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The Macroeconomics of Health Savings Accounts

by

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The Macroeconomics of Health Savings Accounts*†

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Abstract

We analyze whether the introduction of Health Savings Accounts (HSAs), which is a health insurance reform coupled with a capital tax reform, can reduce health care expenditures in the United States, while simultaneously increasing the fraction of insured individuals. Unlike previous studies on HSAs, our analysis relies on a general equilibrium framework and therefore fully accounts for feedback effects from general equilibrium price adjustments. Our results from numerical simulations indicate that the introduction of HSAs increases the percentage of the working age population with health insurance in the long run but fails to curtail spending on health care. These results depend critically on the interaction of general equilibrium effects and the annual contribution limits to HSAs. Finally, the long-run tax revenue loss due to the introduction of HSAs is substantial and can amount to up to 5 percent of GDP.

JEL: H51, I18, I38

Keywords: Health saving accounts, health care reform, privatization of health care systems, health insurance, endogenous health, stochastic dynamic general equilibrium

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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. The introduction of HSAs is a dual reform that combines a health insurance reform with a capital income tax reform. The tax reform portion of the HSA reform lowers the effective tax rate imposed on household savings income, whereas the health insurance reform portion aims at lowering insurance premiums and increasing the price of discretionary medical services for some households in an effort to reduce moral hazard. As such the reform affects the amount of resources spent on health care by not only influencing the prices of medical services and health insurance, but also by influencing the income of U.S. households more directly. HSAs were introduced with two main goals in mind. The first goal is to control the rise in health expenditures (i.e. "bend the cost curve"), and the second goal is 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 like Goodman (2004) hail consumer driven health care plans as the panacea to the health care problem in the United States[1], whereas opponents like Burman and Blumberg (2003) discredit the idea as "more tax cuts for the rich."[2] Since data is sparse, research on HSAs has focused on case studies, micro-simulations and partial equilibrium models (e.g. Keeler et al. (1996), Ozanna (1996), Zabinski et al. (1999), Pauly and Herring (2000), Cardon and Showalter (2007), and Aaron, Healy and Khitatrakun (2008)) and concentrated on moral hazard and adverse selection issues triggered by the insurance component of HSAs. This literature is inconclusive as to whether HSAs will decrease total health expenditures. Estimates range from decreases in total health expenditures of 8 percent to increases in total health expenditures of 1 percent. Insurance coverage issues have been addressed in GAO (2006) and Greene et al. (2006). Their results seem to indicate that healthier and higher income households will be more likely to use HSAs.

While there is a growing empirical literature on the effects of HSAs (e.g. Parente and Feldman (2008)), we find a paucity of economic models that address the macroeconomic implications of reforming the U.S. health care system with HSAs.[3] There are several reasons why it is important to analyze the effects of HSAs from within a dynamic general equilibrium framework. First, the introduction of a tax-favored savings account is essentially a capital income tax cut that induces agents to save more, similar to tax favored retirement accounts analyzed in İmrohoroğlu, İmrohoroğlu and Joines (1998). Parente and Feldman (2008) find weak evidence that HSAs do not crowd out other tax free savings for retirement, so that HSAs are likely to generate significant increases in net savings. As well established in previous studies, in a general equilibrium framework changes in savings behavior trigger general equilibrium adjustments of capital accumulation, market wage rates, interest rates, insurance premiums, as well as income. The latter have impacts on the demand for health insurance and medical services. We call this

[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), and Aaron, Healy and Khitatrakun (2008).

[3] Steinorth (2011) is one notable exception. However, her model is more stylized than ours and concentrates on the qualitative effects of HSAs.

the *savings effect.* Second, savings in an HSA are tied to purchasing a high deductible health insurance. These types of health insurance plans are cheaper and therefore a larger fraction of the population is able to afford it. In addition, the high deductible alleviates the moral hazard problem of standard health insurance plans. These effects are summarized under the moniker of *insurance effect.* Third, 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), human capital formation will be affected. Changes in human capital influence market prices, household income and the demand for health insurance and medical services. We call this the *human capital effect.* Forth, the introduction of a tax-favored HSA is also a capital income tax reform that has important implications for tax revenues and the government budget.

The sequence of dynamic effects triggered by the introduction of HSAs results in important macroeconomic implications, which are crucial in determining the outcome of HSAs. This is especially important in the long run when all general equilibrium effects have fully played out. The previous literature on HSAs is inconclusive about the outcome of HSAs partly because these general equilibrium channels have not been addressed. In this paper we therefore explore the general equilibrium effects triggered by HSAs and to what extent these effects determine whether or not HSAs can deliver on their goals.

We develop a dynamic general equilibrium model with endogenous health accumulation and a health care sector. We use a standard incomplete market overlapping generations model with heterogeneous agents and incorporate the following key features. First, we introduce health as a consumption and investment good and explicitly model the health production process as argued by Grossman (1972). Second, we incorporate individual insurance choices and private and public health insurance markets. Third, we model the most important institutional features of HSAs.[4] Our model is novel in the following aspects: (i) health insurance choices, utilization of health care and spending on health are endogenously determined together with consumption/savings in a household maximization problem; (ii) the formation of health insurance premiums, interest rates and wage rates are simultaneously determined in insurance, capital and labor markets respectively. The model explicitly accounts for general equilibrium effects from price changes in factor markets and insurance markets on savings and health care expenditures. It also accounts for important general equilibrium channels that influence the accumulation of physical capital and the formation of human capital. We calibrate the model to the U.S. economy. In order to study the quantitative importance of the described economic mechanisms of HSAs we then introduce HSAs into this framework. We briefly summarize our results:

First, HSAs are successful in insuring more workers if the annual contribution limit is large enough. However, we find that the positive savings effect does not allow for a reduction of total health expenditures in the economy. The additional capital accumulation generates more income so that spending on health care increases in absolute value but also as fraction of GDP. That is, once all general equilibrium effects are accounted for, agents spend more on their health due to positive income effects that are generated from additional savings. Based on our model,

[4] Macroeconomic frameworks that model tax sheltered savings accounts or endogenous health capital formation, but not both, include Hubbard, Skinner and Zeldes (1995), İmrohoroğlu, İmrohoroğlu and Joines (1998), Palumbo (1999), Jeske and Kitao (2009), 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).

