0.314	0.313	0.313	0.313	0.313
$Error - in - \%$	0.012	0.004	0.013	0.010	0.004	0.026	0.008	0.012	0.012	0.012
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6: No HSA, varying deductible: ρ' given coinsurance rate $\rho = 0.5$ and given $\gamma = 0.5$ and deductible: $\rho = 0.05$.

$\gamma' =$	NO HSA				
	0	0.25	0.5	0.75	1
Y	22.552	22.547	22.545	22.520	22.497
K	7.205	7.200	7.199	7.177	7.156
K/Y	3.195	3.194	3.193	3.187	3.181
a	7.202	7.203	7.203	7.174	7.160
a^m	0.000	0.000	0.000	0.000	0.000
$HealthCap$	5.514	5.514	5.514	5.514	5.514
$HealthCap/Y$	2.445	2.446	2.446	2.449	2.451
M	0.378	0.378	0.378	0.378	0.378
M/Y	0.017	0.017	0.017	0.017	0.017
C	12.079	12.083	12.084	12.037	12.001
C/Y	0.536	0.536	0.536	0.534	0.533
Hk	1.173	1.173	1.173	1.173	1.173
$R(J)$	1.864	1.865	1.865	1.867	1.869
R	1.064	1.064	1.064	1.064	1.065
w	12.300	12.298	12.297	12.283	12.271
τ^{Soc}	0.169	0.169	0.169	0.169	0.169
$Income - Tax$	2.992	2.993	2.994	2.990	2.989
T^{Si}	0.000	0.000	0.000	0.000	0.000
$\%low - deductible$	0.249	0.249	0.000	0.000	0.000
$\%high - deductible$	0.000	0.000	0.249	0.744	0.746
$Worker - Insured$	0.249	0.249	0.249	0.744	0.746
$All - Insured$	0.324	0.324	0.324	0.663	0.665
p^{Ins}	0.405	0.405	0.202	0.087	0.000
p'^{Ins}	0.392	0.294	0.393	0.104	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000
$TBeq$	0.036	0.036	0.036	0.036	0.036
G	2.992	2.993	2.994	2.990	2.989
$Gini$	0.312	0.312	0.312	0.313	0.313
$Error - in - \%$	0.010	0.008	0.014	0.008	0.012
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000

Table 7: No HSA, varying coinsurance rate: γ' given deductible: $\rho' = 0.05$ and given $\gamma = 0.5$ and deductible: $\rho = 0.05$.

$\rho =$	HSA									
	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.5
Y	19.978	19.982	19.983	19.983	19.983	19.983	19.983	19.983	19.983	19.983
K	5.259	5.262	5.262	5.262	5.262	5.262	5.262	5.262	5.262	5.262
K/Y	2.256	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257	2.257
a	4.145	4.148	4.149	4.149	4.149	4.149	4.149	4.149	4.149	4.149
a^m	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122	1.122
$HealthCap$	3.759	3.759	3.759	3.759	3.759	3.759	3.759	3.759	3.759	3.759
$HealthCap/Y$	1.613	1.612	1.612	1.612	1.612	1.612	1.612	1.612	1.612	1.612
M	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
M/Y	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
C	8.334	8.336	8.336	8.336	8.336	8.336	8.336	8.336	8.336	8.336
C/Y	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
Hk	1.159	1.159	1.159	1.159	1.159	1.159	1.159	1.159	1.159	1.159
$R(J)$	2.151	2.151	2.151	2.151	2.151	2.151	2.151	2.151	2.151	2.151
R	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
w	11.031	11.034	11.034	11.034	11.034	11.034	11.034	11.034	11.034	11.034
τ^{Soc}	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
$Income - Tax$	2.273	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272
T^{Si}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$Worker - Insured$	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689	0.689
$All - Insured$	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746
p^{Ins}	0.054	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
T^{Beq}	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
G	2.273	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272	2.272
$Gini$	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
$Error - in - \%$	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8: HSA, varying deductible: ρ given coinsurance rate = 0.5.

$\gamma =$	HSA				
	0	0.25	0.5	0.75	1
Y	19.983	19.983	19.983	19.983	19.983
K	5.262	5.262	5.262	5.262	5.262
K/Y	2.257	2.257	2.257	2.257	2.257
a	4.149	4.149	4.149	4.149	4.149
a^m	1.122	1.122	1.122	1.122	1.122
$HealthCap$	3.759	3.759	3.759	3.759	3.759
$HealthCap/Y$	1.612	1.612	1.612	1.612	1.612
M	0.094	0.094	0.094	0.094	0.094
M/Y	0.005	0.005	0.005	0.005	0.005
C	8.336	8.336	8.336	8.336	8.336
C/Y	0.417	0.417	0.417	0.417	0.417
Hk	1.159	1.159	1.159	1.159	1.159
$R(J)$	2.151	2.151	2.151	2.151	2.151
R	1.100	1.100	1.100	1.100	1.100
w	11.034	11.034	11.034	11.034	11.034
τ^{Soc}	0.129	0.129	0.129	0.129	0.129
$Income - Tax$	2.272	2.272	2.272	2.272	2.272
T^{Si}	0.000	0.000	0.000	0.000	0.000
$Worker - Insured$	0.689	0.689	0.689	0.689	0.689
$All - Insured$	0.746	0.746	0.746	0.746	0.746
p^{Ins}	0.000	0.000	0.000	0.000	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000
T^{Beq}	0.026	0.026	0.026	0.026	0.026
G	2.272	2.272	2.272	2.272	2.272
$Gini$	0.400	0.400	0.400	0.400	0.400
$Error - in - \%$	0.018	0.018	0.018	0.018	0.018
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000

Table 9: HSA, varying coinsurance rate: γ given deductible: $\rho = 0.05$.

$\rho' =$	HSA									
	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.5
Y	23.884	23.888	23.854	23.854	23.859	23.865	23.857	23.857	23.857	23.857
K	8.450	8.454	8.420	8.420	8.426	8.431	8.423	8.424	8.424	8.424
K/Y	3.538	3.539	3.530	3.530	3.531	3.533	3.531	3.531	3.531	3.531
a	6.747	6.750	6.693	6.698	6.704	6.709	6.678	6.679	6.679	6.679
a^m	1.707	1.708	1.726	1.726	1.726	1.725	1.749	1.749	1.749	1.749
$HealthCap$	5.514	5.514	5.514	5.514	5.514	5.514	5.514	5.514	5.514	5.514
$HealthCap/Y$	2.309	2.308	2.312	2.312	2.311	2.311	2.311	2.311	2.311	2.311
M	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378	0.378
M/Y	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
C	12.751	12.757	12.745	12.751	12.755	12.759	12.757	12.757	12.757	12.757
C/Y	0.534	0.534	0.534	0.535	0.535	0.535	0.535	0.535	0.535	0.535
Hk	1.173	1.173	1.173	1.173	1.173	1.173	1.173	1.173	1.173	1.173
$R(J)$	1.755	1.755	1.757	1.757	1.757	1.756	1.757	1.757	1.757	1.757
R	1.058	1.058	1.058	1.058	1.058	1.058	1.058	1.058	1.058	1.058
w	13.027	13.029	13.010	13.011	13.014	13.016	13.012	13.013	13.013	13.013
τ^{Soc}	0.170	0.170	0.170	0.169	0.169	0.169	0.169	0.169	0.169	0.169
$Income - Tax$	3.077	3.073	3.063	3.062	3.061	3.059	3.055	3.055	3.055	3.055
T^{Si}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\%low - deductible$	0.249	0.249	0.248	0.248	0.248	0.248	0.238	0.238	0.238	0.238
$\%high - deductible$	0.493	0.494	0.498	0.498	0.498	0.498	0.508	0.508	0.508	0.508
$Worker - Insured$	0.742	0.744	0.746	0.746	0.746	0.746	0.746	0.746	0.746	0.746
$All - Insured$	0.823	0.824	0.826	0.826	0.826	0.826	0.826	0.826	0.826	0.826
p^{Ins}	0.290	0.290	0.271	0.262	0.263	0.264	0.242	0.242	0.242	0.242
p'^{Ins}	0.295	0.212	0.174	0.134	0.090	0.046	0.003	0.000	0.000	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$TBeq$	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
G	3.077	3.073	3.063	3.062	3.061	3.059	3.055	3.055	3.055	3.055
$Gini$	0.326	0.325	0.325	0.325	0.325	0.324	0.324	0.324	0.324	0.324
$Error - in - \%$	0.011	0.011	0.003	0.011	0.011	0.011	0.011	0.011	0.011	0.011
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 10: HSA, varying deductible: ρ' given coinsurance rate $l = 0.5$ and given $\gamma = 0.5$ and deductible: $\rho = 0.05$.

