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Abstract

We analyze whether a consumer driven health care plan like the newly established Health Savings Accounts (HSAs) can reduce health care expenditures in the United States and increase the fraction of the population with health insurance. Unlike previous literature, our analysis relies on a dynamic general equilibrium framework with heterogenous agents. We endogenize health care expenditure and insurance choice, so that the model fully accounts for feedback effects from both factor markets and insurance markets. We then highlight the importance of including general equilibrium effects into the policy analysis. Specifically, our results from numerical simulations indicate that the success of HSAs depends critically on the productivity of health and the annual contribution limit to HSAs. In addition, we find that taxpayers can face substantial costs when HSAs are introduced to insure more people and to curb aggregate health expenditures.

JEL: H51, I18, I38

Keywords: Health Savings Accounts, Consumer Driven Health Care Plans, Health Insurance, Privatization of Health Care, General Equilibrium Health Uncertainty Model, Numerical Simulation of Health Care Reform

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1 Introduction

In 2003 about 250 million Americans became eligible to save tax free for their health care expenses in Health Savings Accounts (HSAs) via the Medicare Prescription Drug, Improvement, and Modernization Act. HSAs were introduced with two main goals in mind. The first goal was to control the rise in health expenditures, and the second goal was to increase the number of Americans with health insurance.

Can HSAs deliver on these goals? Evidence is sparse, and the discussion has become increasingly polemic. Proponents of HSAs hail consumer driven health care plans as the panacea to the health care problem in the United States (Goodman (2004)[1]), whereas opponents discredit the idea as "more tax cuts for the rich" (Burman and Blumberg (2003)).[2]

Since data is sparse, research on HSAs has focused on micro-simulations and partial equilibrium models (e.g. Keeler, Malkin, Goldman and Buchanan (1996), Ozanna (1996), Zabinski, Selden, Moeller and Banthin (1999), Pauly and Herring (2000), and Cardon and Showalter (2007)) and concentrated on moral hazard and adverse selection of the insurance component of HSAs.[3] This literature is inconclusive as to whether HSAs will decrease total health expenditures. Estimates range from decreases in total health expenditures of 8% to increases in total health expenditures of 1%. Insurance coverage issues have been addressed in GAO (2006) and Greene, Hibbard, Dixon and Tusler (2006). Their results seem to indicate that healthier and higher income households will be more likely to save in HSAs.

While there is an emerging empirical literature on the effects of HSAs, we find a paucity of economic models that address the macroeconomic implications of reforming the U.S. health care system with HSAs. In this paper we argue that the effects of HSAs should be analyzed in a general equilibrium framework for several reasons. First, a HSA is a tax-favored savings account with the potential to induce agents to save more (see Imrohoroglu, Imrohoroglu and Joines (1998)). The general equilibrium framework fully accounts for changes in capital accumulation, the market wage rate, interest rates, as well as changes in income. The latter will have impacts on the demands for health insurance and medical services. We call this the *savings effect.* Second, the introduction of HSAs will affect the investment into the production of health. If health is associated with labor productivity and spending on health is an investment as argued in Grossman (1972*b*), human capital formation will be affected. Changes in human capital will also influence market prices, individual incomes and the respective demands for health insurance and medical services. We call this the *human capital effect.* These economic mechanisms arise naturally in the general equilibrium framework and have therefore been unexplored by the empirical literature and the literature concentrating on partial equilibrium models. In this paper we explore the economic mechanism underlying HSAs and to what extent these two general equilibrium channels determine whether or not HSAs can deliver on their goals.

To that end, we use a dynamic general equilibrium overlapping generations model that includes the following features. First, we introduce health as a consumption and investment good and explicitly model the health production process. Second, we incorporate individual insurance choices and private and public health insurance markets. We then model the most important institutional features of HSAs.[4] This framework allows us to make statements about

[1] Compare also the publications of the National Center for Policy Analysis (NCPA) at http://www.ncpa.org/pub/ba/ba464/

[2] See also the more critical views in Hsiao (1995), Hsiao (2001) and Barr (2001).

[3] Four countries have implemented HSAs so far – Singapore, South Africa, China (experimental stage), and the United States. We present a brief summary of the literature on HSAs in these countries in Appendix B, which is available on the authors' website at: http://pages.towson.edu/jjung/papers/hsa_appendixB.pdf

[4] Macroeconomic frameworks that model tax sheltered savings accounts or endogenous health capital formation, but not both, include Hubbard, Skinner and Zeldes (1995), Imrohoroglu, Imrohoroglu and Joines (1998),

endogenous health insurance choices, the formation of health insurance premiums, and aggregate spending on health. In addition, it allows us to study the general equilibrium effects of physical capital accumulation and human capital formation. Our model also explicitly accounts for general equilibrium effects from price changes in factor markets and insurance markets on savings and health care expenditures.

The model predicts that the success of HSAs depends critically on the productivity of health, which governs the *human capital effect*, and the annual contribution limit to HSAs, which governs the *savings effect*. HSAs create two opposing effects on the accumulation of production factors and output. Depending on the relative strength of these two effects, we can either observe a decrease or an increase in output, which translates into a decrease or an increase in household income. If the income effect is negative enough, some agents will decide to opt out of buying health insurance and therefore demand fewer health services. Aggregate spending on health will then decline. If, on the other hand, the income effect is positive enough, more agents will start buying health insurance and consequently demand more health services. In that case aggregate spending on health increases.

The details of the economic mechanism in the model can be described as follows: (*i*) the introduction of HSAs make high deductible health insurances more attractive to households, (*ii*) high deductible health insurances increase the effective price of medical services for holders of such a policy so that the demand for health services decreases, (*iii*) lower demand for medical services decreases the health levels of households, (*iv*) if health is not productive in the formation of human capital, then human capital will be unaffected by changes in medical spending; if, on the other hand, health is a productive factor in the formation of human capital, then human capital will decrease as a result of reduced spending on health care, (*v*) physical capital increases due to the tax free savings in HSAs, (*vi*) the net effect of (*iv*) and (*v*) determines whether output increases or decreases, finally (*vii*) depending on the income effect from aggregate output, either a larger or a smaller number of households buys health insurance.

In our policy experiments, we first shut down the *human capital effect* assuming that health is unproductive so that we can isolate the *savings effect*. We calibrate this version of the model to the U.S. economy and then introduce HSAs into this framework. We find that the positive savings effect does not allow for a reduction of total health expenditure in the economy. If we increase the annual savings limit in HSAs, we find that more people will buy health insurance and spending for health care increases. Next, we phase in the human capital effect into the model by allowing health to play a productive role in the model. We find that if health becomes more productive, the positive savings effect from HSAs is counterbalanced by a negative human capital effect. The equilibrium outcome is that people spend less on health care due to the high deductible insurances that come with HSAs. We are able to identify the range of health productivity where HSAs decrease aggregate health expenditure and increase the fraction of people with health insurance. If, however, health is "very" productive, then the negative human capital effect outweighs the positive savings effect, so that agents end up with lower income. The latter leads to fewer people buying health insurance, so that HSAs only deliver on the first goal of decreasing aggregate spending on health.

Finally, we find that the price the government has to pay for insuring more people and curbing total health expenditure with HSAs, can be substantial. After introducing HSAs, the government has to raise up to 3% of GDP in additional tax revenue in order to finance the old level of government consumption.

Palumbo (1999), Jeske and Kitao (2005), and Suen (2006). Models addressing the effects of Medicare on labor supply, retirement decisions, and moral hazard include Rust and Phelan (1997), Gilleskie (1998), French and Jones (2004), Khwaja (2002), and Khwaja (2006).

Our key contribution to the literature is to show the importance of the general equilibrium effects in determining whether or not the introduction of HSAs are able to deliver on their goals. We are also able to identify substantial differences between partial equilibrium outcomes and general equilibrium outcomes. In addition, our paper is the first attempt to incorporate health insurance choice and endogenous health spending in an overlapping generations framework. Our results carry policy implications. That is, a meaningful policy analysis must consider the general equilibrium effects of HSAs before drawing conclusions about the potential success or failure of HSAs in reducing total health expenditure and increasing the number of insured individuals.

In the next section, we describe the institutional details of HSAs. In section 3 we introduce our model and define the equilibrium. We address the calibration of the benchmark economy without HSAs in section 4. The results of our policy experiment are described in section 5. We conclude our findings in section 6. Appendix A contains all tables and figures. Appendix B contains a brief history of HSAs in the U.S. and describes the experience of Singapore, China, and South Africa with HSAs. Furthermore, Appendix B discusses the solution algorithm, explains the estimation technique for health shock transition probabilities, and summarized additional results from our policy experiments.[5]

2 Health Savings Accounts

An HSA is similar to a Flexible Spending Account (FSA), Health Reimbursement Account (HRA), Individual Retirement Account (IRA), or 401(k) in the sense that funds are deposited into the account out of pretax income and interest accumulates tax free. HSAs can only be established in conjunction with a qualified High Deductible Health Plan (HDHP). A qualified HDHP must have at least a $1,100 deductible for an individual ($2,200 for a family). Any individual who is covered by an HDHP, not covered by other health insurance, not enrolled in Medicare, and not claimed as a dependent on someone else's tax return is eligible for an HSA. Contributions can be made by either the employer, the employee, or both, but the HSA is owned by the employee. The maximum annual contribution is $2,850 for an individual ($5,650 for a family). Distribution of the funds is tax-free if taken for "qualified medical expenses" (which now includes over-the-counter drugs). Unused funds are rolled over at the end of the year. Currently, funds cannot be used tax-free to pay premiums of health insurance with some exceptions. Funds withdrawn for non-medical purposes are subject to a 10% penalty tax (except in cases of death, disability, or Medicare eligibility) and regular income tax. After the account holder turns 65, the 10% tax penalty no longer applies. In case of death the HSA can be transferred tax-free to a spouse.[6]

3 The Model

3.1 Demographics

We use an 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. The population grows exogenously at an annual net rate n. We assume stable demographic patterns, so that similar to Huggett

[5] Appendix B is available on the authors' website at: http://pages.towson.edu/jjung/papers/hsa_appendixB.pdf

[6] Appendix B contains all institutional details of HSAs and the important differences to the alternative forms of tax sheltered savings.

(1996), age j agents make up a constant fraction μ_j of the entire population at any point in time.

The relative sizes of the other generations alive μ_j is recursively defined as

$$\mu_j = \frac{\pi_j}{(1+n)^{\frac{years}{J}}} \mu_{j-1},$$

where $years$ denotes the number of years modeled. The relative size of agents dying each period (conditional on survival up to the previous period) can be defined similarly as

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

3.2 Preferences

The consumer values consumption and health, so that the within period preferences are

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

where c is consumption, h is the health stock, η_j is the age dependent intensity parameter of consumption, and σ is the inverse of the relative risk aversion parameter.

3.3 Production of Health

We use the idea of health capital as introduced in Grossman (1972*b*). In this economy there are two commodities: a consumption good c and medical services m. The consumption good is produced via a neoclassical production function that is described later. We do not model the production sector for medical services. Each unit of consumption good can be transformed into $\frac{1}{p_m}$ units of medical care. All medical care is used to produce new units of health. The accumulation process of health is given by

$$h_j = \phi_j m_j^{\xi} + (1 - \delta(h_j)) h_{j-1} + \varepsilon_j, \tag{1}$$

where h_j denotes the current health status, $\phi_j m_j^{\xi}$ denotes the production of new health with inputs of medical care m_j and parameters $\xi > 0$, ϕ_j being an age dependent productivity parameter, and $\delta(h_j)$ 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 larger the health depreciation becomes. Finally, ε_j is an age dependent health shock, where $\varepsilon_j \leq 0$. The relative price of health and consumption can be expressed as $p_m\left(\frac{1}{\phi\xi} m^{1-\xi}\right)$, where the term in brackets is the marginal contribution to health of an additional unit of health care.[7]

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 endogenous total medical expenses. Our setup assumes that given the same magnitude of health shock ε_j, a richer individual will outspend a poor individual. This may be realistic in some circumstances. However, a large fraction of health expenditures are probably non-discretionary (e.g. health expenditures caused by a catastrophic health event that requires surgery etc.). In

[7] Compare Suen (2006) for a similar formulation.

such cases a poor individual could still incur large health care costs. We do not cover this case in the current model.