HSAs are not able to limit expenditures on health in the long run. Note that in the first set of policy experiments, we only focus on isolating the workings of the insurance- and savings effects so that we assume that health is unproductive and the human capital effect is shut off. Next, we introduce the human capital effect into the model by allowing health to influence individual productivity. We find that the results from the previous analysis still hold and only marginally differ. We conclude that the human capital effect is not very strong as the model calibration does not allow health to be overly productive in the final goods production sector.

Second, to demonstrate the importance of the described general equilibrium channels we conduct a partial equilibrium analysis where we hold market prices constant at initial steady state levels. It is telling that some of the results generated from a partial equilibrium model come to a different conclusion as this model variant does not factor in important feedback effects from general equilibrium price adjustments including adjustments of wages, interest rates and insurance premiums. We find that the partial equilibrium model substantially underestimates spending on health care compared to the general equilibrium outcome.

Finally, the price that the government has to pay for insuring more people with HSAs can be substantial when accounting for general equilibrium channels. After introducing HSAs, the government has to raise up to 5.16 percent of GDP in additional tax revenue in order to remain revenue neutral.

Our key contribution to the literature is to quantify the long-run macroeconomic implications of this rather comprehensive health insurance reform in a dynamic macroeconomic model with heterogeneous agents and to highlight the significant differences between partial equilibrium outcomes and general equilibrium outcomes. Our results have important policy implications as they demonstrate that a thorough policy analysis of this comprehensive health insurance reform should account for the general equilibrium effects of HSAs before drawing conclusions about the potential success or failure of HSAs in reducing total health expenditures and increasing the number of insured individuals.

Our paper is closely related to the literature on incomplete markets macro-models with heterogeneous agents started by Huggett (1993) and Aiyagari (1994). These quantitative models with idiosyncratic incomes shocks are extensively used to analyze the general equilibrium effects of unfunded social security (e.g. see Imrohoroglu, Imrohoroglu and Jones (1995) and İmrohoroğlu (1998)) and to analyze saving effects of tax-favored retirement accounts (e.g. see İmrohoroğlu, İmrohoroğlu and Joines (1998)). Different from these studies, this paper introduces health as durable good and health shocks as a source of heterogeneity and analyzes the dynamic effects of public health policy.

This paper contributes directly to that emerging macro-health economics literature. Recent work by Jeske and Kitao (2009) has introduced exogenous health spending shocks as additional source of agent heterogeneity to study the effects of tax deductible health insurance premiums. More recent work by Suen (2006), Fonseca et al. (2013), Feng (2009), Jung and Tran (2009), Halliday, He and Zhang (2010) and De Nardi, French and Jones (2010) endogenize health spending and insurance choice. This paper is one of the first attempts to incorporate health insurance choice between various types of health insurance contracts and endogenous health spending into a macroeconomic framework.

In the next section, we describe the institutional details of HSAs. In section 3 we introduce our model. 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. The appendix contains the definition of equilibrium and all tables and figures.[5]

2 The economics of Health Savings Accounts (HSAs)

2.1 Health insurance and a tax reforms via HSAs

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). The 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. In general, funds cannot be used tax-free to pay for health insurance premiums with some exceptions. Funds withdrawn for non-medical purposes are subject to a 10 percent penalty tax (except in cases of death, disability, or Medicare eligibility) and regular income tax. After the account holder turns 65, the 10 percent tax penalty no longer applies. In case of death the HSA can be transferred tax-free to a spouse.

The introduction of HSAs is intended to induce individuals to save more for future health expenses through the HSA tax shelter and to encourage individuals to participate more consciously in their health care by making cost-conscious decisions (via the high deductible insurance). Thus, the adverse selection and the moral hazard problems of health insurance can both be reduced.

2.2 Empirical facts

The take-up rate of HSAs has been somewhat sluggish since they became available. According to Gates et al. (2009) a sizable number of firms offering HSA eligible insurance do not offer HSAs, so that by January 2008 about 6.1 million people were covered by HSAs (up from 1 million three years before according to Gates, Kapur and Karaca-Mandic (2008)). A recent Reuters report notes that HSAs have attracted about $8.6 billion in assets since they were established in 2003.[6] However, this figure is dwarfed by the $2.4 trillion that are held in tax favored retirement accounts like $401(k)s$ at the end of 2008. According to Fronstin (2010) the annual contribution limits are also not high enough to adequately fund the premium and out-

[5] Jung and Tran (2011) that accompanies this paper contains supplementary material that is not included in this paper due to space constraints. The document contains a brief history of HSAs in the U.S. and describes the experience of Singapore, China, and South Africa with HSAs. These are the only four countries that have introduced HSAs. Furthermore, we provide a discussion of the solution algorithm. This supplementary document is available on the authors' website at: http://pages.towson.edu/jjung/papers/hsa_appendixB.pdf

[6] Reuters, Tuesday March 23, 2010 retrieved from: http://www.reuters.com/article/idUSTRE62M4AY20100323

of-pocket health expenditures of the elderly. However, industry experts predict that the volume of HSAs will rise to about $50 billion to $100 billion in coming years.