$\gamma' =$	HSA				
	0	0.25	0.5	0.75	1
Y	23.857	23.857	23.857	23.857	23.857
K	8.423	8.423	8.423	8.424	8.424
K/Y	3.531	3.531	3.531	3.531	3.531
a	6.678	6.678	6.678	6.678	6.679
a^m	1.749	1.749	1.749	1.749	1.749
$HealthCap$	5.514	5.514	5.514	5.514	5.514
$HealthCap/Y$	2.311	2.311	2.311	2.311	2.311
M	0.378	0.378	0.378	0.378	0.378
M/Y	0.016	0.016	0.016	0.016	0.016
C	12.756	12.757	12.757	12.757	12.757
C/Y	0.535	0.535	0.535	0.535	0.535
Hk	1.173	1.173	1.173	1.173	1.173
$R(J)$	1.757	1.757	1.757	1.757	1.757
R	1.058	1.058	1.058	1.058	1.058
w	13.012	13.012	13.012	13.012	13.013
τ^{Soc}	0.169	0.169	0.169	0.169	0.169
$Income - Tax$	3.055	3.055	3.055	3.055	3.055
T^{Si}	0.000	0.000	0.000	0.000	0.000
$\%low - deductible$	0.238	0.238	0.238	0.238	0.238
$\%high - deductible$	0.508	0.508	0.508	0.508	0.508
$Worker - Insured$	0.746	0.746	0.746	0.746	0.746
$All - Insured$	0.826	0.826	0.826	0.826	0.826
p^{Ins}	0.242	0.242	0.242	0.242	0.242
p'^{Ins}	0.006	0.005	0.003	0.002	0.000
p^{Med}	0.000	0.000	0.000	0.000	0.000
$TBeq$	0.043	0.043	0.043	0.043	0.043
G	3.055	3.055	3.055	3.055	3.055
$Gini$	0.324	0.324	0.324	0.324	0.324
$Error - in - \%$	0.011	0.011	0.011	0.011	0.011
$overrun - Iter2w$	0.000	0.000	0.000	0.000	0.000
$overrun - Iter2r$	0.000	0.000	0.000	0.000	0.000

Table 11: HSA, varying coinsurance rate: γ' given deductible: $\rho' = 0.05$ and given $\gamma = 0.5$ and deductible: $\rho = 0.05$.

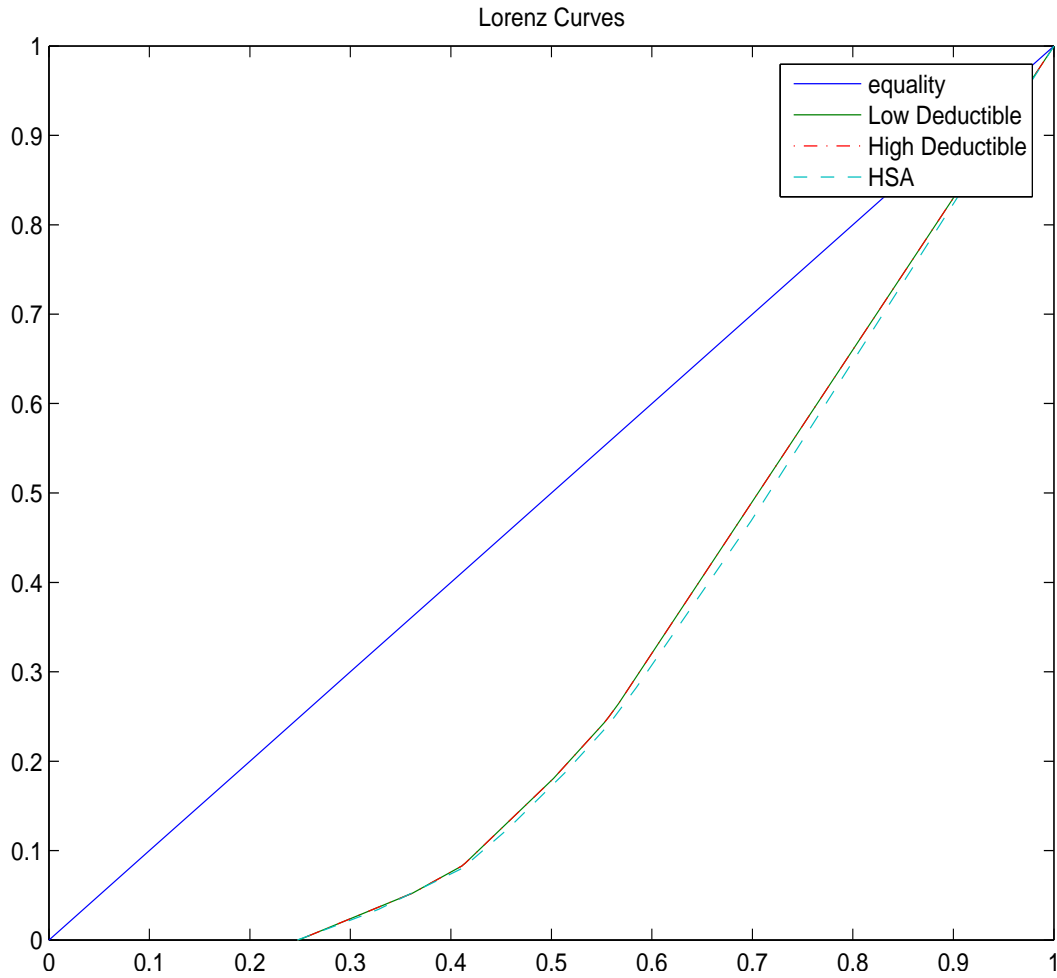


Figure 1: Lorenz Curves for [1] Low Deductible Insurance, [2] High Deductible Insurance and [3] HSAs with High Deductible Insurance