Exogenous health shocks ε_j follow a Markov process with age dependent transition matrix P_j. Transition probabilities from one state to the next depend on the past health shock ε_{j-1} so that an element of transition matrix P_j is defined as

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

3.4 Human Capital Profile

Effective human capital over the life-cycle evolves according to

$$e_j = \left(e^{\beta_0+\beta_1 j+\beta_2 j^2}\right)^{\chi}\left(h_{j-1}^{\theta}\right)^{1-\chi} \quad \text{for} \quad j = \{1, ..., J_1\}, \tag{2}$$

where $\beta_0, \beta_2 < 0$, $\beta_1 > 0$ and $\chi \in [0,1]$. This mimics a hump-shaped income process over the life-cycle and makes the wage income of agents dependent on their health state as well. This expression says that an otherwise identical individual will be more productive and have higher income if she has relatively better health (e.g. fewer sick days, better job matching because job provided health insurance is less of an issue for a healthy individual, better career advancement of healthy individuals, etc.).

Tuning parameter θ allows us to gradually diminish the influence of health on the production process and individual household income, holding the exogenous age dependent component fixed. This parameter determines to what degree health is an investment good.

3.5 Health Insurance and Out-of-Pocket Medical Expenses

We do not distinguish between group insurance (employer provided) and individual insurance (bought by individuals in the private insurance market). We therefore combine elements of group insurance (e.g. tax deductibility of premium payments) with elements from the individual insurance market (e.g. screening by age) in order to make a statement about the entire private insurance market.

In the model, the working agent can decide between a low deductible health insurance, a high deductible health insurance, or no health insurance. These health insurances are employer provided so that health insurance premiums are tax deductible. In addition, we assume that health insurance companies can screen the worker by age but not by health status.[8]

We can interpret the model as if the employee can choose to work for three different types of employers. Employer one is offering a low deductible health insurance via an insurance company, employer two is offering a high deductible health insurance via a different insurance company, and employer type three offers no health insurance. The tax deductible health insurance premium that enters the workers budget constraint together with the wage income can then be interpreted as the effective wage income. As a consequence, an employee with a health insurance package receives a lower effective wage than an employee working a job without health insurance. Since we do not model employer matching, we abstract from these details and simply claim that the employee can make the employment and insurance type choice. This

[8] We are aware that employers are not allowed to discriminate according to health status or age when offering health insurance. However, we think this is still an acceptable assumption. Between 2000 and 2002, older workers experienced rising unemployment rates that were greater in relative magnitude than those for younger workers over the same period (Six (2003)). This suggests that older worker are more likely to lose their employer provided health insurance. They are then forced to buy insurance in the individual market, where they have to pay higher premiums because of their age.

also allows us to only have one representative firm that pays one wage rate. Employees then decide on their efficiency wage by deciding which insurance they want to have.

Insurance companies offer two types of health 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 premiums are tax deductible.

In order to be insured against a health shock, households have to buy insurance one period prior to the realization of their health shock. Agents in their first period of life are thus not covered by any insurance. We distinguish between three possible insurance states, $in_{j-1} = \{1, 2, 3\}$, where $in_{j-1} = 1$ is the state of having a low deductible health insurance in period j, $in_{j-1} = 2$ denotes the high deductible health insurance in period j and $in_{j-1} = 3$ indicates that the agent has no health insurance in period j. The working household's out of pocket health expenditure is therefore denoted as

$$o^W(m_j) = \begin{cases} \min\left[p_{m,Ins}m_j, \rho + \gamma\left(p_{m,Ins}m_j - \rho\right)\right] & \text{if } in_{j-1} = 1 \\ \min\left[p_{m,Ins}m_j, \rho' + \gamma'\left(p_{m,Ins}m_j - \rho'\right)\right] & \text{if } in_{j-1} = 2 \\ p_{m,noIns}m_j & \text{if } in_{j-1} = 3 \end{cases} \quad \text{for } j \leq J_1,$$

where $p_{m,Ins}$ is the relative price of health expenditures paid by insured workers and $p_{m,noIns}$ is the price of health expenditures paid by uninsured workers. An uninsured worker pays a higher price $p_{m,noIns} > p_{m,Ins}$. The copayment rate γ is the fraction the household pays after the insurance company pays $(1-\gamma)$ of the post deductible amount $p_{m,Ins}m_j - \rho$. Since households have to buy insurance before health shocks are revealed we assume that working households in their last period $j = J_1$ already decide to buy into Medicare.

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 $\left(1-\gamma^{Med}\right)$ of the health expenditures that exceed the amount of the deductible ρ^{Med}. The total out of pocket expenditures of a retiree are

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

where $p_{m,Med}$ is the price of health expenditures that retirees with Medicare have to pay. 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.[9]

3.6 Health Savings Accounts

If agents buy a high deductible health insurance they can decide on the amount of assets a_j^m they want to carry tax free into the next period at the market interest rate. Agents can only contribute to their HSA when they are younger than 65. Agents can pay their out-of-pocket medical expenses $o(m_j)$ directly with savings from their HSAs. If they oversave in HSAs they can roll over the account balance into the next period.[10] Savings accumulate tax free.

If agents decide to use funds from the HSA to pay for non qualified health expenses, they have to pay a tax penalty at rate τ^m and forgone income tax. This penalty only applies to

[9] According to the Medical Expendiure Panel Survey (MEPS) 2001, only 15% of total health expenditures of individuals older than 65 are 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.

[10] This feature distinguishes HSAs from Flexible Spending Accounts (FSAs).

agents younger than 65 years. Agents older than 65 can use the money in their HSA for non-health related expenses without having to pay the tax penalty τ^m. However, they have to pay income taxes on income spent in this way. An 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 HSAs.

If they undersave and the funds in the HSAs do not cover all medical expenses, then the household has to use standard savings income to finance her residual medical expenses and consumption when old. In addition, there is an upper limit on the annual contribution to an HSA which we denote $\bar{s}^m$.[11]

3.7 Households

Age j year old agents enter the period with state vector $x_j = \left(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j\right)$, where a_{j-1} is the capital stock at the beginning of the period , a_{j-1}^m is the capital stock accumulated in HSAs at the beginning of the period, h_{j-1} is the health state at the beginning of the period, in_{j-1} is the insurance state in period j (chosen by the agent in the previous period $j-1$), and $\varepsilon_j \in \{\varepsilon_{1j}, \varepsilon_{2j}, \varepsilon_{3j}, \varepsilon_{4j}, \varepsilon_{5j}\}$ is one of five possible negative health shocks where $0 \geq \varepsilon_{1j} > \varepsilon_{2j} > ..., \varepsilon_{5j}$.

The state vector of a household (not counting age j) is defined as

$$x_j = \begin{cases} \left(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j\right) \in R_+ \times R_+ \times R_+ \times In^w \times R_- = D \text{ if } j \leq J_1, \\ \left(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j\right) \in R_+ \times R_+ \times R_+ \times In^R \times R_- = D \text{ if } j > J_1, \end{cases}$$

where $In^W = \{1, 2, 3\}$ and $In^R = \{1, 2\}$. Retired agents have only two insurance states, $In^R = 1$ they have Medicare Plan B and $In^R = 2$ they don't have Medicare Plan B. The latter is only an option in their first period of retirement. Thereafter all retirees are forced to have Medicare Plan B, so that $in_{j-1} = 1$, for $j > J_1 + 1$. For each $x_j \in D(x_j)$ let $\Lambda(x_j)$ denote the measure of age-j agents with $x_j \in D$. The fraction $\mu_j \Lambda(x_j)$ then denotes the measure of age-j agents with $x_j \in D$ with respect to the entire population of agents in the economy.

3.7.1 Workers

Agents receive income in the form of wages, interest income, accidental bequests, and social insurance. The latter guarantees a minimum consumption level of $\underline{c}$. After health shocks are realized, agents simultaneously decide their consumption c_j, stocks of capital for the next period a_j, and health expenditures m_j. They also pick the insurance state for the next period $in_j = \{1, 2, 3\}$, which requires them to pay a premium p_j for $in_j = 1$, p_j' for $in_j = 2$, or nothing for $in_j = 3$.

If agents decide to buy a high deductible insurance, i.e. if $in_j = 2$, then they are eligible to hold a_j^m in an HSA. If they do not purchase a high deductible insurance for the following period, then they are not eligible for HSAs anymore and they have to dissolve their existing HSAs completely.[12]

[11] The contribution limit to HSA for 2007 for individuals is \$2,850. Compare http://www.treas.gov/offices/public-affairs/hsa/07IndexedAmounts.shtml

[12] This is a simpifying assumption. What the law actually states is that if the policy holder ends her participation in the HDHP (High Deductible Health Plan), she loses eligibility to deposit further funds, but funds already in the HSA remain available for use. Since our period is actually 9 years long, we think that the assumption that the agent has to completely dissolve the account in that period is not too strong.

In their last period of work, agents decide whether to buy into Medicare Plan B. We make the assumption that premium payments for Medicare Plan B are not tax deductible and that agents can only continue to save in HSAs if they buy into Medicare Plan B. We later calibrate the model so that all workers in their last period buy into Medicare Plan B.[13]

With HSAs we have to distinguish in each period between agents who contribute to HSAs and those who take funds out of HSAs. Among those who do not contribute each period, we have to further distinguish between those that use these funds for health related expenses and those that use them for consumption. The latter have to pay a penalty tax τ^m when they are younger than 65 years old. In addition, they have to pay forgone income tax on funds withdrawn for non-qualified expenses.

The household problem for young agents $j = \{1, ..., J_1 - 1\}$ who are net contributors can be formulated recursively as

$$V_j\left(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j\right) = \max_{\left\{c_j, m_j, a_j, a_j^m, in_j\right\}} \left\{u\left(c_j, h_j\right) + \beta \pi_j E_\varepsilon\left[V_{j+1}\left(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}\right) | \varepsilon_j\right]\right\} \quad s.t. \tag{3}$$

$$\begin{aligned}
& c_j + a_j + 1_{\{in_j=2\}} a_j^m + o^W\left(m_j\right) + 1_{\{in_j=1\}} p_j + 1_{\{in_j=2\}} p_j' \\
= {} & \tilde{w}_j + R\left(a_{j-1} + T^{Beq}\right) + R^m a_{j-1}^m - Tax_j + T_j^{SI}, \\
h_j = {} & \phi_j m_j^\xi + \left(1 - \delta\left(h_j\right)\right) h_{j-1} + \varepsilon_j, \\
0 \leq {} & NI_j \leq \bar{s}^m, \\
0 \leq {} & a_j, a_j^m,
\end{aligned}$$

where

$$o^W\left(m_j\right) = \begin{cases} \min\left[p_{m,Ins} m_j, \rho + \gamma\left(p_{m,Ins} m_j - \rho\right)\right] & \text{if } in_{j-1} = 1, \\ \min\left[p_{m,Ins} m_j, \rho' + \gamma'\left(p_{m,Ins} m_j - \rho'\right)\right] & \text{if } in_{j-1} = 2, \\ p_{m,noIns} m & \text{if } in_{j-1} = 3, \end{cases}$$

$$NW_j = R^m a_{j-1}^m - o^W\left(m_j\right), \tag{4}$$

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

$$\tilde{w}_j = \left(1 - 0.5\tau^{Soc} - 0.5\tau^{Med}\right) w e_j, \tag{5}$$

$$Tax_j = \tilde{\tau}\left(\tilde{y}_j^W\right) + 0.5\left(\tau^{Soc} + \tau^{Med}\right)\left(\tilde{w}_j - 1_{\{in_j=1\}} p_j - 1_{\{in_j=2\}} p_j'\right),$$

$$\tilde{y}_j^W = \tilde{w}_j + r a_{j-1} + R T^{Beq} - NI_j,$$

$$T_j^{SI} = \max\left[0, \underline{c} + Tax_j - \tilde{w}_j - R\left(a_{j-1} + T_j^{Beq}\right) - \left(R^m a_{j-1}^m - o^W\left(m_j\right)\right)\right].$$

Variable c_j is consumption, a_j is next period's capital stock,[14] a_j^m is next period's capital stock

[13] Although Medicare Plan B payments are itemizable as qualified medical expenses in the income tax statement, there is the additional provision that says that only medical payments that exceed 7.5% of the adjusted gross income (Form 1040, line 38) are tax deductible. Compare the IRS publication at: http://www.irs.gov/publications/p502/ar02.html#d0e299

What we implicityly assume here is that Medical expenses do not exceed this limit and therefore premiums for Medicare are not tax deductible.