2.3 The economic mechanism

The HSA reform is a combination of two implicit reforms: a health insurance reform and a capital tax reform. As such HSAs affect the allocation of resources towards health care by influencing individuals' incomes and the prices of medical services and health insurance. The tax reform portion of HSAs lowers the effective tax rate imposed on household savings income whereas the health insurance reform portion lowers insurance premiums by offering capital income tax breaks when high deductible health insurances are purchased. High deductible health insurances are less expensive than low deductible plans purchased in the individual insurance market. On the other hand, a high deductible health insurance increases the price of medical services for the holder of such a policy compared to the price paid by the holder of a low deductible insurance contract.

Intuitively, the introduction of HSAs alters the effective prices of private insurance and medical services, which triggers a sequence of substitution and income effects. This subsequently could increase the demand for health insurance while also lowering the demand for medical care. As shown in the simple example in Figure 1 the ultimate effects of the introduction of HSAs depend on the size of the income effects. Since this is a very comprehensive health care reform that could ultimately affect the majority of working age Americans in the long run, general equilibrium effects can be substantial. The effects of the introduction of HSAs are even more ambiguous when accounting for general equilibrium price adjustments. With regard to the first goal of controlling health expenditures, the policy outcome is not clear and will depend on the net outcome of various opposing general equilibrium effects. That is, the substitution effect induces individuals to demand fewer medical services (Panel A in Figure 1) while the income effect induces individuals to consume more (Panel B). If the substitution effect is dominant, then a decrease in health expenditure can be observed and the first goal of HSAs is achieved as consumers reduce their level of consumption from q_{m0} to q_{m2} (with the small income effect in Panel B). However, if the positive income effect is very large, then the price substitution effect is overpowered and individuals end up spending even more on health services than without HSAs so that their consumption of health services increases from q_{m0} to q_{m2} (with the large income effect in Panel B). Similarly, the effect on the health insurance coverage depends on substitution (Panel C) and income effects (Panel D). However, in this case both effects work in the same direction, so that HSAs will always increase the number of individuals with health insurance from q_0 to q_2 in Panel D of Figure 1.

Tax reform. The lower effective capital income tax triggers a sequence of effects on the accumulation of physical capital as individuals adjust their precautionary savings and react optimally to the altered tax incentives. These adjustments affect the accumulation of other production factors like human capital as well. HSAs provide a savings stimulus due to the tax shelter so that agents will save more in physical capital.[7] The increase in physical capital stimulates aggregate output. This *savings effect* has been intensively analyzed in the capital taxation literature (e.g. İmrohoroğlu, İmrohoroğlu and Joines (1998)). It is suggested that

[7] Compare Steinorth (2011) for a stylized qualitative model factoring in the effects of HSAs on savings.

general equilibrium income effects can be very large.

Insurance reform. On the other hand, as a health insurance reform, HSAs make high deductible health insurance plans more attractive as HSAs are required to be combined with this particular insurance type. This obviously affects a households choice of insurance and has wider implications for existing and nascent insurance markets. Particularly, the implicit price of high deductible health insurances will decrease as HSAs become available on a wider basis. In responding to lower insurance premiums, agents will start to switch from low deductible health insurances to high deductible health insurances. This is especially true for young and low risk individuals. In addition, previously uninsured agents can now buy "subsidized" health insurance. As more agents buy high deductible health plans, the high deductible ensures that the marginal cost of health care services increases for agents who were previously insured under low deductible plans and whose spending stays below the amount of the deductible. Agents will respond to the higher implicit price of health care services and buy less health care which potentially decreases their health stock. The balance between the newly insured spending more on their health due to moral hazard caused by having insurance and the previously insured spending potentially less will determine the direction of the *insurance effect.* In addition, if health is affecting the productivity of labor as argued in Grossman (1972), the formation of human capital will be affected. Depending on the productivity of health in the formation of human capital, aggregate human capital can increase or decrease with health capital. We call this the *human capital effect.*

In a general equilibrium framework these three effects are modeled simultaneously and will lead to changes in aggregate physical capital, human capital, market wage rates, interest rates as well as income. Changes in income trigger changes in household demand for health insurance and utilization of medical services. In addition, income changes affect the aggregate stock of health in the economy. Whether the aggregate health stock increases or decreases will depend on the balance of the positive savings effect and the outcome of the insurance effect. On the other hand, changes in health stocks affect the rate of capital accumulation and income.

We briefly summarize the sequence of these effects as follows: (i) the introduction of HSAs makes 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) similarly, newly insured individuals have more incentive to spend money on health care services due to moral hazard, (iv) the net effect of (ii) and (iii) determines whether aggregate demand for medical services increases or decreases the aggregate health level, (v) 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 increase or decrease as a result of the increased/reduced spending on health care, (vi) physical capital increases due to the tax free savings in HSAs, (vii) the net effect of (v) and (vi) determines whether output increases or decreases.

Hence depending on the relative strength of the savings, insurance and human capital effects, we can either observe an increase or a decrease in spending on health, which can trigger increases or decreases in aggregate output. In the next section we develop a dynamic general equilibrium model with heterogeneous agents to quantify these effects.

3 The model

3.1 Demographics and preferences

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 age j agents make up a constant fraction μ_j of the entire population at any point in time. The relative sizes of the cohorts alive μ_j and the mass of individuals dying $\tilde{\mu}_j$ in each period (conditional on survival up to the previous period) can be recursively defined as

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

where $years$ denotes the number of years modeled for each agent.

Households value consumption c, services s that are derived from health h, and leisure. Household preferences are described by a utility function $u(c,s)$ where $u : R^2_{++} \rightarrow R$ is C^2 and satisfies the standard Inada conditions. We assume the following technology for the production of health services that transfers health capital from the current period into health services,

$$s = f(h), \tag{1}$$

where $f' \geq 0$ and $f'' \leq 0$.