7.4 Figures

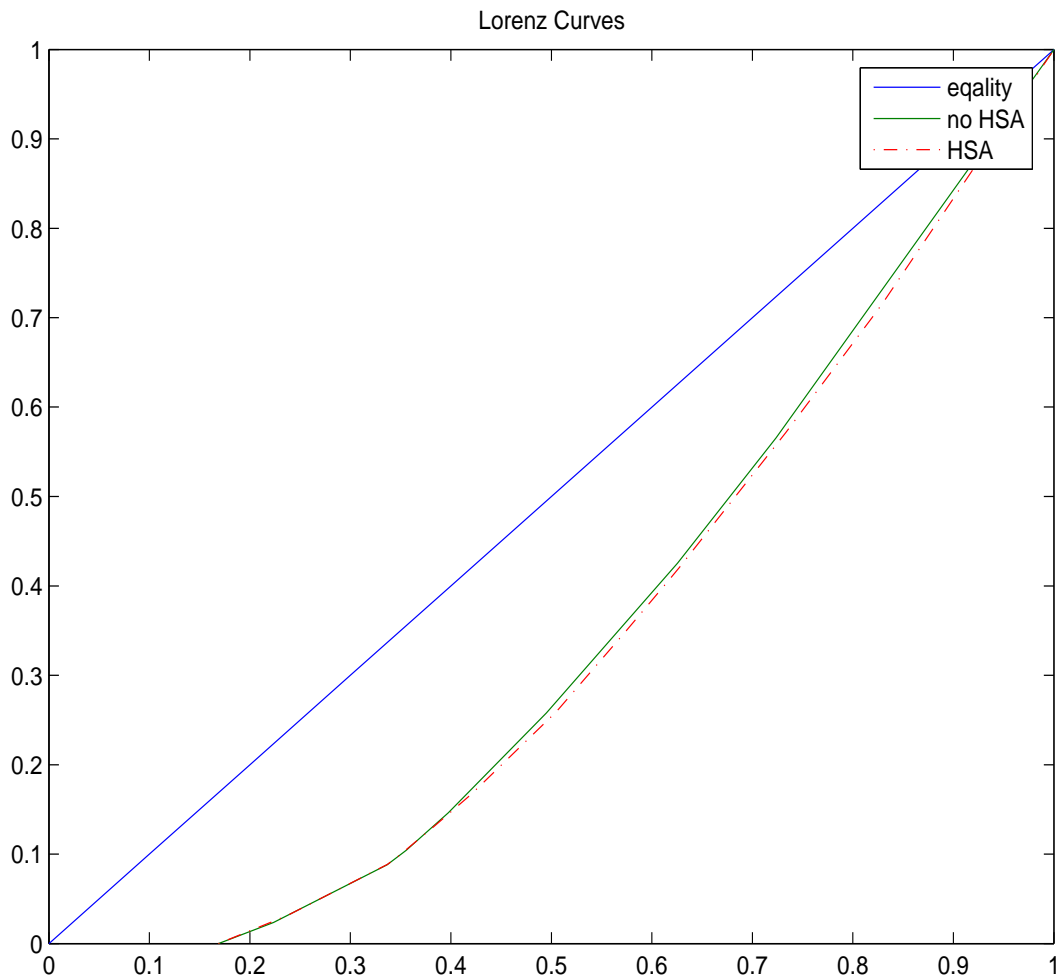


Figure 2: Lorenz Curves for [1] no HSA and [2] HSAs. Agents can choose between high and low deductible insurances. If they choose the high deductible insurance they can invest into a HSA.

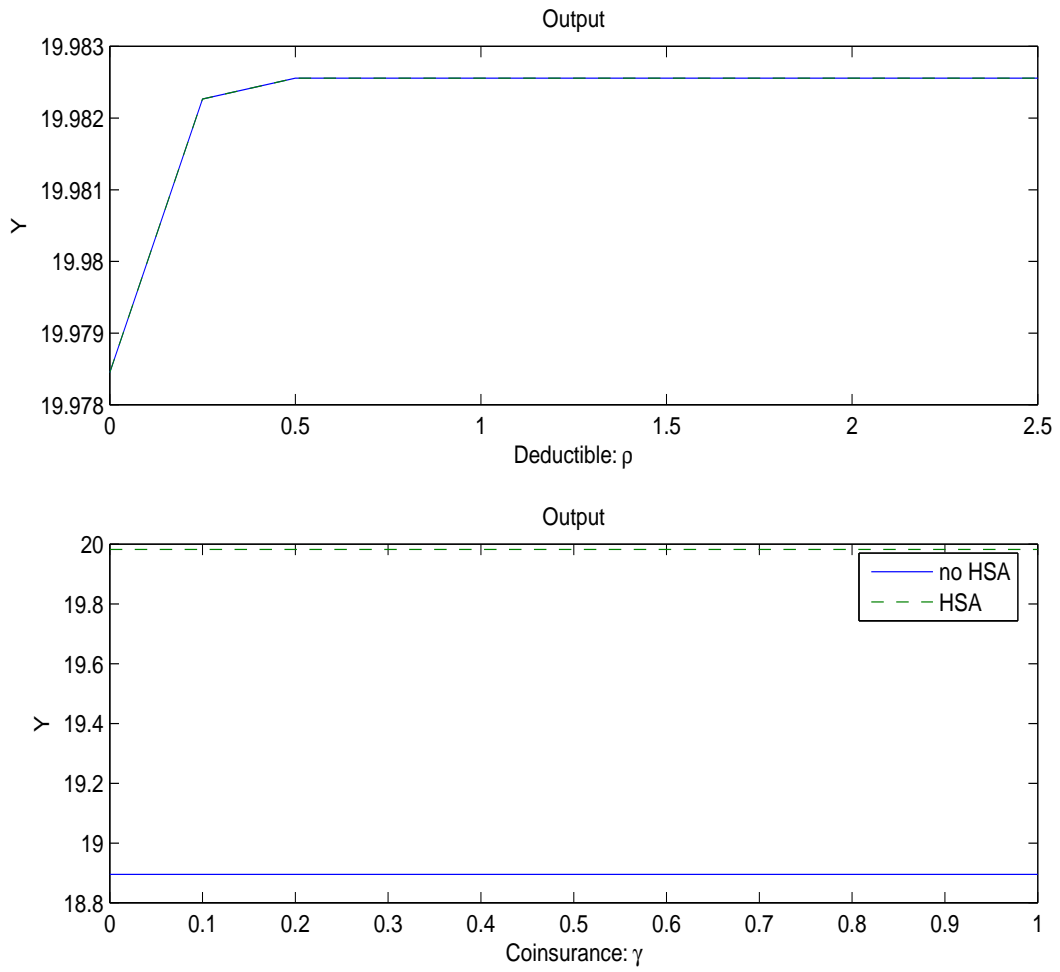


Figure 3: Change in aggregate output Y due to changes in the deductible ρ and changes in the coinsurance rate γ .