[14] Agents are borrowing constrained, in the sense that that $a_j \geq 0$. Without a borrowing constraint households would make the maximum allowable contribution to their HSAs if interest rates were fully tax deductible (this was possible until 1986). Borrowing constraints can either be modeled as a wedge between the interest rates on

in HSAs, $\bar{s}^m$ 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 insurance premium for the low deductible health insurance, p'_j is the insurance premium for the high deductible health insurance, $\tilde{w}_j$ is wage income net of the employer contribution to Social Security and Medicare, R is the gross interest rate paid on assets a_{j-1} from the previous period and accidental bequests T_j^{Beq}, Tax_j is total taxes paid[15] 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 $\tilde{\tau}\left(\tilde{y}_j^W\right)$ leads to a double taxation of a portion of wage income due to the flat payroll tax $0.5\left(\tau^{Soc}+\tau^{Med}\right)\tilde{w}_j$ that is added. This mimics the institutional feature of income and payroll taxes.[16]

NW_j is net wealth in the HSA after subtracting out-of-pocket health expenses, NI_j is net investment in the HSA, we_j is the effective wage income. The function $\tilde{\tau}\left(\tilde{y}_j^W\right)$ captures progressive income tax, $0.5\left(\tau^{Soc}+\tau^{Med}\right)\tilde{w}_j$ 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 assets and accidental bequests. We subtract net contributions NI_j to HSAs because they are tax deductible.

For net contributors it has to hold that $NI_j \geq 0$, that is, next periods funds a_j^m in the HSA 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 that can be financed with HSA funds).

For net non-contributors the corresponding constraints are

$$\begin{aligned} NI_j &< 0, \\ Tax_j &= \tilde{\tau}\left(\tilde{y}_j^W\right)+0.5\left(\tau^{Soc}+\tau^{Med}\right)\left(\tilde{w}\left(\varepsilon_j\right)-1_{\{in_j=1\}}p_j-1_{\{in_j=2\}}p'_j\right)-\tau^m NI_j, \end{aligned}$$

with all other constraints being the same as for contributors. 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 $\tau^m NI_j$. In addition they pay the forgone income tax, since the term NI_j is negative and enters the base for taxable income $\tilde{y}_j^W$.

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.[17]

borrowing and lending, or a threshold on the minimum asset position. See also Imrohoroglu, Imrohoroglu and Joines (1998) for a further discussion.

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

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

where ψ is the fraction of the premium paid for by the employer. Jeske and Kitao (2005) use a similar formulation to model private vs. employer provided health insurance. They pick $\psi = 0.85$ based on MEPS data in 1997. We simplify this aspect of the model and assume that all health insurance policies are offered via the employer and that the employee pays the entire premium, so that $\psi = 0$. The premium is therefore tax deductible in the employee (or household) budget constraint.

[16] Compare Social Security Tax Reform (Art#3).

[17] The stipulations for Medicaid eligibility encompass maximum income levels but also maximum wealth levels. Some individuals who fail to be classified as 'categorically needy' because they have to much savings could still

Agents can only buy insurance if they have sufficient funds to do so, that is whenever

$$\begin{aligned} p_j &< \tilde{w}_j + R\left(a_{j-1} + T_j^{Beq}\right) + R^m a_{j-1}^m - o^W(m_j) - Tax_j, \text{ or} \\ p_j' &< \tilde{w}_j + R\left(a_{j-1} + T_j^{Beq}\right) + R^m a_{j-1}^m - o^W(m_j) - Tax_j. \end{aligned}$$

The social insurance program will not pay for their health insurance. In their last working period J_1 agents decide whether to buy Medicare insurance or not. This determines their insurance state in the first period of retirement. Agents have to enrol in Medicare in order to keep their HSAs. From $J_1 + 1$ onwards, all agents are forced into Medicare.

3.7.2 Retired Agents

Retired agents in their first period of retirement are insured under Medicare if workers in their last period decided to buy into Medicare Plan B. From then onwards we force retirees to buy into Medicare insurance until they die. 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. However, if the individual uses HSA funds for non-health related expenditures, she has to pay income tax. Retirees can pay the Medicare insurance premium p^{Med} with funds from the HSA.

The household problem for a retired agent $j \geq J_1 + 1$ who is a non-contributor and pays no penalty can be formulated recursively as

$$\begin{aligned} V_j\left(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j\right) &= \max_{\{c_j, m_j, a_j, a_j^m\}} \left\{u(c_j, h_j) + \beta \pi_j E_\varepsilon \left[V_{j+1}\left(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}\right) | \varepsilon_j\right]\right\} \\ & \quad s.t. \end{aligned}$$

$$\begin{aligned} c_j + a_j + a_j^m + o^R(m_j) + p^{Med} &= R\left(a_{j-1} + T_j^{Beq}\right) + R^m a_{j-1}^m - Tax_j + T_j^{Soc} + T_j^{SI}, \\ h_j &= \phi_j m_j^\xi + (1 - \delta(h_j)) h_{j-1} + \varepsilon_j, \\ NI_j &= 0, \\ 0 &\leq a_j, a_j^m, \end{aligned} \tag{6}$$

where

$$\begin{aligned} o^R(m_j) &= \begin{cases} \min\left[p_{m,Med} m_j, \rho^{Med} + \gamma^{Med}\left(p_{m,Med} m_j - \rho^{Med}\right)\right] & \text{if } in_{j-1} = 1, \\ p_m m & \text{if } in_{j-1} = 2, \end{cases} \\ NW_j &= R^m a_{j-1}^m - o^W(m_j) - p^{Med}, \\ NI_j &= a_j^m - \max[0, NW_j], \\ Tax_j &= \tilde{\tau}\left(\tilde{y}_j^R\right), \\ \tilde{y}_j^R &= r a_{j-1} + R T_j^{Beq} - NI_j, \\ T_j^{SI} &= \max\left[0, \underline{c} + o^W(m_j) + Tax_j + p^{Med} - R\left(a_{j-1} + T_j^{Beq}\right) - R^m a_{j-1}^m - T_j^{Soc}\right]. \end{aligned}$$

be eligibile as 'medically needy' (e.g. caretaker relatives, aged persons older than 65, blind individuals, etc.)

We will therefore make the simplifying assumption that before the Social Insurance program kicks in the individual has to use up all her wealth. Jeske and Kitao (2005) follows a similar approach.

See http://www.cms.hhs.gov/MedicaidEligibility
for details on Medicaid eligibility.

Non-contributors who use HSA funds for non-health related expenses have to pay income tax on these funds (no penalty τ^m applies for agents older than 65). Therefore only constraint (6) changes to

$$NI_j < 0,$$

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

3.8 Insurance Companies

Insurance companies satisfy their budget constraint within each period. We allow for cross subsidizing across generations. The constraints for two insurance companies selling the low and high deductible health insurance respectively are

$$\begin{aligned} & (1+\omega_1) \times \sum_{j=2}^{J_1+1} \mu_j \int \left[I_{\{in_j(x_j)=1\}} (1-\gamma) \max\left(0, p_{m,Ins} m_j(x_j) - \rho\right)\right] d\Lambda(x_j) \qquad (7) \\ = \;& R \sum_{j=1}^{J_1} \mu_j \int I_{\{in_j(x_j)=1\}} p_j d\Lambda(x_j), \text{ and} \end{aligned}$$

$$\begin{aligned} & (1+\omega_2) \times \sum_{j=2}^{J_1+1} \mu_j \int \left[I_{\{in_j(x_j)=2\}} \left(1-\gamma'\right) \max\left(0, p_{m,Ins} m_j(x_j) - \rho'\right)\right] d\Lambda(x_j) \\ = \;& R \sum_{j=1}^{J_1} \mu_j \int I_{\{in_j(x_j)=2\}} p'_j d\Lambda(x_j), \end{aligned} \tag{8}$$

where ω_1 and ω_2 are markup factors that determine the profits of insurance companies, $I_{\{in_j(x_j)=1\}}$ is an indicator function equal to 1 whenever agents bought the low deductible health insurance policy and $I_{\{in_j(x_j)=2\}}$ is an indicator function equal to one whenever agents bought the high deductible insurance. Since agents have to buy their insurance one period prior to the realization of the health shock, first period agents are not insured. In addition, this lag implies that insurance premiums gain interest over one period. We clear low and high deductible insurances separately by adjusting the respective premium. Profits are redistributed in equal amounts to all surviving agents. Alternatively, we could discard the profits ("thrown in the ocean"). In this sense we think of them as loading costs (fixed costs) associated with running private insurance companies.

3.9 Firms

There is a continuum of identical firms that use a standard Cobb-Douglas technology. Firms solve

$$\max_{\{K,\ L\}} \left\{ AK^{\alpha} L^{1-\alpha} - qK - wL \right\}, \tag{9}$$

taking (q, w) as given.

3.10 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 $\tilde{y}$ and finances the social insurance program T^{SI} as well as government consumption G. The government budget is balanced so that

$$G + \sum_{j=1}^{J} \mu_j \int T_j^{SI}(x_j) d\Lambda(x_j) = \sum_{j=1}^{J} \mu_j \int Tax_j(x_j) d\Lambda(x_j). \tag{10}$$

Government spending G plays no further role ("thrown in the ocean").

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

$$\sum_{j=1}^{J} \mu_j \int T_j^{Beq}(x_j)\, d\Lambda(x_j) = \sum_{j=1}^{J} \nu_j \int a_j(x_j)\, d\Lambda(x_j) + \sum_{j=1}^{J} \nu_j \int a_j^m(x_j)\, d\Lambda(x_j), \tag{11}$$

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

$$\begin{aligned} & \sum_{j=J_1+1}^{J} \mu_j \int T_j^{Soc}(x_j)\, d\Lambda(x_j) \\ = & \sum_{j=1}^{J_1} \mu_j \int 0.5\tau^{Soc} we_j(x_j) + 0.5\tau^{Soc}\left(\tilde{w}_j(x_j) - 1_{\{in_j(x_j)=1\}}p_j - 1_{\{in_j(x_j)=2\}}p_j'\right) d\Lambda(x_j). \end{aligned} \tag{12}$$

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)

$$\begin{aligned} & \sum_{j=J_1+1}^{J} \mu_j \int \left(1-\gamma^{Med}\right) \max\left(0, m_j(x_j) - \rho^{Med}\right) d\Lambda(x_j) \\ = & \sum_{j=1}^{J_1} \mu_j \int \left[0.5\tau^{Med} we_j(x_j) + 0.5\tau^{Med}\left(\tilde{w}_j(x_j) - 1_{\{in_j(x_j)=1\}}p_j - 1_{\{in_j(x_j)=2\}}p_j'\right)\right] d\Lambda(x_j) \\ & + \sum_{j=J_1+1}^{J} \mu_j \int p^{Med} d\Lambda(x_j). \end{aligned} \tag{13}$$

3.11 Equilibrium

Definition 1 *Given the exogenous, transition probabilities P_j, realizations of health shocks $\varepsilon_j = \{\varepsilon_{1j}, \varepsilon_{2j}, \varepsilon_{3j}, \varepsilon_{4j}, \varepsilon_{5j}\}_{j=1}^{J}$, the survival probabilities $\{\pi_j\}_{j=1}^{J}$ and the exogenous government policies $\left\{\tilde{\tau}(\tilde{y}(x_j)), \tau^K\right\}_{j=1}^{J}$, a competitive equilibrium **with health savings accounts** is a collection of sequences of distributions $\left\{\mu_j, \Lambda_j(x_j)\right\}_{j=1}^{J}$ of individual household decisions $\{c(x_j),\ a(x_j),\ a^m(x_j),\ m(x_j),\ in(x_j)\}_{j=1}^{J}$, aggregate stocks of physical capital and human capital $\{K, L\}$, factor prices $\{w, q, R\}$, and insurance premiums $\left\{p_j, p_j', p^{Med}\right\}_{j=1}^{J}$ such that*

(a) $\{c(x_j), a(x_j), a^m(x_j), m(x_j), in(x_j)\}_{j=1}^{J}$ *solves the consumer problem* (3),

(b) *the firm first order conditions hold*

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

(c) *markets clear*

$$\begin{aligned} K' &= S = \sum_{j=1}^{J} \mu_j \int \left(a(x_j) + a^m(x_j)\right) d\Lambda(x_j), \\ L &= \sum_{j=1}^{J_1} \mu_j \int e(j, x_j) d\Lambda(x_j), \end{aligned}$$

(*d*) *the aggregate resource constraint holds*

$$G + S + \sum_{j=1}^{J_1} \mu_j \int \left(c\left(x_j\right) + p_m\left(x_j\right) m\left(x_j\right)\right) d\Lambda\left(x_j\right) = Y + (1-\delta) K,$$

(*e*) *the government programs clear so that* $(11), (12), (13)$, *and* (10) *hold,*

(*f*) *the budget constraints of insurance companies* (7) *and* (8) *hold*

(*g*) *the distribution is stationary*

$$\Lambda\left(x_{j+1}\right) = \sum_{j=1}^{J} \mu_j \int 1_{\left\{a'=a\left(x_j\right),\ a^{m\prime}=a^m\left(x_j\right),\ m'=m\left(x_j\right)\right\}} P_j\left(\varepsilon', \varepsilon\right) d\Lambda\left(x_j\right),$$

where 1 *is an indicator function.*

We use a standard numeric algorithm to solve the model.[18]

4 Calibration

We calibrate the model without HSAs to the U.S. economy before 2003. We target key ratios from the U.S. National Income Accounts (NIPA), the U.S. Census and the Medical Expenditure Panel Survey (MEPS). In addition, we match some demographic features of the U.S. as well as features of average U.S. life cycle profiles.