3.2 Production of health and human capital profile

In this economy there are two commodities: a consumption good c and medical services m. The price of consumption goods is normalized to one and the price of medical services is denoted p_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. We follow Grossman (1972) and use the following accumulation process for health capital h_j,

$$h_j = \overbrace{i(m_j)}^{\text{Smooth}} + \overbrace{(1-\delta_j)\,h_{j-1}}^{\text{Trend}} + \overbrace{\varepsilon_j}^{\text{Disturbance}} . \tag{2}$$

The law of motion consists of three elements. The first is a health production function using health services m_j as inputs.[8] Agents can use health services to smooth their holdings of health capital. The second component presents the trend of natural health deterioration over time with

[8]Note that we only model discretionary health expenditures m_j in this paper so that 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 in the U.S. are probably non-discretionary (e.g. health expenditures caused by catastrophic health events that require surgery etc.). In such cases a poor individual could still incur large health care costs. We do not cover this case in the current model.

age dependent health depreciation rate δ_j. Finally, the third component represents a stochastic disturbance to health which is assumed to be age dependent, where $\varepsilon_j \leq 0$.

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

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

Effective human capital $e\left(j, h_{j-1}\right)$ is a function of age and health capital at the beginning of the period.

3.3 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) due to computational limitations. 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 approximate 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.[9]

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 assume that the employee can make the employment and insurance type choice. This 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 γ and co-payment rate ρ at an age dependent premium p_j and a high deductible policy with deductible γ' and co-payment ρ' at an age dependent premium p'_j. These premiums are tax deductible.

[9] We are aware that group insurance contracts are not allowed to discriminate according to health status or age. However, 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. In this sense we think it is not overly inconsistent to combine the tax deductibility of group insurances with the screening feature of individual insurances.

In order to be insured against a health shock, households have to buy insurance one period prior to the realization of their health shock. By construction, agents in their first period of life are therefore 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 no insurance in period j, $in_{j-1} = 2$ denotes that the agent bought the low deductible health insurance for period j, and $in_{j-1} = 3$ indicates that the agent bought the high deductible health insurance for period j. The working household's out of pocket health expenditure is therefore denoted as

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

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 coinsurance rate ρ is the fraction the household pays after the insurance company pays $(1-\rho)$ of the post deductible amount $p_{m,Ins} m_j - \gamma$. 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 $\left(1 - \rho^{Med}\right)$ of the health expenditures that exceed the amount of the deductible γ^{Med}. The total out of pocket expenditures of a retiree are

$$o^R(m_j) = \min\left[p_{m,Med} m_j, \gamma^{Med} + \rho^{Med}\left(p_{m,Med} m_j - \gamma^{Med}\right)\right] \text{ if } j > J_1, \tag{4}$$

where $p_{m,Med}$ is the price of health expenditures that retirees with Medicare have to pay. We assume that old agents $j > J_1$ 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.[10]

3.4 Health Savings Accounts

If agents buy a high deductible health insurance they can hold assets a_j^m tax free 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. Leftover funds can be rolled over into the next period.[11] Savings in HSAs accumulate tax free.

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

[10] According to the Medical Expenditure 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.

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

taxes. An agent's out of pocket expenses when retired can still be paid with funds from the HSAs without paying income taxes. The Medicare premium also qualifies for penalty free deductions from HSAs. In addition, there is an upper limit on the annual contribution to an HSA which we denote $\bar{s}^m$.[12]

3.5 Households

Age j year old agents enter the period with state vector $x_j = \left(a_{j-1}, a^m_{j-1}, h_{j-1}, in_{j-1}, \varepsilon_j\right)$, where a_{j-1} is the capital stock at the beginning of the period, a^m_{j-1} 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 ε_j is a negative health shock. The state vector of a household (not counting age j) is defined as

$$x_j = \begin{cases} \left(a_{j-1}, a^m_{j-1}, h_{j-1}, in_{j-1}, \varepsilon_j\right) \in R_+ \times R_+ \times R_+ \times In^w \times R_- = D \text{ if } j \leq J_1, \\ \left(a_{j-1}, a^m_{j-1}, h_{j-1}, in_{j-1}, \varepsilon_j\right) \in R_+ \times R_+ \times R_+ \times In^R \times R_- = D \text{ if } j > J_1, \end{cases} \tag{5}$$

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 do not 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 $x_j \in D\left(x_j\right)$ let $\Lambda\left(x_j\right)$ denote the measure of age-j agents with $x_j \in D$. The fraction $\mu_j \Lambda\left(x_j\right)$ then denotes the measure of age-j agents with $x_j \in D$ with respect to the entire population of agents in the economy.

3.5.1 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 $in_j = 2$, p'_j for $in_j = 3$, or nothing for $in_j = 1$.

If agents decide to buy a high deductible insurance, i.e. if $in_j = 3$, then they are eligible to hold a^m_j 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.[13]

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.[14]

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

[13] This is a simplifying 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 8 years long, we think that the assumption that the agent has to completely dissolve the account in that period is not very strong.

[14] Although Medicare Plan B payments are itemizable as qualified medical expenses in the income tax

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 other consumption. The latter have to pay a penalty tax τ^m and forgone income tax on funds withdrawn for non-qualified expenses when they are younger than 65.

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

$$\begin{aligned} V_j(x_j) &= \max_{\{c_j, m_j, a_j, a_j^m, in_j\}} \left\{ u(c_j, s_j) + \beta \pi_j E_{\varepsilon_{j+1}|\varepsilon_j} \left[V_{j+1}(x_j) \right] \right\} \\ & \quad s.t. \end{aligned} \tag{6}$$

$$\begin{aligned} & c_j + a_j + 1_{\{in_j=2\}} a_j^m + o^W(m_j) + 1_{\{in_j=1\}} p_j + 1_{\{in_j=2\}} p_j' \\ = \; & w \times e(j, h_j, \epsilon_j) + R\left(a_{j-1} + T^{Beq}\right) + R^m a_{j-1}^m - Tax_j + T_j^{SI}, \end{aligned}$$