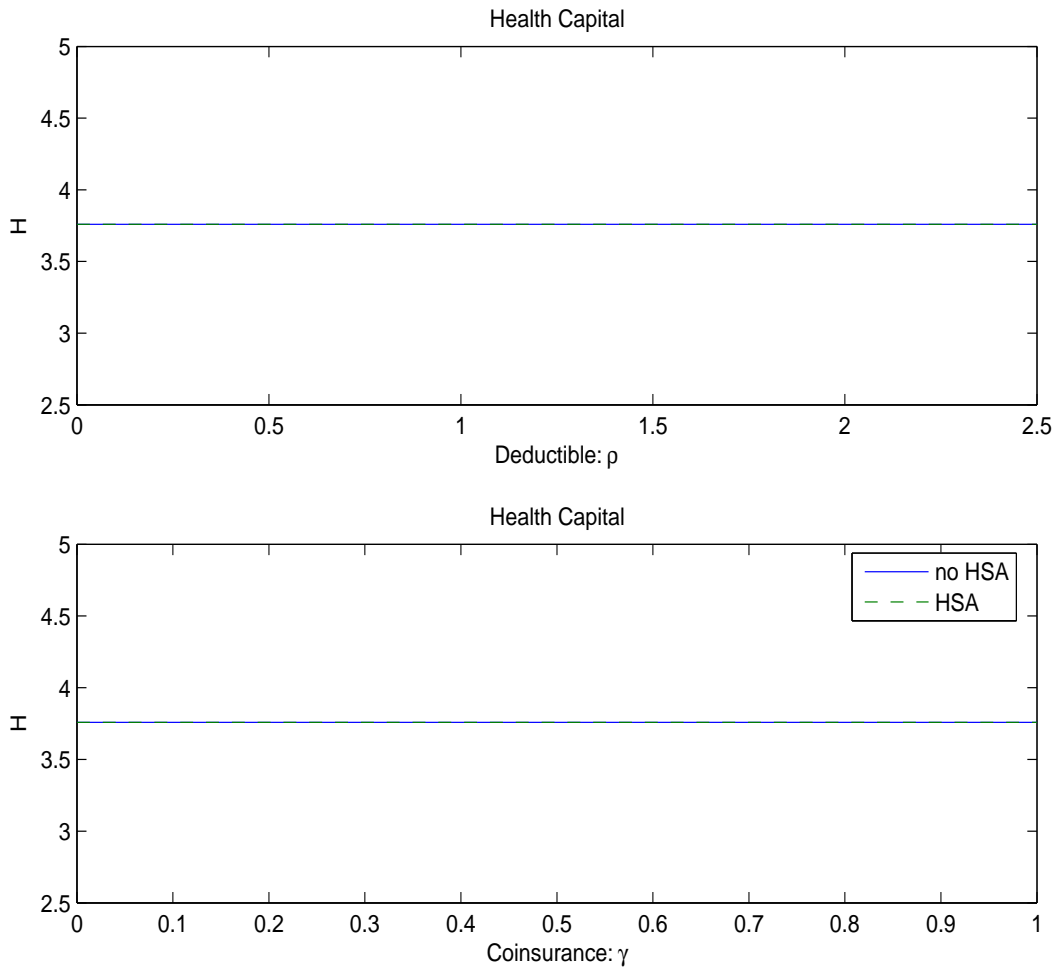


Figure 4: Change in aggregate health capital H due to changes in the deductible ρ and changes in the coinsurance rate γ .

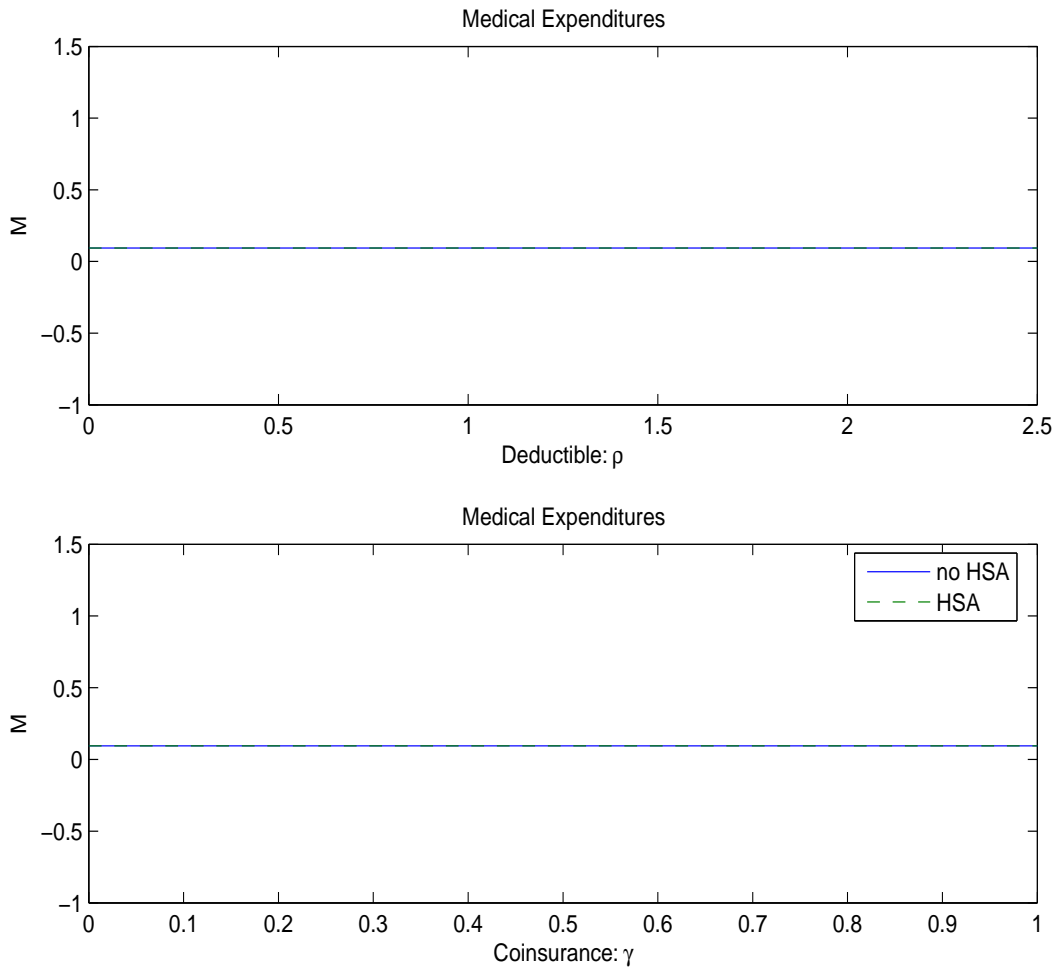


Figure 5: Change in aggregate medical expenditures M due to changes in the deductible ρ and changes in the coinsurance rate γ .