4.1 Demographics

One period is defined as 9 years. We model $J = 8$ periods, that is households from age 20 to 92. The annual conditional survival probabilities are taken from the U.S. Life-Tables in 2003 and adjusted for the period length.[19] We plot the survival curves in panel 1 of figure 1. The total population over the age of 65 is 13.97%, which is between the numbers in the U.S. Census (12.4%) and the 20% used in Jeske and Kitao (2005) who only look at heads of households.

4.2 Preferences

The relative risk aversion parameter is $\sigma = 1.5$ and the annual discount factor is $\beta = 1.025$. Both parameters are picked to match the capital output ratio and the interest rate. It is clear that in a general equilibrium model every parameter affects all equilibrium variables. Here we associate parameters with those equilibrium variables that are the most directly (quantitatively) affected.

The weight of consumption in the utility function is age dependent and summarized in vector $\eta_j = \{0.65, 0.95, 0.96, 0.96, 0.95, 0.85, 0.80, 0.80\}$. In conjunction with the magnitudes of the health shocks these weights ensure that the model matches total health spending and the take-up ratio of health insurance. We thereby assume that the very young and the very old have a higher preference weight on their health than the middle aged. In the model we need the relatively large preference for health of the young generation in order to induce them to buy insurance.

[18] We discuss the algorithm in Appendix B, which is available on the authors' website at http://pages.towson.edu/jjung/papers/hsa_appendixB.pdf

[19] ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/54_14/Table01.xls

4.3 Production of Health

The productivity parameter ϕ_j of the health production function is age dependent and summarized in vector $\phi = \{1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.65, 1.65\}$. This is similar to the production parameter in Suen (2006) for a very similar production function of health. In addition, Grossman (1972*a*) and Stratmann (1999) estimate positive effects of medical services on measures of health outcomes.

The second parameter is picked at $\xi = 0.35$. We do not have data on these parameters and conduct sensitivity analysis. We assume that health depreciation depends on the current health state but is independent of age and current health care spending. Health depreciates at rates between $\delta(h_j = h_{\min}) = 0.8658$ and $\delta(h_j = h_{\max}) = 0.7145$. We chose this structure so that health depreciates faster when the health state is already low. This feature captures the urgency of treatment. We pick these numbers to match total health expenditures in the economy and the take up ratios for insurance over the life-cycle.

4.3.1 Transition Probabilities

We estimate the health shocks in the law of motion of health capital using data from seven waves of the RAND-HRS (Health and Retirement Survey) between 1992 and 2004. We first use a linear probability model and estimate expression (1) where we impose that health capital h_j can attain five possible health states. These health states correspond to five self reported health states in the HRS. In addition, we impose an $AR(1)$ structure on the health shocks (the errors in expression (1)). After estimating the $AR(1)$ process for the shocks, we simulate health shocks for $10,000$ agents for each of 10 starting health shocks that we obtain from the data. We then collect the shocks into five risk classes and label them from 1 (lowest shock) to 5 (highest shock). We then count how many of the simulated agents move from health shock 1 at age $j-1$ to health shocks $1, 2, ..., 5$ at age j. This will give us the conditional transition probabilities $P(\varepsilon_j | \varepsilon_{j-1} = 1)$. We follow the same procedure for $\varepsilon_{j-1} = \{2, 3, 4, 5\}$. We adjust for the period length of 9 years and allow for age group specific transition probabilities. In an eight period model this will result in seven 5×5 Markov switching matrices. Since we need one Markov switching matrix for each generation, we impose that the first two age groups have the same Markov switching matrix between health shocks.[20] All transition matrices for all 8 age groups are reported in table 1 in Appendix B which also contains the details about the estimation technique.[21]

4.3.2 Magnitude of Health Shocks

The shocks to health $\varepsilon_j = \{\varepsilon_{1,j}, \varepsilon_{2,j}, ..., \varepsilon_{5,j}\}$ are chosen to match the insurance coverage take-up rate (percentage of workers buying the low deductible health insurance per age group) and the share of medical spending in GDP. Table 3 presents the matrix of age dependent health shocks associated with each one of the five health states. In order to identify the model we put restrictions on the shock structure. Shocks 1, 2, and 3 do not change over age for workers and shocks 1,2,3, and 4 do not change over age for retirees. All other shocks are unrestricted, so that the number of free parameters from the 8×5 shock matrix is 19.

[20] Alternatively we could estimate an AR1 process for the health shocks in expression (1) and then use Tauchen's method (see Tauchen (1986) or Heer and Maussner (2005) for more details) to transform the estimated AR1 process into a discrete Markov switching process.

[21] Appendix B is available on the authors' website at: http://pages.towson.edu/jjung/papers/hsa_appendixB.pdf

4.4 Human Capital Profile

Effective human capital evolves according to expression (2). We use the following estimates for $\left\{\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2\right\} = \{8.12,\ 0.14,\ -0.0015\}$. These estimates are obtained by fitting a second order polynomial to summarized income data from the CPS (see *Income, Poverty, and Health Insurance Coverage in the United States: 2005* (2006)), according to

$$\log(income) = \beta_0 + \beta_1 age + \beta_2 age^2 + \varepsilon.$$

This represents the exogenous part of expression (2). After taking the endogenous health capital into account, the model reproduces the hump shaped average efficiency units of the human capital profile depicted in panel 2 of figure 2. We normalized the profile and compare it to the normalized income profile from the data. Fernandez-Villaverde and Krueger (2004) show similar income patterns using data from the Consumer Expenditures Survey over the period 1980-1998.

For parameter χ we pick 0.85. We pick this rather large weight on age because it produces more stable results as the feedback from the endogenous health choice is diminished. We also do not want to inflate the effects of health. We are not aware of any estimates for parameter χ and will therefore conduct sensitivity analysis.

This modelling restriction together with the empirical evidence in the literature on medical services, health, and productivity [22] suggests that parameter θ is strictly greater than zero so that health is a consumption and investment good. A strictly positive parameter θ will capture the negative income effect of bad health to some extent. In general it is challenging to infer the exact magnitude of health productivity parameter θ from existing microeconomic studies. Ashraf, Lester and Weil (2007) conduct an empirical analysis of health productivity and use a similar functional structure of technology. They conclude that given the existing empirical literature it is not possible to infer the exact magnitude of such health productivity parameters. We therefore analyze the effects of HSAs for the range of $\theta \in [0, 1]$, where $\theta = 0$ indicates that health is a pure consumption good and as such unproductive and $\theta = 1$ indicates that health is also an investment good with strong effects on the formation of human capital.

4.5 Health Insurance and Out-of-Pocket Medical Expenses

4.5.1 Insurance Premiums, Coinsurance Rates and Deductibles

Insurance premiums are age dependent. We use a base premium p_0 and an exogenous age dependent premium growth rate g_j to calculate the premium for each age group. We express the premium of j year old agents for high and low deductible health insurances as

$$p_j = p_0 \times g_j, \text{ and } p'_j = p'_0 \times g_j \text{ for all } j \in \{1, ..., J_1\}. \tag{14}$$

We estimate a common growth factor for insurance premiums g_j for each age group using summary data on individual health insurance premiums from *The Cost and Benefit of Individual Health Insurance Plans* (2005) and impose that both low and high deductible insurance premiums grow at the same rate g_j. We then fit a simple second order polynomial to the growth

[22] There is a growing empirical literature documenting the relationship between medical services, health, and productivity or growth (e.g. Grossman (1972*a*), Stratmann (1999), Grossman (2000), Behrman, Hoddinott, Maluccio, Martorell, Quisumbing and Stein (2003), Bloom, Canning and Sevilla (2004), Jamison and Wang (2005), Maccini and Yang (2005), Alderman and Kinsey (2006), Cawley (2004), Schultz (2005), Greve (2007), and Weil (2007)).

rate of age dependent premiums which results in an estimate of the following equation

$$g_j = x_0 + x_1 \times age + x_2 \times age^2 + \varepsilon \text{ for all } j \in \{1, ..., J_1\}. \tag{15}$$

The estimates for the regressors are $\{\hat{x}_0, \hat{x}_1, \hat{x}_2\} = \{0.7781,\ 0.0036,\ 0.0007\}$. We present the age dependent premium growth rates in panel 2 of figure 1. Expressions (14) and (15) together with endogenous base premiums p_0 and p_0' will determine all insurance premiums (low - and high deductibles) for all age groups.[23]

Following Suen (2006) we pick coinsurance rate $\gamma = 25\%$ for the low deductible insurance. The coinsurance rate for the high deductible insurance is slightly lower at $\gamma = 20\%$. We pick this number lower so that in the benchmark economy the majority of agents buys the low deductible insurance. The coinsurance rate for Medicare γ^{Med} is also 25%.[24]

Since deductibles are level variables, calibrating them is more involved because we need to find expressions for suitable ratios that can be normalized. In the following we match the ratios of the deductibles against each other, as well as ratios of average insurance premiums to median income, and finally, ratios of deductibles themselves to median income and average insurance premiums.

We use data reported in Fronstin and Collins (2006), Claxton, Gabel, Gil, Pickreign, Whitmore, Finder, DiJulio and Hawkins (2006), GAO (2006), and the U.S. Census to calculate these fractions.[25] In our benchmark model without HSAs, the average premium for low deductible insurance is 0.88 vs. 1.22 for the high deductible insurance and the premium for Medicare is 0.72. These premiums result in premium ratios that are close to the ratios in the data. All ratios, data and model generated, are reported in table 6.

4.5.2 Price of Medical Services

In order to pin down the relative price of consumption goods vs. medical care goods, we use the average ratio of the consumer price index (CPI) and the Medical CPI between 1992 and 2006. We calculate the relative price to be $p_m = 1.52$.[26]

The price of medical services for uninsured agents is higher than for insured agents. Various studies have pointed to the fact that uninsured individuals pay up to 50% (and more) higher prices for prescription drugs as well as hospital services (see *Playing Fair, State Action to Lower Prescription Drug Prices* (2000)). The national average is a markup of around 60% for the uninsured population (Brown (2006)).

We therefore pick a markup factor of 1.6 so that $p_{m,nIns} = 1.6 \times p_{m,Ins}$. According to the U.S. Census 2004, the fraction of the population without insurance is roughly 15.7%.[27] Using all this information we solve the following system of equations for the relative prices that the insured and uninsured pay for medical services

$$\begin{cases} 1.52 = 0.843 \times p_{m,Ins} + 0.157 \times p_{m,nIns}, \\ \qquad p_{m,nIns} = 1.6 \times p_{m,Ins}, \end{cases}$$

[23] Base premiums p_0 and p_0' will adjust to clear the insurance companies budget constraints (7) and (8). The premium for Medicare p^{Med} is assumed to be age independent and clears (13).

[24] According to Medicare News from November 2005 the coinsurance rates for hospital services under the Outpatient Prospective Payment System (OPPS) will be reduced to 20% of the hospital's total payment. Overall, average beneficiary copayments for all outpatient services are expected to fall from 33% of total payments in 2005 to 29% in 2006.

Visit: http://www.cms.hhs.gov/apps/media/press/release.asp?Counter=1506

[25] See the Appendix B for details.

[26] Compare: http://data.bls.gov/cgi-bin/surveymost?cu

[27] http://www.census.gov/hhes/www/hlthins/hlthin04/hlth04asc.html

which results in $p_{m,nIns} = 2.2226$ and $p_{m,Ins} = 1.3891$. This assumes that the overall price difference between consumption and health services is a weighted average of the prices that the insured and uninsured pay for health services.