$$\begin{aligned} 0 &\leq NI_j \leq \bar{s}^m, \\ 0 &\leq a_j, a_j^m, \end{aligned}$$

where

$$\begin{aligned} NW_j &= R^m a_{j-1}^m - o^W(m_j), \qquad (7) \\ NI_j &= a_j^m - \max[0, NW_j], \\ IncomeTax_j &= \tilde{\tau}\left(\tilde{y}_j^W\right), \\ PayrollTax_j &= \left(\tau^{Soc} + \tau^{Med}\right)\left(w \times e(j, h_j, \epsilon_j) - 1_{\{in_j=1\}} p_j - 1_{\{in_j=2\}} p_j'\right), \\ Tax_j &= IncomeTax_j + PayrollTax_j, \qquad (8) \\ \tilde{y}_j^W &= \max\left[\begin{array}{c} 0, w \times e(j, h_j, \epsilon_j) + r(1-\Phi) a_{j-1} + rT^{Beq} - NI_j - 0.5\left(\tau^{Soc} + \tau^{Med}\right) \times \\ \left(w \times e(j, h_j, \epsilon_j) - 1_{\{in_j=1\}} p_j - 1_{\{in_j=2\}} p_j'\right) - 1_{\{in_j=1\}} p_j - 1_{\{in_j=2\}} p_j' \end{array}\right], \\ T_j^{SI} &= \max\left[0, \underline{c} + Tax_j - \tilde{w}_j - R\left(a_{j-1} + T_j^{Beq}\right) - \left(R^m a_{j-1}^m - o^W(m_j)\right)\right]. \end{aligned}$$

Variable c_j denotes consumption, a_j is next period's capital stock,[15] a_j^m is next period's capital stock in HSAs, $\bar{s}^m$ is the maximum contribution into HSAs per period, $o^W(m_j)$ is out-of-pocket health expenditure from expression (3), 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

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

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

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}.

Agents invest a fixed fraction Φ of their savings into tax free accounts like IRAs. Assuming a fixed fraction as opposed to a full scale portfolio choice problem with three savings assets (i.e. assets, tax free savings assets, and HSAs) significantly reduces the state space while allowing for the calibration of other tax free savings vehicles. Tax_j is total taxes paid[16], and T_j^{SI} is social insurance (e.g. 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.[17]

NW_j is net wealth in the HSA after subtracting out-of-pocket health expenses, NI_j is net investment in the HSA, $w \times e_j$ is the effective wage income. The function $\tilde{\tau}\left(\tilde{y}_j^W\right)$ captures progressive income tax, 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

$$\begin{aligned} NI_j &< 0, \\ Tax_j &= \tilde{\tau}\left(\tilde{y}_j^W\right) - \tau^m NI_j, \end{aligned}$$

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 $in_j = 1$ (the no insurance state) so that social insurance cannot be used to finance savings, savings into HSAs and private health insurance.[18]

[16] 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.

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

[18] The stipulations for Medicaid eligibility encompass maximum income levels but also maximum wealth levels.

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 enroll in Medicare in order to keep their HSAs. From $J_1 + 1$ onwards, all agents are forced into Medicare.

3.5.2 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 are not allowed to make tax exempt contributions to HSAs anymore. 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

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

$$\begin{aligned} c_j + a_j + a_j^m + o^R(m_j) + p^{Med} &= R\left(a_{j-1} + T_j^{Beq}\right) + R^m a_{j-1}^m - IncomeTax_j + T_j^{Soc} + T_j^{SI}, \\ NI_j &= 0, \\ 0 &\leq a_j, a_j^m, \end{aligned} \tag{9}$$

where

$$\begin{aligned} NW_j &= R^m a_{j-1}^m - o^R(m_j) - p^{Med}, \\ NI_j &= a_j^m - \max\left[0, NW_j\right], \\ IncomeTax_j &= \tilde{\tau}\left(\tilde{y}_j^R\right), \\ \tilde{y}_j^R &= r a_{j-1} + r T_j^{Beq} - NI_j, \\ T_j^{SI} &= \max\left[0, \underline{c} + o^R(m_j) + Tax_j + p^{Med} - R\left(a_{j-1} + T_j^{Beq}\right) - R^m a_{j-1}^m - T_j^{Soc}\right]. \end{aligned}$$

Some individuals who fail to be classified as 'categorically needy' because they have to much savings could still be eligible 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) follow 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 (9) changes to

$$NI_j < 0,$$

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

3.6 Insurance companies

Insurance companies satisfy a zero profit condition within each period. We allow for cross subsidizing across generations. The constraints for the low and high deductible health insurance plans are

$$\begin{aligned} & \sum\nolimits_{j=2}^{J_1+1} \mu_j \int \left[1_{\{in_j(x_j)=1\}} (1-\rho) \max\left(0, p_{m,Ins} m_j(x_j) - \gamma\right)\right] d\Lambda(x_j) \qquad (10) \\ = \quad & R \sum\nolimits_{j=1}^{J_1} \mu_j \int 1_{\{in_j(x_j)=1\}} p_j d\Lambda(x_j), \text{ and} \\ & \sum\nolimits_{j=2}^{J_1+1} \mu_j \int \left[1_{\{in_j(x_j)=2\}} \left(1-\rho'\right) \max\left(0, p_{m,Ins} m_j(x_j) - \gamma'\right)\right] d\Lambda(x_j) \\ = \quad & R \sum\nolimits_{j=1}^{J_1} \mu_j \int 1_{\{in_j(x_j)=2\}} p'_j d\Lambda(x_j), \qquad (11) \end{aligned}$$

where indicator function $1_{\{in_j(x_j)=1\}}$ equals 1 whenever agents bought the low deductible health insurance policy and $I_{\{in_j(x_j)=2\}}$ equals 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.