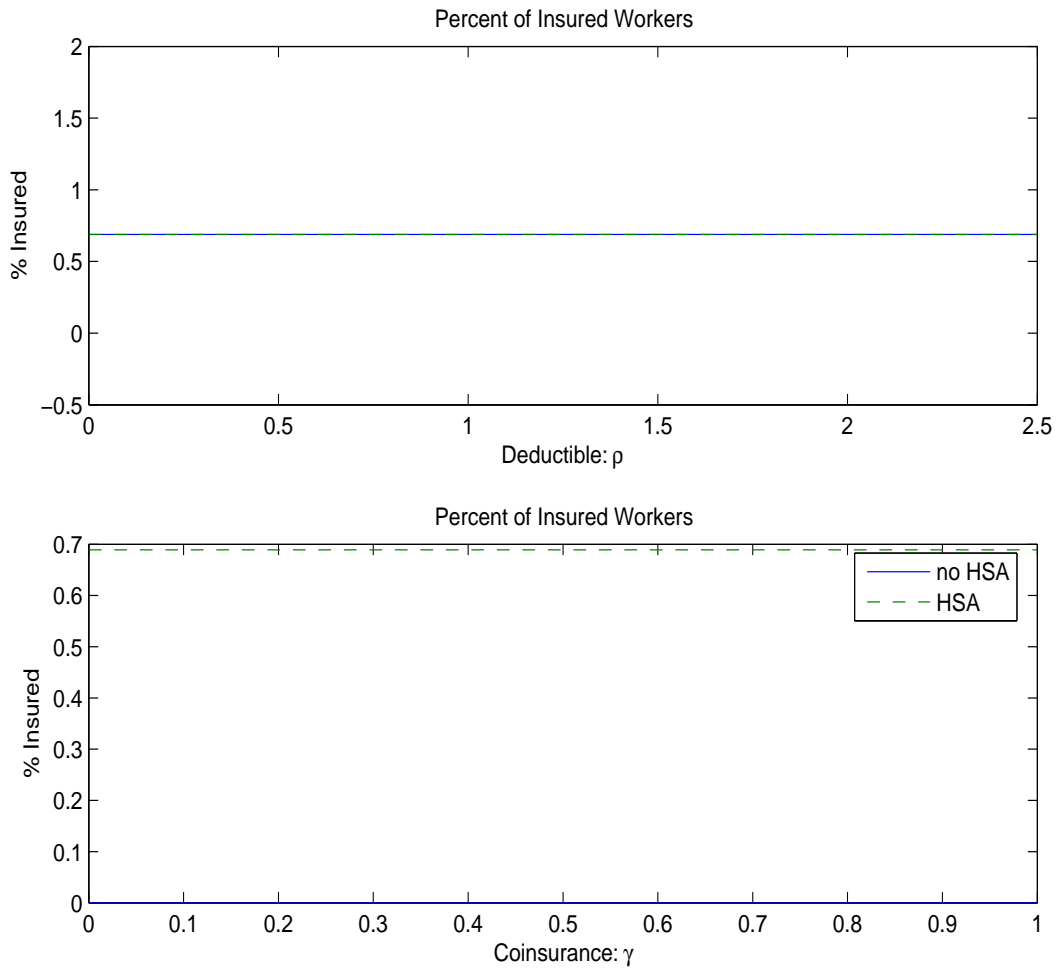


Figure 6: Change in the fraction of insured workers due to changes in the deductible ρ and changes in the coinsurance rate γ .

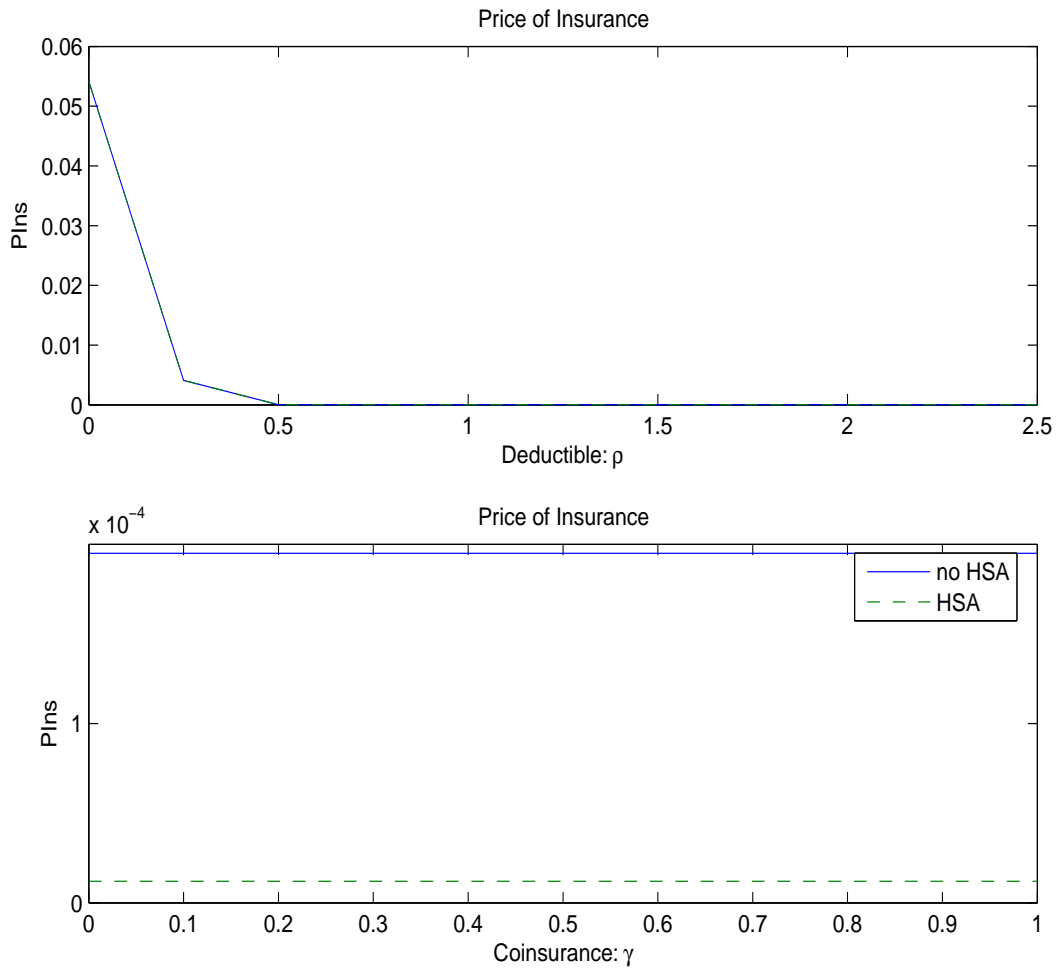


Figure 7: Change in the price of insurance P^{Ins} due to changes in the deductible ρ and changes in the coinsurance rate γ .