4.6 Health Savings Accounts

There is an annual contribution limit to HSAs. According to the Revenue Procedure 2006-53 the upper limit is $\bar{s}^m = \$2,850$ for an individual ($\$5,650$ for a family). In order to relate the level of the upper limit to the variables in the model we will tie the contribution limit to the high deductible using the following formula

$$\bar{s}^m = \rho' \times (1 + \nu),$$

where ν is a markup on the high deductible ρ'. Since the average high deductible is around $\$2,330$ according to Fronstin and Collins (2006) we get a markup factor of $(1+\nu) = \frac{\bar{s}^m}{\rho'} = \frac{\$2,850}{\$2,330} = 1.2232$. In our experiments we use the following range of savings limits: $\bar{s}^m = \{\$2,680; \$2,850; ...; \$10,000\}$. The tax penalty for withdrawing funds that are not used for eligible health expenses is $\tau^m = 10\%$.

4.7 Insurance Companies

The fraction of insured in our model economy is highly sensitive to the equilibrium prices of insurance contracts. We start the baseline model with a zero profit condition on insurance companies, $\omega = 0$, and let the base premiums p_0 and p_0' adjust to satisfy the the budget constraint of the insurance companies.

4.8 Firms

We choose a standard capital share in production of $\alpha = 0.33$. Total factor productivity $A = 4$. Nadiri and Prucha (1996) report estimates for depreciation rates of physical capital of 5.9% and depreciation of R&D capital is 12%. In our model we pick a capital depreciation rate of $\delta = 10\%$ which is a standard value in the calibration literature (e.g. Kydland and Prescott (1982)). The depreciation per period is then $1 - (1-\delta)^{(years/J)} = 1 - 0.9^{72/8} = 0.6126$.

4.9 Government

The tax penalty for withdrawing funds from HSAs before the age of 65 and using them on non-health related consumption is $\tau^m = 10\%$. 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. The Old-Age and Survivors Insurance Security tax rate is a little lower at 10.6% and has been used by Jeske and Kitao (2005) in a similar calibration. We therefore match τ^{Soc} at 10.6% picking the appropriate pension replacement ratio Ψ to be 21%.[28] The size of the social security program is then 6% of GDP. This is close the number reported in *The 2002 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds* (2002) which is 5% for 2002.

[28] Social security transfers are defined as $T_j^{Soc}(x) = \Psi w e_j (h_{j-1})$ and they are the same for all agents. Transfers are a function of the active wage of a worker in her last period of work, so that $j = J_1$. In addition we assume that h_{j-1} is a constant and the same for all agents. We pick it to be equal $\frac{h_{0,J_1} + h_{ggridh,J_1}}{2}$, which is the "middle" health state of the health grid vector. Biggs, Brown and Springstead (2005) report a 45% replacement rate for the average worker in the U.S. and Whitehouse (2003) finds similar rates for OECD countries.

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)). In order to get an appropriate premium for Medicare p^{Med}, so that the Medicare premium is lower than the private health insurance premiums, we have to pick the payroll tax (which helps to finance Medicare) sufficiently high. We use $\tau^{Med} = 4\%$ which leads to a slightly larger Medicare program (4.44% of GDP) than what we observe in the data (2.5% of GDP according to *2002 Annual Report of the Board of Trustees of the Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds* (2002)).

Using the income tax rates of the U.S. income tax of 2005 we follow Guner, Kaygusuz and Ventura (2007) and estimate the following equation

$$marginalTaxRate\,(income) = \beta_0 + \beta_1 \log\,(income) + \varepsilon, \tag{16}$$

where $marginalTaxRate\,(income)$ is the marginal tax rate that applies when taxable income equals $income$. Variable $income$ is household income normalized with an assumed maximum income level of $\$400,000$. We then fit equation (16) to the normalized income data. The estimated coefficients for the tax function are then $\hat{\beta}_0 = 0.3411$ and $\hat{\beta}_1 = 0.0659$ so that the income tax function becomes

$$T\,(income) = \overbrace{[0.3411 + 0.659 \times \log\,(income)]}^{marginalTaxRate(income)} \times \text{taxable income}, \tag{17}$$

where $T\,(income)$ is total income tax paid. In addition, we impose a lower bound of 0% and an upper bound of 35% on the marginal income tax rate. Picking the maximum income level at $\$400,000$ will affect the estimates for the marginal tax function in (16) since it will determine the "tax bins" that individuals fall into. We report a graph of the approximation of the marginal tax rate against the tax code in panel 3 of figure 1. Note that the approximated marginal income tax is slightly below the marginal income tax from the tax code. We think this is justified since we do not explicitly account for negative income tax of low income households, tax loopholes, and the fact that marginal income taxes only apply for the specific brackets.

In our model, we similarly normalize taxable income of every agent with the maximum income of the richest agent in the economy to get the normalized variable $income$. We use this normalized income directly in (17) to get the marginal tax rate and the sum total of payable income tax for each individual.[29]

Since income tax revenue is collected to pay for the social insurance program T^{SI} (e.g. foodstamps, etc.) and the residual becomes government consumption G, we want to make sure that the size of government consumption also conforms to the data ($G/Y = 20.3\%$ compared to 20.2% reported in Castaneda, Diaz-Gimenez and Rios-Rull (2003)).

4.10 Calibration Results

Medical Expenditures We match two important measures of medical expenditures; the share of medical spending as a fraction of GDP and the distribution of medical expenditures by population size.[30] First, our model generates total medical expenditures of 17.6% in terms of GDP, which is in the range between 16% and 17% of GDP for US in 2005 according to Baicker (2006) and Fang and Gavazza (2007). Second, our model does a good job in matching

[29] Another method is to use the tax function estimated in Gouveia and Strauss (1994).

[30] Another measure of health expenditures, the medical expenditure profile, is not matched well by the model. The model overstates health care spending of the young as a fraction of their income and understates the fraction of health spending as a percentage of income of the elderly.

the distribution of health care expenditure by population size (see Yu and Ezzati-Rice (2005) and table 4). We see that a small fraction of the population is responsible for a large amount of total health expenditures e.g. 1% of the population is responsible for 22% of total health expenditures. The model matches the high concentration of health care expenditures fairly well but slightly understates the concentration of the 1% of highest spenders (20.6% in the model vs. 22% reported in the data). The model underpredicts the concentration of health care spending if we look at larger shares of the population. At higher percentages the model's match improves again.

Number of Insured Workers Panel one in figure 2 shows the fraction of insured workers and distinguishes between private and public insurance. We overlay the information from the data with the insurance take-up ratios from the model. For the latter we distinguish between low and high deductible health insurances. In the model we concentrate on private insurance for workers and public insurance (Medicare) for retirees. We see that the model slightly underestimates the takeup rate of insurance for young workers and overestimates the takeup rate for older workers.

We calibrate the fraction of agents buying health insurance to be the 76.5% where 95.4% of this group buys the low deductible insurance and the residual 4.6% buy the high deductible insurance.[31] According to MEPS data of 2005, 86.1% of the population under age 65 do have health insurance (70.1% is private and 16% is public). In addition, almost 100% of all retired workers do have health insurance via Medicare.

The model's low take up ratio for the high deductible insurance needs some justification. Fronstin and Collins (2006) find that enrollment in HDHPs that would qualify for HSAs is roughly 8% and that only 1% is currently holding HSAs.[32] In the benchmark model without HSAs we practically model the situation in the U.S. prior to 2003. We therefore think the low take up rate of high deductible insurances of only 4.6% is justified.

Life-Cycle Wealth Panel 3 in figure 2 shows the asset distribution over various age groups. We see that the model reproduces the hump shaped pattern in the data. The data is from the U.S. Census in 2000. Table 5 reports the asset and income distributions of the model by quintiles and compares them to the data from Diaz-Gimenez, Quadrini and Rios-Rull (1997) and Budria-Rodriguez, Diaz-Gimenez, Quadrini and Rios-Rull (2002). The model does not match the wealth and income distributions accurately. One of the main reasons is the lack of a bequest motive. We therefore cannot match the high wealth concentrations that we observe in U.S. data. Including a bequest motive into the current framework poses a challenge, both on theoretical as well as on computational grounds. The wealth Gini coefficient is 0.73 which is smaller than the 0.80 from 1998 data. The Gini coefficient of income is 0.43 in the model compared to 0.553 in Budria-Rodriguez et al. (2002).

5 Results

In this section we first explain the economic mechanism underlying our model. We then systematically explore two important general equilibrium effects that both determine the performance of HSAs, a *savings effect* and a *human capital effect*. At the end of this section we run a quantitative experiment and calculate an upper threshold for the likely cost of HSAs for the U.S. taxpayer.

[31] We exclude the first generation from this calculation because the first generation does not have health insurance by construction.

[32] Other surveys find slightly larger numbers for the prevalence of high deductible health insurances (e.g. www.eHealthinsurance.com).

5.1 The Economic Mechanism

The introduction of HSAs creates two opposing effects on the accumulation of production factors. HSAs provide a savings stimulus due to the tax shelter. Agents will save more in physical capital. The increase in physical capital accumulation represents a positive effect on output. This *savings effect* has been documented in the literature (e.g. see Imrohoroglu, Imrohoroglu and Joines (1998)). In our general equilibrium framework this savings effect will lead to changes in aggregate capital, market wage rates and interest rates as well as incomes. Changes in income trigger changes in household demands for health insurance and medical services.

On the other hand, since HSAs have to be combined with a high deductible health insurance, the implicit price of high deductible health insurances will decrease as HSAs become available on a larger basis. Consequently, agents will start to switch from low deductible health insurances to high deductible health insurances. In addition, previously uninsured agents can now buy "subsidized" health insurance. As more and more agents buy high deductible health insurances, the implicit price of health care services increases. This is only true for agents who previously spent less than the high deductible on health care. Agents will respond to the higher implicit price of health care services and buy less health care which decreases their health stock. If health is associated with labor productivity (health is an investment good) as argued in Grossman (1972*b*), the formation of human capital will be affected. Depending on the productivity of health in the formation of human capital, aggregate human capital decreases. We call this the *human capital effect.* It affects output negatively.

Depending on the relative strength of these two effects, we can either observe a decrease or an increase in output, which translates into a decrease or an increase in household income. If the income effect is negative enough, some agents will decide to opt out of buying health insurance and therefore demand fewer health services. Aggregate spending on health will then decline. If, on the other hand, the income effect is positive enough, more agents will start buying health insurance and consequently demand more health services as documented in the RAND Health Insurance Experiment (see Manning, Newhouse, Duan, Keeler, Leibowitz and Marquis (1987)). As a result we can observe increases or decreases in total medical expenditure as well as increases or decreases in the total number of insured individuals.

5.2 Contribution Limits and the Savings Effect

There has been a lot of discussion whether HSAs could be misused for tax evasion. Policy makers have therefore introduced an annual savings limit, $\bar{s}^m = \$2.850$ for an individual ($\$5,650$ for a family). On the other hand, critics have questioned whether this savings limit is too low and therefore does not allow agents to save enough for their health. In a general equilibrium framework the annual contribution limit to HSAs is critical to determine the size of the savings effect, which in return influences the demand for health insurance and health care.

To isolate the *savings effect* we shut down the *human capital effect* and set $\theta = 0$. Note that when $\theta = 0$ health is only a consumption good which does not affect the accumulation of human capital anymore. We calibrate the model to U.S. data for this parameter selection. In our policy experiments we allow for annual savings limits in the range $\bar{s}^m \in [\$2,680, \ \$10,000]$. We plot the steady state results in figures 3. In addition, we overlay the graph with steady values from the benchmark economy without HSAs.

The tax stimulus associating with HSAs induces households to save more. This positive effect on the accumulation of physical capital will increase output and therefore household income. At the same time, agents purchase more high deductible health insurance which will increase the effective price of health care. However, the income effect outweighs the price effect, so that overall households will spend more on their health care after HSAs are introduced. If we now gradually increase the annual contribution limit, output increases even further and households spend more on their health care. Once the annual contribution limit reaches $5,500, agents are not constrained by the savings limit anymore, so that further increases won't change the outcome anymore.