3.7 Firms

There is a continuum of identical firms that use capital and human capital to produce output. Firms solve

$$\max_{\{K,\ L\}} \left\{F(K, L) - qK - wL\right\}, \qquad (12)$$

taking (q, w) as given. Capital depreciates every period at rate δ.

3.8 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

$$G + \sum\nolimits_{j=1}^{J} \mu_j \int T_j^{SI}(x_j) d\Lambda(x_j) = \sum\nolimits_{j=1}^{J} \mu_j \int IncomeTax_j(x_j) d\Lambda(x_j). \qquad (13)$$

Government spending G plays no further role. Accidental bequests are redistributed in a lump-sum fashion to all households

$$\sum_{j=1}^{J}\mu_j\int T_j^{Beq}\left(x_j\right)d\Lambda\left(x_j\right)=\sum_{j=1}^{J}\tilde{\mu}_j\int a_j\left(x_j\right)d\Lambda\left(x_j\right)+\sum_{j=1}^{J}\tilde{\mu}_j\int a_j^m\left(x_j\right)d\Lambda\left(x_j\right), \tag{14}$$

where $\tilde{\mu}_j$ denotes the deceased mass of agents aged j in time t. An equivalent notation applies to the surviving population of workers and retirees denoted μ_j. The Social Security program is self-financing

$$\begin{aligned}&\sum_{j=J_1+1}^{J}\mu_j\int T_j^{Soc}\left(x_j\right)d\Lambda\left(x_j\right) \qquad (15)\\ =\ &\sum_{j=1}^{J_1}\mu_j\int\tau^{Soc}\left(we\left(x_j\right)-1_{\{in_j(x_j)=1\}}p_j-1_{\{in_j(x_j)=2\}}p_j'\right)d\Lambda\left(x_j\right).\end{aligned}$$

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 the last period)

$$\begin{aligned}&\sum_{j=J_1+1}^{J}\mu_j\int\left(1-\gamma^{Med}\right)\max\left(0,p_{m,Med}m_j\left(x_j\right)-\rho^{Med}\right)d\Lambda\left(x_j\right) \qquad (16)\\ =\ &\sum_{j=1}^{J_1}\mu_j\int\tau^{Med}\left(we\left(x_j\right)-1_{\{in_j(x_j)=1\}}p_j-1_{\{in_j(x_j)=2\}}p_j'\right)d\Lambda\left(x_j\right)\\ &+\sum_{j=J_1+1}^{J}\mu_j\int p^{Med}d\Lambda\left(x_j\right).\end{aligned}$$

4 Calibration

We provide a definition of a competitive equilibrium with HSAs in the appendix. We use a standard numeric algorithm to solve the model.[19]

We calibrate the model without HSAs to the U.S. economy 2004/2005. 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. We distinguish two sets of parameters. The first set is estimated independently from our model and based on either our own estimates or estimates provided by other studies. These exogenous parameters are summarized in Table 1. The second set of free parameters is chosen so that model-generated data match a given set of targets. These parameters are presented in Table 2. Finally, the target moments that we match with our model are shown in Table 5.

4.1 Demographics and preferences

One period is defined as 8 years. We model $J = 9$ periods, that is households from age 18 to 90. The annual conditional survival probabilities are taken from the U.S. Life-Tables in 2003 and adjusted for the period length.[20] The annual population growth rate is chosen to be 1.2 percent according to the U.S. Census 2006. The total population over the age of 65 is 13.97

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

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

percent, which is between the numbers in the U.S. Census (12.4 percent) and the 20 percent used in Jeske and Kitao (2005) who only look at heads of households.

We choose a Cobb-Douglas type utility function of the form

$$u(c,s) = \frac{\left(c^{\eta} s^{1-\eta}\right)^{1-\sigma}}{1-\sigma},$$

where c is consumption, s is services derived from the stock of health, η is the intensity parameter of consumption, and σ is the inverse of the intertemporal rate of substitution (or relative risk aversion parameter). The functional form of the utility function accounts for the observation that the marginal utility of consumption declines as health deteriorates as pointed out by **?**.

We set $\sigma = 3.11$ and the annual time preference parameter $\beta = 0.98$. Both parameters are chosen to match the capital output ratio and the interest rate. It is clear, however, 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 $\eta = 0.90$. In conjunction with the magnitudes of the health shocks this weight ensures that the model matches total aggregate health spending and the take-up ratio of health insurance. In addition, we assume that health services are produced according to a simple identity function

$$s = f(h) = h.$$

4.2 Production of health and human capital profile

The new health investment is produced according to

$$i(m_j) = \phi_j m_j^{\xi}.$$

The productivity parameter ϕ_j of the health production function is age dependent and summarized in vector ϕ ={0.65, 0.9, 1, 1, ...1}. We choose these values to match health expenditures over the life-cycle. In addition, Grossman (1972b) and Stratmann (1999) estimate positive effects of medical services on measures of health outcomes. We also assume that young agents whose health is much better to begin with are faced with a slightly lower productivity of health production. The second parameter in the health production function is $\xi = 0.35$ and determines the level of spending on medical services.

Calibrating the remaining parts of the law of motion (2) is non-trivial, since reliable estimates for health processes within macro frameworks are very scarce. In order to discretize health capital in our model, we need to find actual thresholds for minimum and maximum holdings of health capital in the data and then translate these thresholds into suitable model values. We start by normalizing the distance between the observed minimum value $h_d^{\min}$ and the observed maximum value $h_d^{\max}$ (subscript d indicates that this variable originates from the data) of a health index variable reported in MEPS called the Short-Form 12 Version 2, or short $SF-12v2$.[21] The normalized range of the empirical health capital measure can be written as $r_d =$

[21] The SF-12v2 includes twelve health measures about physical and mental health. There are two versions of this index available, one for physical health and one for mental health. Both measures use the same variables to construct the index but the physical health index puts more weight on variables measuring physical health com-

$\left(\frac{h_d^{max}-h_d^{\min}}{h_d^{\min}}\right)$. We next pick the lower bound of the health grid in the model $h_m^{\min}$ (subscript m indicates that this variable originates from the model) and calculate the corresponding upper bound of health capital in the model as $h_m^{\max} = r_d \times h_m^{\min} + h_m^{\min}$. The lower bound $h_m^{\min}$ is treated as a free parameter whose magnitude will influence the model outcome. It therefore has to be calibrated.