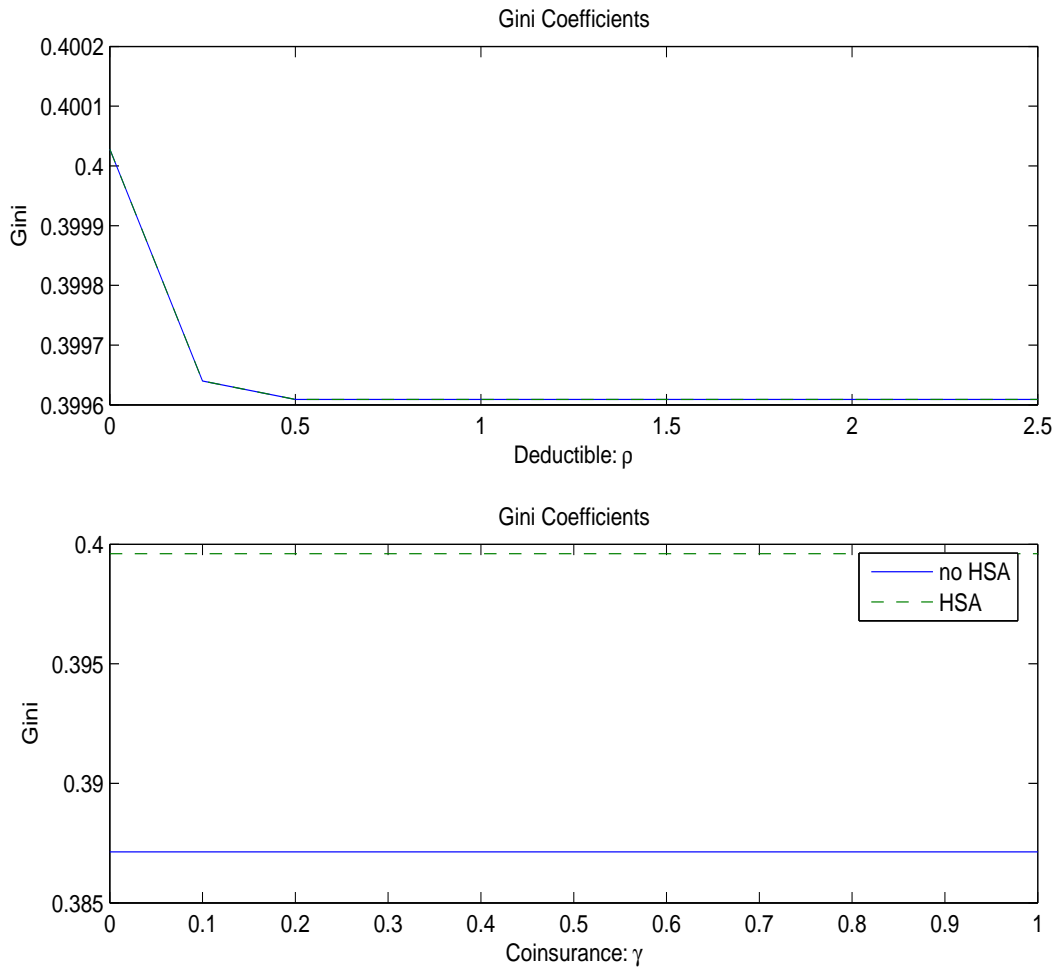


Figure 8: Change in the Gini coefficient due to changes in the deductible ρ and changes in the coinsurance rate γ .

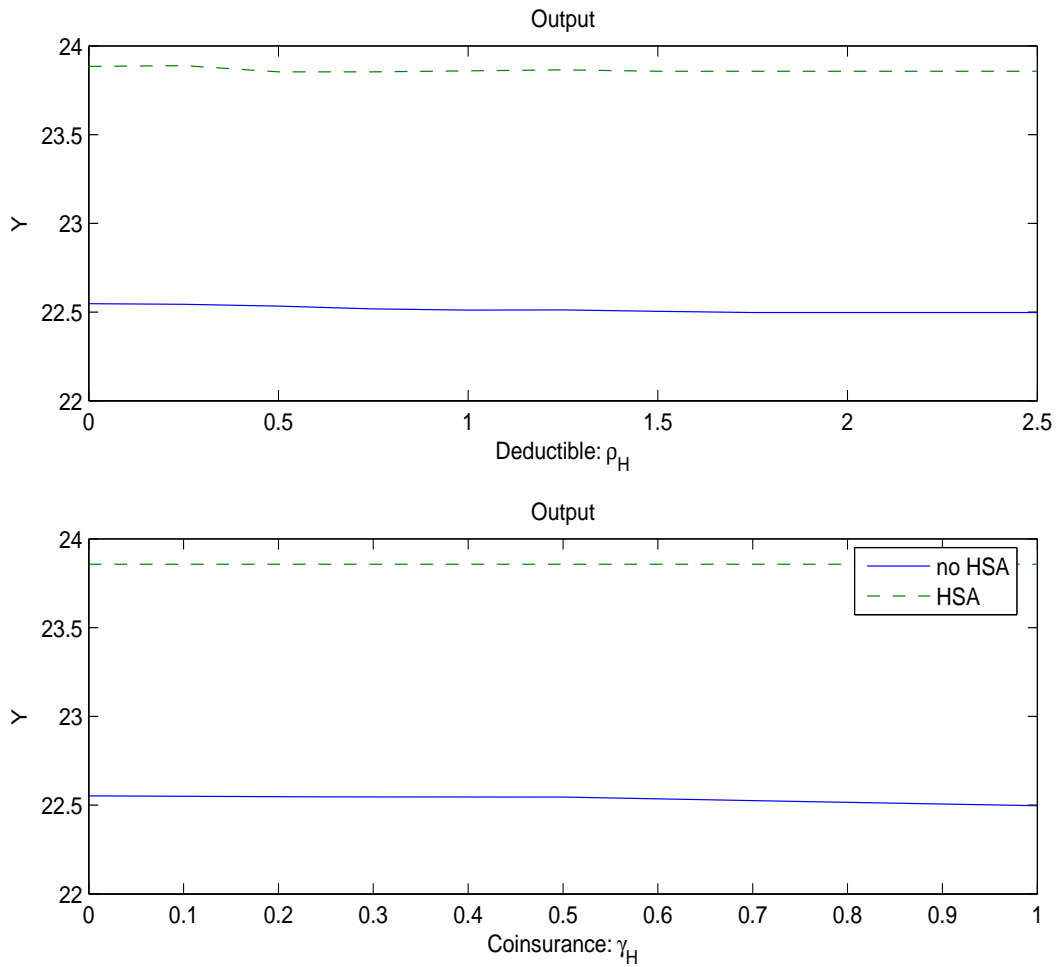


Figure 9: Choice between low and high deductible insurance. Change in aggregate output Y due to changes in the deductible ρ' and changes in the coinsurance rate γ' .

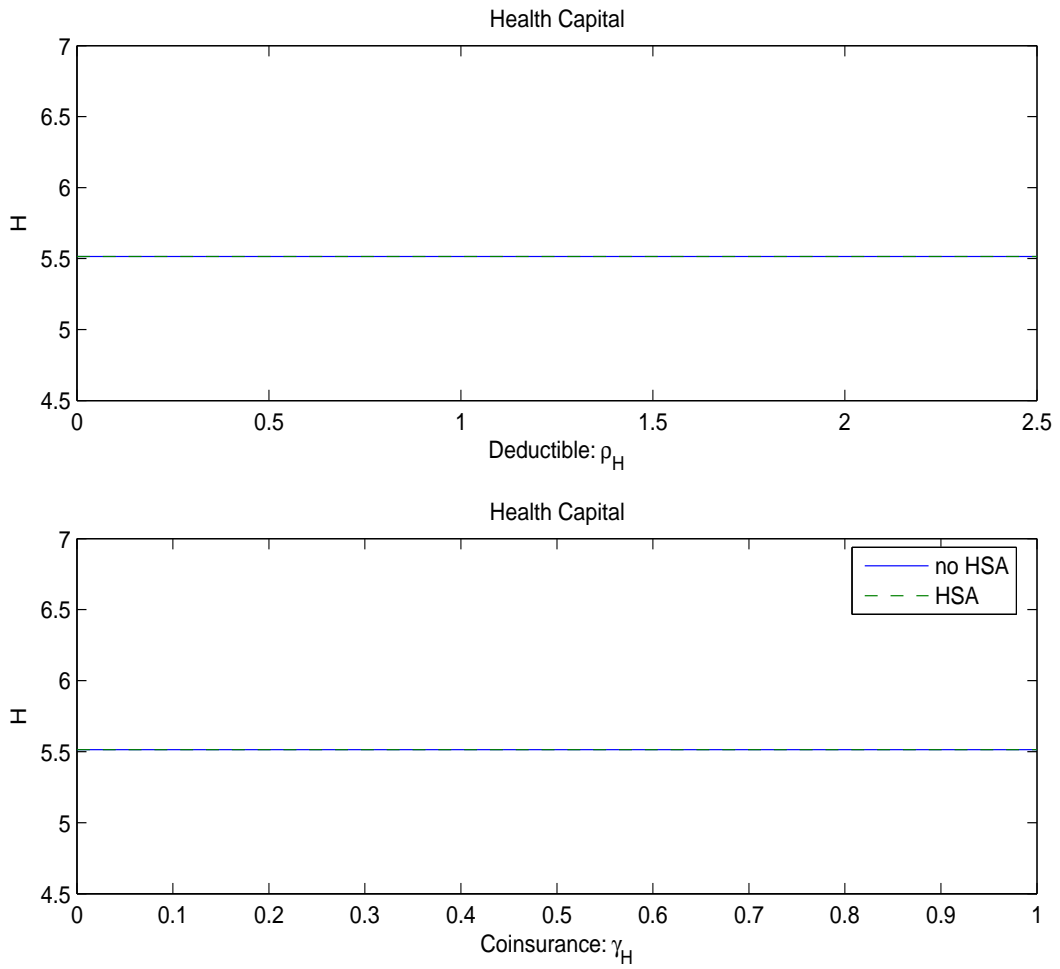


Figure 10: Choice between low and high deductible insurance. Change in aggregate health capital H due to changes in the deductible ρ' and changes in the coinsurance rate γ' .