We conclude that HSAs can deliver only one out of two goals in this environment - where we restrict health to be non-productive. That is, HSAs can increase the number of insured people but they also increase total health expenditures in the economy. In addition, there are additional costs associated with HSAs. Panel 8 shows that residual government expenditure G drops off steadily as the annual savings limit increases. This is the effect from lost government revenue due to tax free savings. We can interpret this as the price the government has to pay in order to increase the number of individuals with health insurance. A policy recommendation would have to factor in how productive this government revenue is for the economy as a whole. We run a revenue neutral experiment at the end of this section in order to partly address this issue.

5.3 Health Productivity and the Human Capital Effect

If one believes the argument that households only forego unnecessary treatment after buying high deductible health insurances (e.g. Manning et al. (1987), or Matisson (2002)), then parameter θ in expression (2) should be close to zero. Choosing $\theta = 0$ effectively turns off the influence of health in the formation of human capital. In this case health stops being an investment good and is only replenished for its consumption value. Health then does not affect income or output via the production process anymore. If, on other hand, one believes in Grossman's argument (Grossman (1972*b*)) that health is an investment good as it produces more healthy work time, the formation of human capital will be affected. The latter has important consequences for output and household income.

In order to explore the effect of health productivity systematically, we allow for positive values of parameter θ. We report the results of introducing HSAs for $\theta = 0, 0.3, 0.5, 0.6, 0.7, 0.8, 0.9$, and 1 while fixing the contribution limit to HSAs at the current threshold, $\bar{s}^m = \$2,850$, in figure 4.

Panel one of figure 4 reports the effects on the *intensive margin*, that is the change in total health service expenditures due to the introduction of HSAs. When health is productive (θ close to one), negative income effects from lower health states add to the decrease in health service expenditures. The direct price effect from the high deductible insurance which makes health services relatively more expensive works in the same direction. Partial equilibrium results are very close to the general equilibrium results. If, on the other hand, health becomes more of a consumption good, the negative income effects are diminished and households spend more on their health than in the benchmark economy. We now observe large differences between partial- and general equilibrium outcomes because price effects become the important distinguishing feature.

We plot the change in the percentage of insured workers between the benchmark economy and the economy with HSAs in panel two of figure 4. We call this the *extensive margin*. We see that as long as health capital is an investment good, the introduction of HSAs has a negative effect on the number of insured workers. HSAs increase the relative price of medical services to households. As households spend less on health services, their health capital deteriorates. Since health is productive, households lose income. This negative income effect dominates the decline in premiums. As a result, households forgo buying insurance.

If, on the other hand, θ is small, health capital loses its investment good characteristic and turns into a consumption good. Households average health capital is still declining, but does not carry the large negative income effect. Since savings increase due to the tax deductibility of savings in HSAs, physical capital drives up production in the economy. Households experience a positive income effect and more workers buy insurance. There is no substantial difference between the partial equilibrium results and the general equilibrium results since the large income effects always dominate the price effects.

Note also that only in the range of $\theta \in (0.5, 0.8)$ can HSAs deliver on both goals, they increase the number of insured and decrease total health expenditures. If θ is outside of this range, only one of the two goals can be achieved.

5.4 Contribution Limits and the Savings Effect: Revisited

We next investigate the role of the contribution limits when health is being productive. We choose $\theta = 1$ so that health is not only a consumption good but also an investment good. We calibrate the model to U.S. data for this parameter selection. In our policy experiments we again allow annual savings limits in the range between $\bar{s}^m \in [\$2,680,\ \$10,000]$ and report steady state results in figure 5

The savings effect is different when health is productive. The biggest contrast to the earlier discussion (where health was not productive) is that now aggregate health expenditures and the number of insured individuals will decrease after introducing HSAs. Only when the annual contribution limit is beyond $5,450 will the number of insured individuals increase as well. If the annual contribution limit is between $5,450 and $8,000, then HSAs increase the number of the insured population and decrease total health expenditures (see panel 1 and 2 in figure 5). If the annual savings limit is larger than $8,000 then the physical capital accumulation dominates the drop in human capital and output increases. This will make households richer and as a consequence they spend more on health care. HSAs then lose their cost savings feature.

On the other hand, panel 8 shows that residual government expenditure G drops off steadily as the annual savings limit increases. Again, this is the effect from lost government revenue due to tax free savings and represents the price tag the government faces when it wants to insure more people and decrease health care spending.

We conclude that with the current annual contribution limit in place ($\bar{s}^m = \$2,850$), HSAs can decrease total health expenditures in this economy. However, this effect is "paid for" with a larger number of uninsured individuals and lower government revenue. Sensitivity analysis suggests that these results are robust to changes in the yearly contribution limits to HSAs. The fraction of individuals with health insurance increases only if the annual contribution limit is almost doubled to $5,450.

5.5 Taxpayer Liability from Health Savings Accounts

In order to determine the cost of HSAs for tax payers, we run the following experiment. We introduce HSAs into the benchmark economy, holding government spending (in levels) constant. We do this by introducing a lump sum tax on all surviving households that balances the government budget constraint in reaction to the introduction of HSAs. We find that if the government were to hold its spending constant, then the introduction of HSAs requires additional tax revenues of 3% of GDP (raised by this lump sum tax on all surviving households). When running this experiment we used a health productivity of $\theta = 1$, which is our upper limit for health productivity and produces the strongest adverse effect on output. We therefore conclude that the 3% of GDP "cost" estimate of HSA is also an upper limit.

6 Conclusion

Our model demonstrates that general equilibrium effects from health productivity and the annual contribution limit to HSAs are key components in determining the success or failure of HSAs. As HSAs are introduced and high deductible health insurances become more attractive, households shift from low to high deductible insurances. This increases the effective price of health services for a large number of households which in turn lowers demand for health services. Health capital drops as a consequence and depending on the productivity of health we observe a drop in human capital. The tax free savings via HSAs increases physical capital, so that the net effect of lower human capital and higher physical capital determines whether output increases or decreases. Depending on this income effect, households can go either way and buy more or less health insurance. The success of HSAs in decreasing aggregate health expenditures and increasing the number of individuals with health insurance depends critically on the productivity of health capital and on the annual contribution limit to HSAs. We provide extensive sensitivity analysis to address both issues.

The effects on the wealth distribution are moderate but the effect on the government size are large. After the introduction of HSAs, government revenue drops so that government size (the residual tax revenue after deduction of transfers from the social insurance program) decreases significantly. This raises the question whether HSAs are the most efficient way to curb increases in health expenditures and insure more people as one may suspect that the lost government revenue leads to productivity losses in other sectors (e.g. less funding for public education, infrastructure, etc.). We estimate that the cost of introducing HSAs can run up to 3% of GDP.

How balanced is our assessment of the performance of HSAs? There are a few features that are omitted from the model that we think would weaken the case of HSAs. Among the most prominent features that we did not include are (*i*) adjustment costs to learn the new savings plan (e.g. in the model all consumers immediately understand all aspects of HSAs), (*ii*) no fixed fees of running insurance companies and HSAs[33], and (*iii*) no alternative savings vehicles are available in the benchmark model (e.g. absence of FSAs, HRAs, IRAs, and 401k's). Since our analysis concentrates on long run equilibria, adjustment costs play a minor role. However, it would be of interest to include fixed costs in running HSAs and alternative tax sheltered savings vehicles since both will affect the take up rate of high deductible insurances and the net increase in aggregate savings. Further extensions would encompass solutions for transition paths between the policy regimes in order to study welfare. Another interesting question concerns recent increases in health care productivity. A fully endogenized health care production sector would be able to address this issue. We leave this for future research.

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7 Appendix

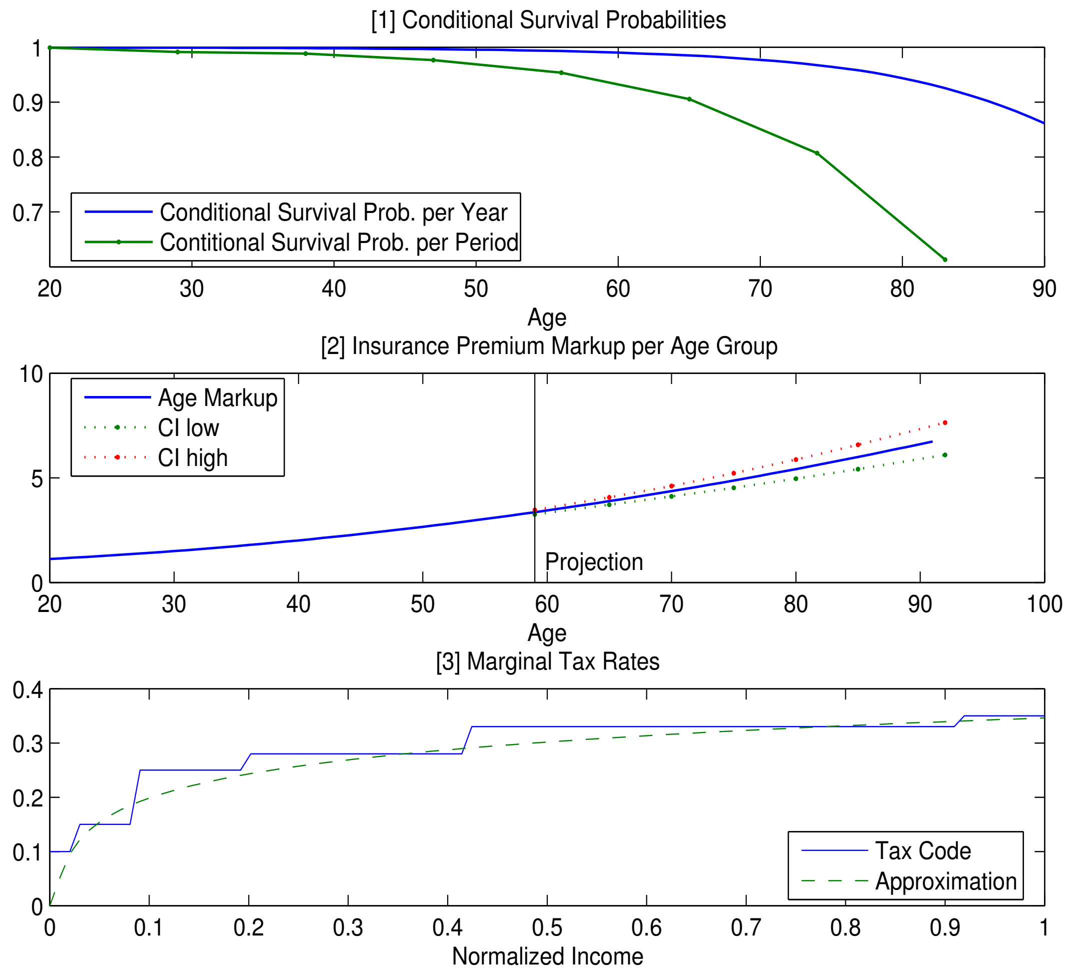

Figure 1: Panel (1): Conditional Survival Probabilities from U.S. Life-Tables 2003. Panel (2): Premium Markup per Age Group. Source: 2005 Data from www.ehealthinsurance.com. Panel (3): Income Tax Function Approximation.