We next approximate the natural rate of health depreciation by calculating the average health capital holdings $\bar{h}_j$, as measured by the $SF-12v2$ index, per age group of individuals with group insurance and zero health spending in any given year. We then postulate that such individuals did not incur a negative health shock as they could easily afford to buy medical services m to replenish their health due to their insurance status. Hence, setting m_j and ε_j in expression expression (2) equal to zero, their "average" law of motion reduces to

$$\bar{h}_j = \overbrace{(1-\delta_j)\,\bar{h}_{j-1}}^{\text{Trend}},$$

from which we can easily calculate the age dependent natural rate of health depreciation δ_j. We then smooth this vector to eliminate "bumps" in the natural rate of health depreciation. We end up with depreciation rates for each age group as follows $\delta_h = \{0.001, 0.005, 0.005, 0.005, 0.005, 0.005, 0.01, 0.01, 0.08\}$. This is the natural health depreciation net of any health shock ε_j.

4.2.1 Magnitude of health shocks

We discretize health shocks into a vector of five shocks, $\varepsilon_j = \{\varepsilon_{1,j}, \varepsilon_{2,j}, ..., \varepsilon_{5,j}\}$. The magnitude of these age dependent shocks are chosen to match the percentage of workers buying the low deductible health insurance per age group and the share of medical spending in GDP. In order to identify the model we put restrictions on the shock structure. E.g. shock 1 does not change over age for all agents, shock 2 does not change over age for all workers etc. Table 3 presents the matrix of age dependent health shocks associated with each one of the five health shocks. Given the number of restrictions on the shock matrix, the number of free parameters from the 9×5 shock matrix is 21.

4.2.2 Transition probabilities

The Markov transition probabilities for age dependent health shocks are estimated with data from MEPS 2004/2005. The MEPS data contains a variable measuring five self reported health states (e.g. excellent, very good, good, fair, and poor). It is natural to assume that health shocks are strongly correlated with self reported health states. We therefore calculate the five conditional probabilities of being in either excellent health, very good health, good health, fair health, or poor health in 2005 given that the health state in 2004 was excellent. We then repeat this for the remaining four health states in 2004. We do this for each age group separately, so that we get age dependent health shock transition probabilities. We then adjust for the period length of 8 years. The health shock transition matrices are reported in Table 3.

ponents (compare Ware, Kosinski and Keller (1996) for further details about this health index). We concentrate on the physical health component of the measure.

4.2.3 Human capital profile

Effective human capital $e(j, h_{j-1})$ evolves according to

$$e(j, h_{j-1}) = \overbrace{\left(e^{\beta_0+\beta_1 j+\beta_2 j^2}\right)^{\chi}}^{\text{exogenous}} \times \overbrace{\left(h_{j-1}^{\theta}\right)^{1-\chi}}^{\text{endogenous}} \text{ for } \; j = \{1, ..., J_1\}, \tag{17}$$

where $\beta_0, \beta_2 < 0,\ \beta_1 > 0,\ \chi \in [0, 1]$, and $\theta \geq 0$. This formulation mimics the usual hump-shaped income process over the life cycle and makes the wage income of agents dependent on their health state. An otherwise identical individual will be more productive and have higher income if she has relatively better health (e.g. fewer sick days, better career advancement of healthy individuals, etc.). Tuning parameter θ allows us to determine the influence of health on the production process holding the exogenous age dependent component fixed. If $\theta = 0$, then health is a consumption good only. If $\theta > 0$, then health is also an investment good.

We obtain estimates $\left\{\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2\right\} = \{8.12,\ 0.14,\ -0.0015\}$ 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

$$\log(income) = \beta_0 + \beta_1 \times j + \beta_2 \times j^2 + \varepsilon,$$

where j represents age in the model. This represents the exogenous part of expression (17). After normalization, the model reproduces the hump shaped average efficiency units of the human capital profile depicted in panel 2 of Figure 2. Fernandez-Villaverde and Krueger (2004) show similar income patterns using data from the Consumer Expenditures Survey over the period 1980-1998.

We set $\chi = 0.85$. We pick this rather large weight because we do not want to inflate the effects of health on productivity. We argue that this is a reasonable assumption for the U.S. economy with its high degree of health spending and aggregate health status compared to, say, developing countries where increases or decreases in aggregate health play a much larger role for final goods production. We are not aware of any estimates for parameter χ for the U.S.

Our modeling restriction together with the empirical evidence in the literature on medical services, health, and productivity suggests that parameter θ is strictly greater than zero so that health is a consumption and investment good.[22] 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. Alternatively, **?** estimate the effect of health on household income and find highly significant and positive parameter estimates using a partial equilibrium model with an endogenous health process.

[22] There is a growing empirical literature documenting the relationship between medical services, health, and productivity or growth (e.g. Grossman (1972b), Stratmann (1999), Grossman (2000), Behrman et al. (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)).

Given the range of parameter estimates, we therefore analyze the effects of HSAs for a 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 the "maximum" productivity of health in the formation of human capital.