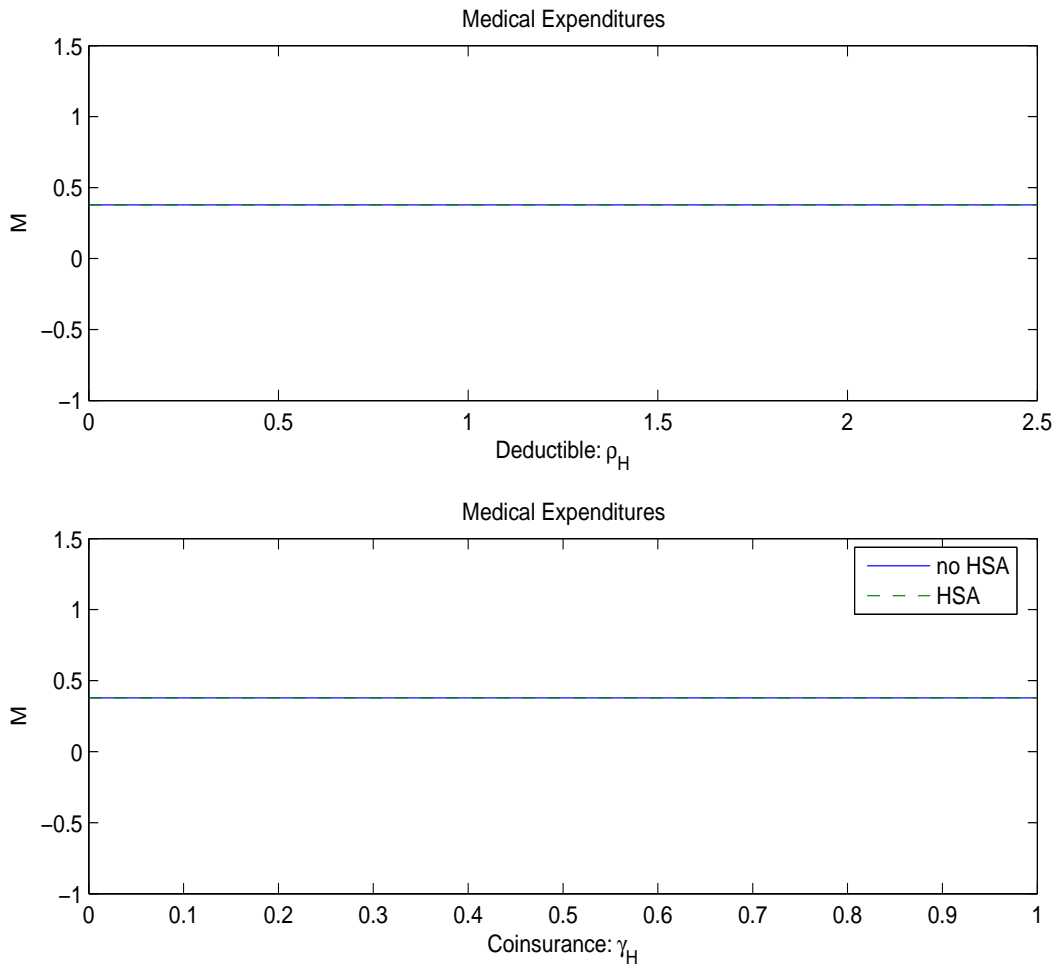


Figure 11: Choice between low and high deductible insurance. Change in aggregate medical expenditures M due to changes in the deductible ρ' and changes in the coinsurance rate γ' .

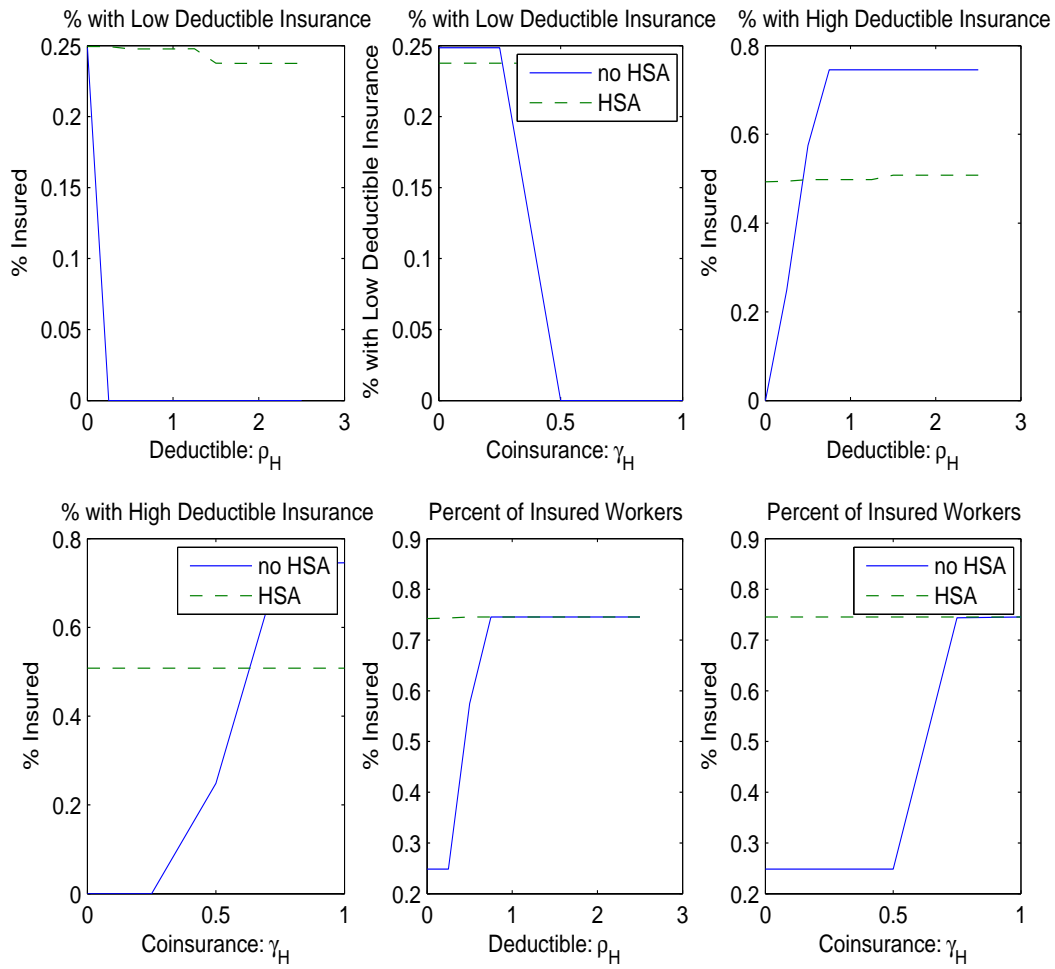


Figure 12: Choice between low and high deductible insurance. Change in the fraction of insured workers due to changes in the deductible ρ' and changes in the coinsurance rate γ' .