Parameters:		Explanation/Source:	Free Paras
- Periods working	$J_1 = 5$		
- Periods retired	$J_2 = 3$		
- Population growth rate	$n = 2.5\%$	to match > 65 at 12.4% of population ($n = 1.2\%$ in U.S. Census 2006)	
- Years modeled	$years = 72$	from age 20 to 92	
- Relative risk aversion	$\sigma = 1.5$	to match $\frac{K}{Y}$ and R	1
- Preference on consumption	$\eta_j = \left\{ \begin{array}{c} 0.65, 0.95, 0.96, 0.96, \\ 0.95, 0.85, 0.80, 0.80 \end{array} \right\}$	to match $\frac{p \times M}{Y}$	8
- Discount factor	$\beta = 1.025^{(72/8)}$	to match $\frac{K}{Y}$ and R	1
- Health production productivity	$\phi_j = \left\{ \begin{array}{c} 1.5, 1.5, 1.5, 1.5, \\ 1.5, 1.5, 1.65, 1.65 \end{array} \right\}$	to match $\frac{p \times M}{Y}$	8
- Production parameter of health	$\xi = 0.35$	to match $\frac{p \times M}{Y}$	1
- Health depreciation	$\delta_{h_{\min}} = 1 - 0.80^{(years/J)} = 0.8658$ $\delta_{h_{\max}} = 1 - 0.87^{(years/gJ)} = 0.7145$	to match $\frac{p \times M}{Y}$	2
- Human capital production	$\chi = 0.85$	to match income distribution	1
- Health productivity	$\theta = [0, 1]$	used for sensitivity analysis	1
- Human capital profile	$\left\{\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2\right\} = \{8.12, 0.14, -0.0015\}$	U.S. Census 2005	
- Insurance premium growth	$\{\hat{x}_0, \hat{x}_1, \hat{x}_2\} = \{0.7781, 0.0036, 0.0007\}$	www.eHealthInsurance.com	
- Price for medical care for insured	$p_{m,Ins} = 1.3891$	U.S. Census 2004	
- Price for medical care for uninsured	$p_{m,nIns} = 2.2226$	U.S. Census 2004	
- Capital share in production	$\alpha = 0.33$	standard value	
- Capital depreciation	$\delta = 1 - 0.9^{(years/J)} = 0.6126$	Kydland and Prescott (1982) Nadiri and Prucha (1996)	
- Total factor productivity	$A = 4$	normalization	
- Health Shocks	see table 3		19
- Asset grid	$a_{Grid} = [0, ..., 24]_{1 \times 80}$		
- HSA asset grid	$a^m_{Grid} = [0, ..., 8]_{1 \times 14}$		
- Health grid	$h_{jGrid} = [0.01, ..., 6]_{1 \times 16}$		
- State space	$1,881,600$		

Table 1: Parameters for Calibration

Policy Parameters:		Explanation/Source:	Nr. of free parameters
- Pension replacement rate	$\Psi = 0.21$	to match τ^{soc}= 10%	1
- Payroll tax Medicare:	τ^{Med}= 4%	- By law this is is 2.92%. Need to pick higher rate, so that workers in last period buy Medicare Plan B, and $p^{Med} < p$.	1
- Low deductible	$\rho = 0.15$	- to match percentage of insured to be close to 80%	1
- High deductible	ρ'= 1.15	- to match $\frac{\rho}{\rho'} = 0.13$ according to Fronstin and Collins (2006)	
- Medicare deductible	ρ^{Med}= 0.46	- to match $\frac{\rho}{\rho^{Med}} = 0.28$ according to Fronstin and Collins (2006) and the U.S. Department of Health	
- Coinsurance rate, low deductible	$\gamma = 0.25$	0.25 in Suen (2006)	
- Coinsurance rate, high deductible	γ'= 0.20	to match insurance take-up rate	1
- Coinsurance rate, Medicare	γ^{Med}= 0.25	- Center for Medicare and Medicaid Services (2005)	
- Saving limit markup	$v = 0.2232$	- Revenue procdure 2006-53 and Fronstin and Collins (2006)	
- Maximum contribution to HSAs	$\bar{s}^m$= \$2,850	- Revenue procdure 2006-53 and Fronstin and Collins (2006)	
-Total number of free parameters incl. table 1			46

Table 2: Policy Parameters for Calibration

	Shock 1	Shock 2	Shock 3	Shock 4	Shock 5
Age					
20-28:	0.00	0.00	-0.02	-0.04	-0.10
29-38:	0.00	0.00	-0.02	-0.34	-1.60
39-47:	0.00	0.00	-0.02	-0.04	-3.25
48-56:	0.00	0.00	-0.02	-0.04	-4.20
57-65:	0.00	0.00	-0.02	-0.14	-4.83
66-74:	0.00	-0.05	-0.20	-0.40	-5.00
75-83:	0.00	-0.05	-0.20	-0.40	-5.00
84-92:	0.00	-0.05	-0.20	-0.40	-6.00

Table 3: Health shocks per age group. Health shocks account for 20 separate free parameters. We use identification restrictions on some of the shocks. Shocks 1,2, and 3 do not change over age for all workers. In addition, Shocks 1,2, 3, and 4 also do not change over age for all retirees.

	Total Health Care Expenditure	
Percent of Total Population	Data (in %)	Model (in %)
1%	22.000	20.609
5%	49.000	34.092
10%	64.000	45.499
50%	97.000	92.493

Table 4: Distribution of Health Expenditures in the U.S. Economy. Data is from MEPS 2002 as summarized in Yu and Ezzati-Rice (2005).

	Gini	1. Quintile	2. Quintile	3. Quintile	4. Quintile	5. Quintile
Wealth:						
Data 1992	0.780	-0.390	1.740	5.720	13.430	79.490
Data 1998	0.803	-0.300	1.300	5.000	12.200	81.700
Model	0.728	0.000	0.000	0.810	17.108	82.082
Income:						
Data 1998	0.553	2.400	7.200	12.500	20.000	58.000
Model	0.430	3.923	8.094	19.089	29.044	39.850

Table 5: Distribution of Wealth in the U.S. Economy (%). 1992 Data from Diaz-Gimenez, Quadrini and Rios-Rull (1997) and 1998 data from Budria-Rodriguez et al. (2002).

Parameters	Model	Data	Source	Nr. of Moments
- Medical expenses per GDP: $\frac{p_m \times M}{Y}$	17.6%	16%-17%	Baicker (2006) and Fang and Gavazza (2007)	1
- Fraction of insured workers: (private insurance)	53%	- 86.1% of <65: private 69% (employment based 59.8%) public: 19%	- MEPS 2005 and U.S. Census Bureay 2006	1
- Fraction of insured workers: (private insurance, not counting uninsured in first generation)	76.55%	- 86.1% of <65: private 69% (employment based 59.8%) public: 19%	- MEPS 2005 and U.S. Census Bureay 2006	1
- Fraction of insured retirees:	99.7%	99.7%	MEPS 2005	1
- Low deductible insurance (of all insured)	95.4%	90%	Fronstin and Collins (2006)	1
- High deductible insurance (of all insured)	4.6%	10%	Fronstin and Collins (2006)	1
- Ratio of low vs. high deductible premium: $\sum_j \mu_j p_j / \sum_j \mu_j p'_j$	0.72	0.6 to 1.2	- Fronstin and Collins (2006) and Claxton et al. (2006)	1
- Ratio of low deductible vs. Medicare premium: $\frac{\sum_j \mu_j p_j}{\sum_j \mu_j p_j^{Med}}$	1.22	0.13 to 3.86	- Fronstin and Collins (2006), Claxton et al. (2006), and U.S. Department of Health 2006	1
- Ratio of average low deductible premium vs. median income: $\frac{\sum_j \mu_j p_j}{med(income)}$	0.12	0.07 to 0.23	- Fronstin and Collins (2006), Claxton et al. (2006) and U.S. Census 2005	1
Ratio deductible vs. average premium				
- Low deductible plan: $\frac{\rho}{\sum_j \mu_j p_j}$	0.17	0.07 to 0.23	- Fronstin and Collins (2006), Claxton et al. (2006), and U.S. Department of Health 2006	1
- Highdeductible plan: $\frac{\rho'}{\sum_j \mu_j p'_j}$	0.95	0.66 to 1.15	- same source as above,	1
- Medicare: $\frac{\rho^{Med}}{\sum_j \mu_j p_j^{med}}$	0.74	1	U.S. Department of Health 2006	1
Ratio deductible vs. median income				
- Low deductible plan: $\frac{\rho}{med(income)}$	0.02	0.017	- Fronstin and Collins (2006) and U.S. Census 2005	1
- Highdeductible plan: $\frac{\rho'}{med(income)}$	0.16	0.13	- Fronstin and Collins (2006) and U.S. Census 2005	1
- Medicare: $\frac{\rho^{Med}}{med(income)}$	0.07	0.06	U.S. Department of Health 2006 and U.S. Census 2005	1
- Capital output ratio: K/Y	2.7	3	NIPA	1
- Interest rate: R	4.6%	4%	NIPA	1
- Residual Government spending: G/Y	20.3%	20.2%	Castaneda et al. (2003)	1
- Size of Social Security: SocSec/Y	6.3%	5%	Social Security Administration 2002	1
- Size of Medicare: Medicare/Y	4.4%	2.5%	U.S. Department of Health 2002	1
- Fraction over 65	13.97%	12.4%	U.S. Census 2005	
- Payroll tax Social Security: τ^{Soc}	10.2%	6%-10%	IRS [34] and	1
- Gini Wealth	0.73	0.8	Budria-Rodriguez et al. (2002)	1
- Gini Income	0.43	0.55	Budria-Rodriguez et al. (2002)	1
- Income and savings profile		see figure 2		13
- Insurance take-up ratios		see figure 2		10
Total number of Moments				46

Table 6: Data vs. Model

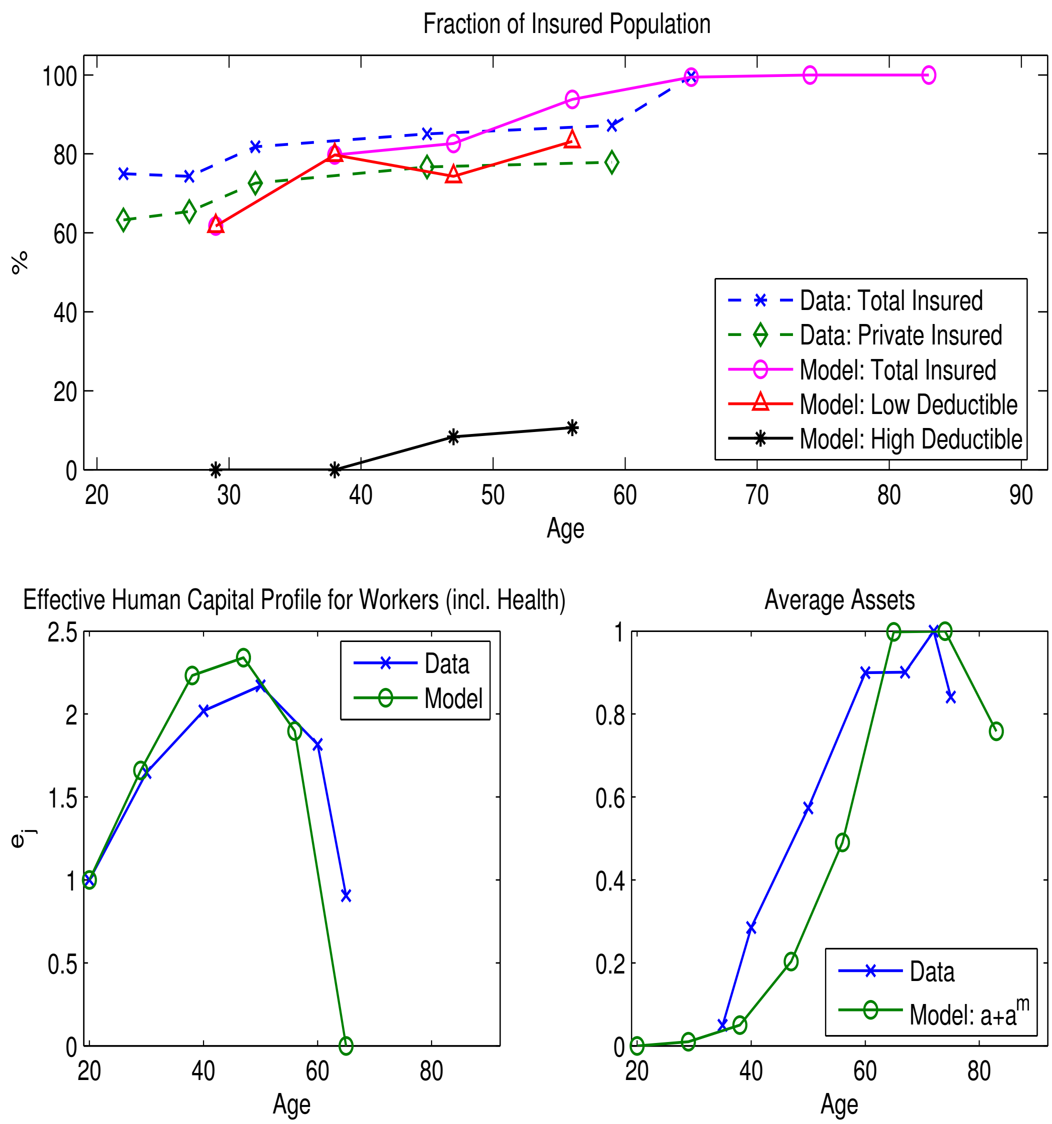

Figure 2: [1] Benchmark Model: 2 Insurances and no HSAs. Panel (1): Health Insurance Coverage of the Civilian Noninsitititutionalized Population in the U.S. 2005. Source: MEPS 2005. Panel (2): Human Capital Profile and Income Data per Age Cohort. Source: U.S. Census 2006, CPS. Panel (3): Wealth Age Distribution. Source: Data U.S. Census 2000.

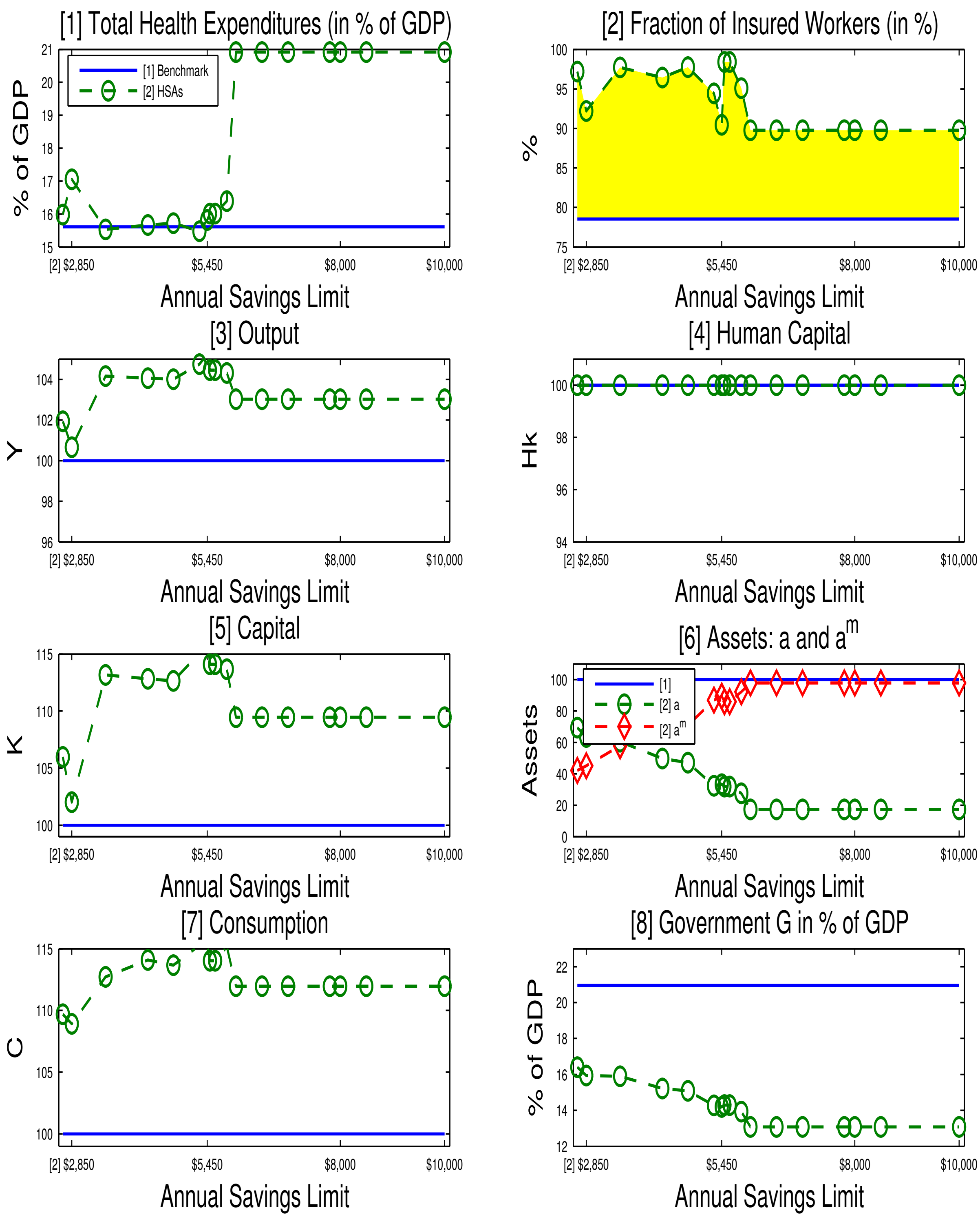

Figure 3: Contribution Limits and the Savings Effect. We fix health productivity parameter $\theta = 0$ and then vary the annual contribution limit to HSAs, according to $s^m = \{\$2,680;\ \$2,850;\ \ldots;\ \$1000\}$ and compare the results to the benchmark economy [1 *Benchmark*] with no HSAs.

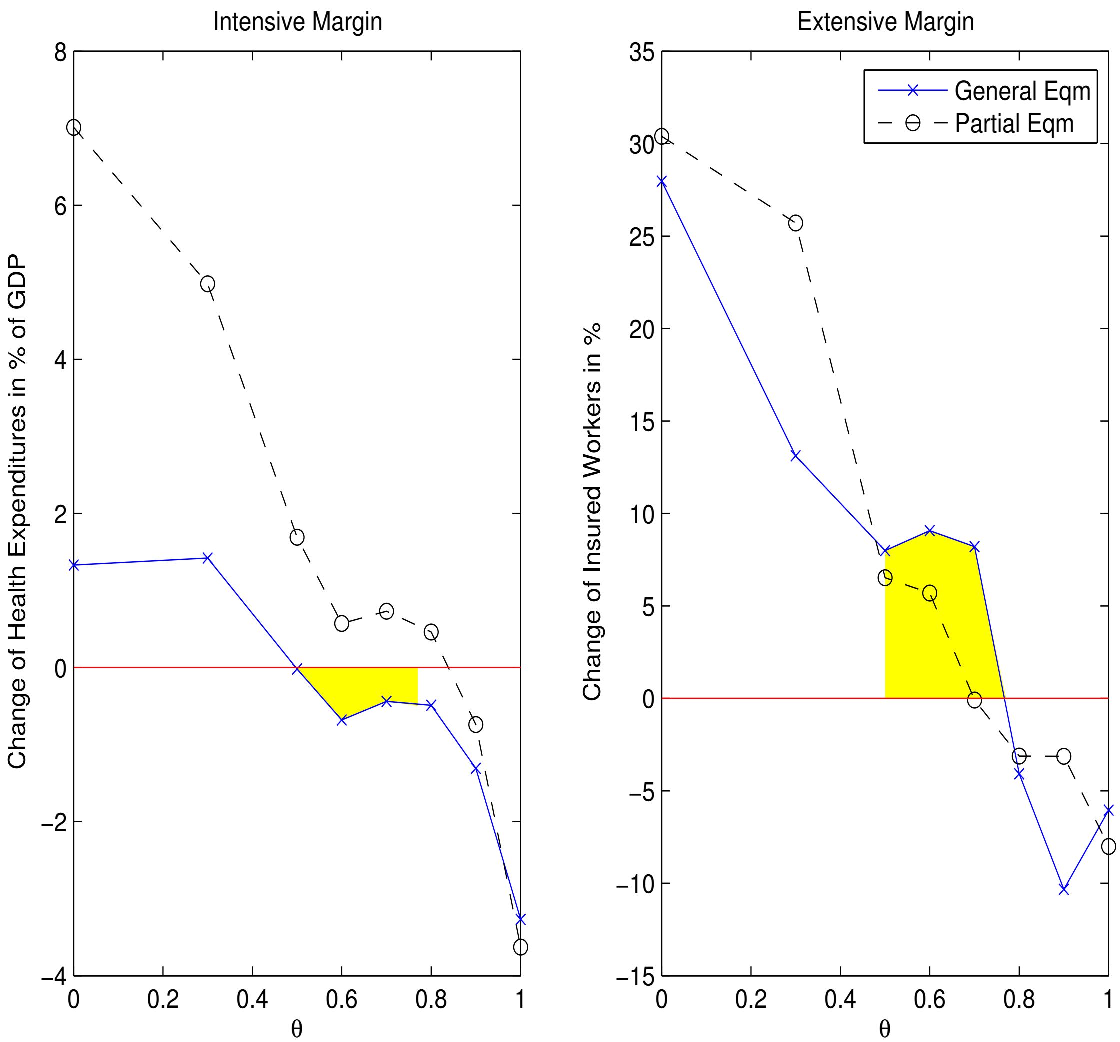

Figure 4: Health Productivity and the Human Capital Effect. We vary the health productivity parameter θ according to $\theta = \{0,\ 0.5,\ 0.6,\ 0.7,\ 0.8,\ 0.9,\ 1\}$ and compare the General Equilibrium with HSAs result and the Partial Equilibrium with HSAs result to the benchmark economy [1 *Benchmark*] with no HSAs.

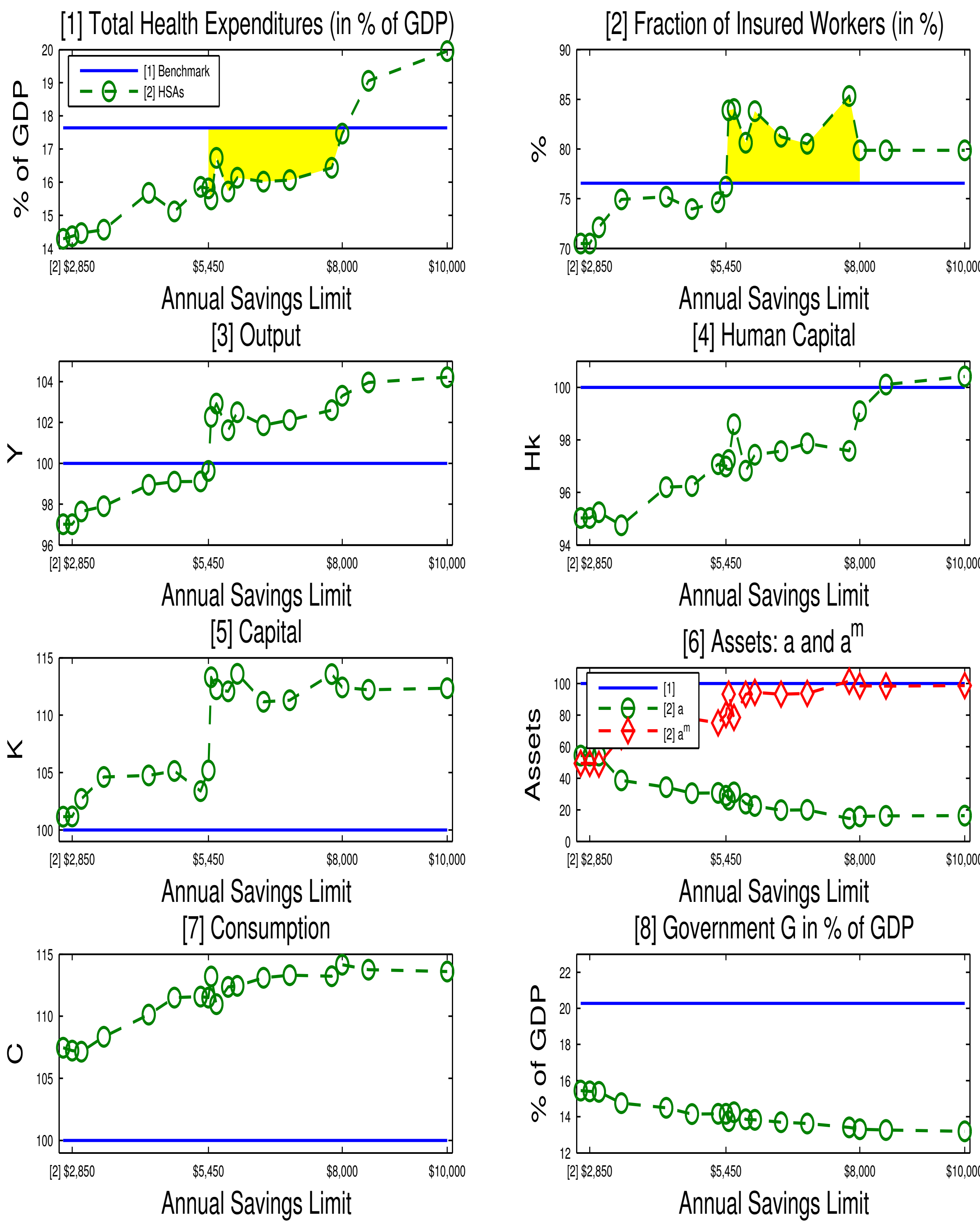

Figure 5: Contribution Limits and the Savings Effect: Revisited. We fix the health productivity parameter $\theta = 1$ and then vary the annual contribution limit to HSAs, according to $\bar{a}^m = \{\$2,680;\ \$2,850;\ ...;10,000\}$ and compare the results to the benchmark economy [1 *Benchmark*] with no HSAs.