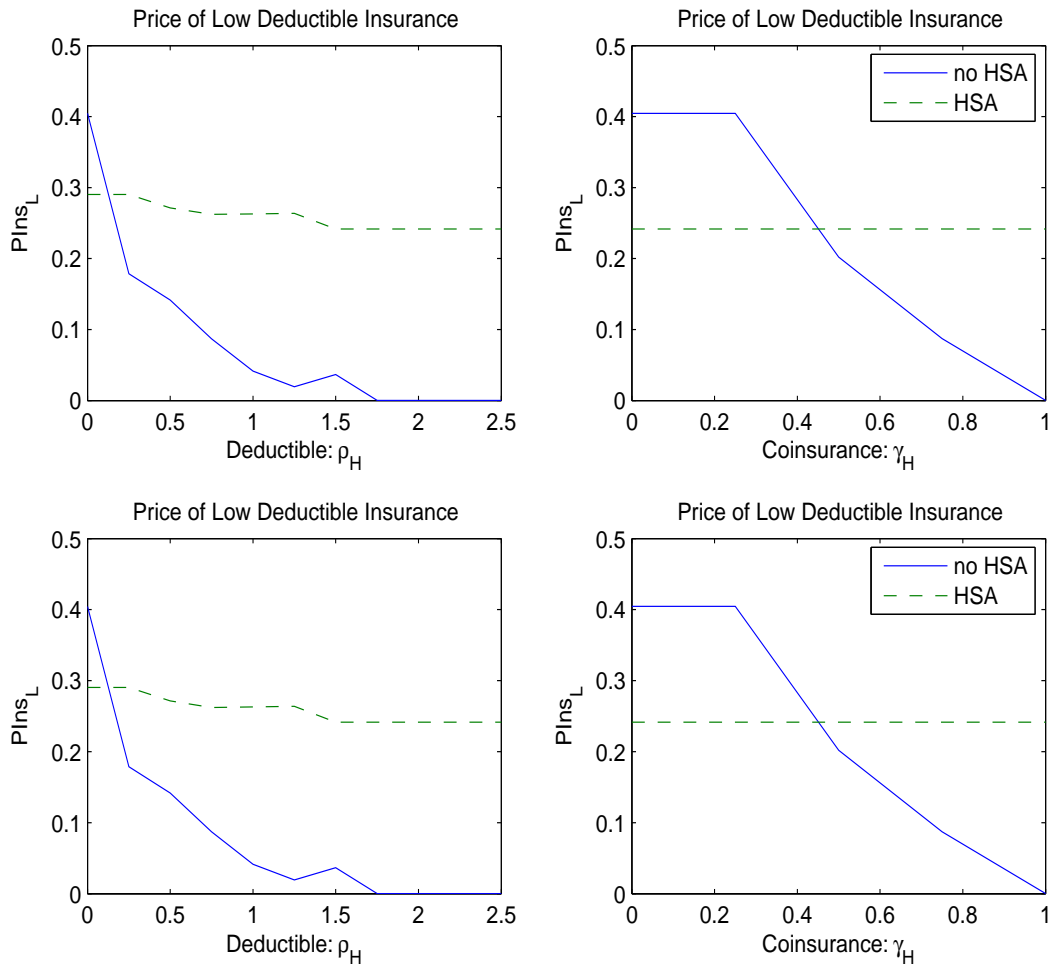


Figure 13: Choice between low and high deductible insurance. Change in the price of insurance P^{Ins} due to changes in the deductible ρ' and changes in the coinsurance rate γ' .

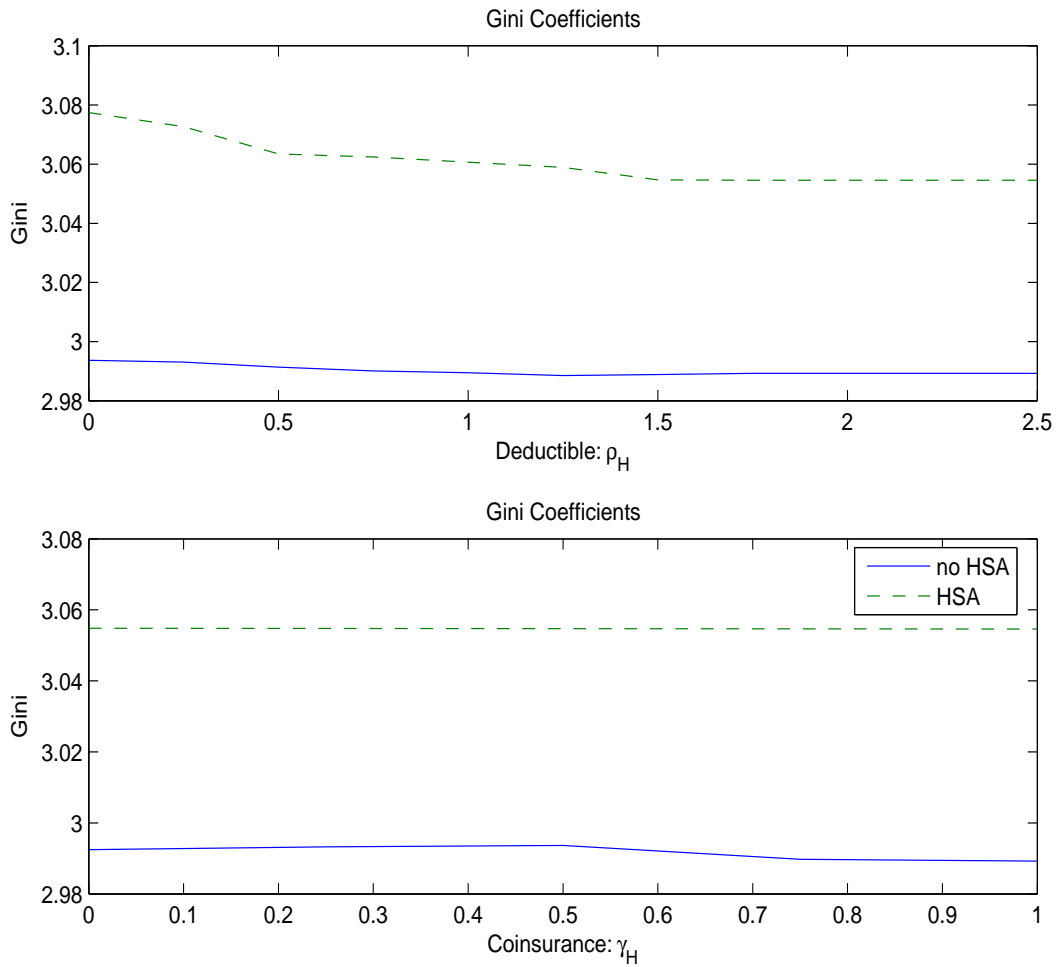


Figure 14: Choice between low and high deductible insurance. Change in the Gini coefficient due to changes in the deductible ρ' and changes in the coinsurance rate γ' .