4.3 Health insurance and out-of-pocket medical expenses

4.3.1 Insurance premiums, coinsurance rates and deductibles

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

$$p_j = p_0 \times g_j, \text{ and } p'_j = p'_0 \times g_j \text{ for all } j \in \{1, ..., J_1\}. \tag{18}$$

We estimate the common growth factor for insurance premiums for each age group, g_j,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 rate of age dependent premiums which results in an estimate of the following equation

$$g_j = x_0 + x_1 \times j + x_2 \times j^2 + \epsilon \text{ for all } j \in \{1, ..., J_1\}. \tag{19}$$

The estimates for the regressors are $\{\hat{x}_0, \hat{x}_1, \hat{x}_2\} = \{0.7781,\ 0.0036,\ 0.0007\}$. Expressions (18) and (19) together with the endogenous base premiums p_0 and p'_0 will determine all insurance premiums (low - and high deductibles) for all age groups. Base premiums p_0 and p'_0 are determined endogenously from the zero profit conditions of the insurance companies.

We use MEPS data from 1996-2007 and estimate a median coinsurance rate of $\rho = 24$ percent for private insurance contracts. The coinsurance rate for Medicare γ^{Med} is estimated to be 30 percent.[23] We choose the coinsurance rate of high deductible health insurance contracts slightly lower at $\rho = 22$ percent.

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), GAO (2006), and the U.S. Census to calculate these fractions. In our benchmark model without HSAs, the average ratio of low deductible premiums to high deductible premiums is 0.44 compared to estimates ranging from 0.6 to 1.2. according to Fronstin and Collins (2006). The ratio of average low deductible premiums to Medicare premiums is 1.79 in the model compared to estimates ranging from 0.13

[23] 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 to 3.86. Additional premium ratios and ratios of deductibles to premiums and median income are reported in Table 5.

4.3.2 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 $p_m = 1.45$.[24]

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 percent higher prices for prescription drugs as well as hospital services (see *Playing Fair, State Action to Lower Prescription Drug Prices* (2000)). We therefore pick the price that the insured pay lower at $p_{m,Ins} = 1.2$. The price of health services that Medicare patients pay is set to equal the price that the privately insured pay, $p_{m,Med} = p_{m,Ins}$.

4.4 Health Savings Accounts

According to the Revenue Procedure 2006-53 the annual contribution limit to HSAs 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 amount of the deductible of the high deductible insurance 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 $(1 + \nu) = \frac{\bar{s}^m}{\rho'} = \frac{\$2{,}850}{\$2{,}330} = 1.2232$. The tax penalty for withdrawing funds that are not used for eligible health expenses is $\tau^m = 10$ percent.

4.5 Insurance companies

The base premiums p_0 and p'_0 will adjust to clear the zero profit conditions (10) and (11) of the insurance companies.

4.6 Firms

We impose a standard Cobb-Douglas production technology,

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

and choose a capital share to be $\alpha = 0.33$ which is a standard value. Nadiri and Prucha (1996) report estimates for depreciation rates of physical capital of 5.9 percent and depreciation of R&D capital is 12 percent. In our model we pick a capital depreciation rate of $\delta = 8.5$ percent per year which is a standard value in the calibration literature (e.g. Kydland and Prescott (1982)). The depreciation per period is then $1 - (1 - \delta)^{(years/J)}$.

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

4.7 Government

Social security taxes are $\tau^{Soc} = 2 \times 6.2$ percent on earnings up to \$97,500. This contribution is made by both, employees and employers. The Old-Age and Survivors Insurance Security tax rate is a little lower at 10.6 percent and has been used by Jeske and Kitao (2005) in a similar calibration. The model results in $\tau^{Soc} = 8.3$ percent using a pension replacement ratio $\Psi = 48$ percent.[25] The size of the social security program is then 5.1 percent 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 percent for 2002.

Medicare taxes are $\tau^{Med} = 2 \times 1.45$ percent on all earnings again split in employer and employee contributions (see *Social Security Update 2007* (2007)). In the model we use $\tau^{Med} = 2.92$ which leads to a slightly larger Medicare program (3.4 percent of GDP) than what we observe in the data (3.1 percent 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)). The premium for Medicare p^{Med} is assumed to be independent of age and clears (16) .

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

$$marginalTaxRate\left(income\right) = \beta_0 + \beta_1 \log\left(income\right) + \varepsilon, \tag{20}$$

where $marginalTaxRate\left(income\right)$ 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 (20) 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

$$T\left(income\right) = \overbrace{\left[0.3411 + 0.659 \times \log\left(income\right)\right]}^{marginalTaxRate(income)} \times \text{taxable income}, \tag{21}$$

where $T\left(income\right)$ is total income tax paid. In addition, we impose a lower bound of 0 percent and an upper bound of 35 percent on the marginal income tax rate. Picking the maximum income level at \$400,000 will affect the estimates for the marginal tax function in (20) since it will determine the "tax bins" that individuals fall into. 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 (21) to get the marginal tax rate and the sum total of payable income tax for each individual. The resulting average marginal income tax in the model is within estimates reported in Stephenson (1998) and Barro and Sahasakul (1986).[26]

[25] Social security transfers are defined as $T_j^{Soc}\left(x\right) = \Psi w e_j\left(h_{j-1}\right)$ 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.

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

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 ($G/Y = 20$ percent compared to 20.2 percent reported in Castaneda, Diaz-Gimenez and Rios-Rull (2003)).

4.8 Calibration results

In this section we will present the calibration result of the benchmark model and discuss how our model match the data.

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. First, our model generates total medical expenditures of 8.4 percent in terms of GDP. Since we target health spending as fraction of income per age group using MEPS data, the aggregate health spending of our model is below the 14 percent of GDP of personal health care (PHC) sector spending in 2007 according the National Health Expenditure Accounts (NHEA). The aggregate health spending figure from MEPS is very close to our estimate. MEPS in this sense "underestimates" health expenditures since it does not include some populations (i.e. veterans, long term nursing home care, etc.) and certain spending components (i.e. over the counter medications, R&D, etc.). Bernard et al. (2012) provides details about how to align MEPS data with NHEA data.

Second, our model also matches the distribution of health care expenditures by population proportion (see Yu and Ezzati-Rice (2005) and Table 6). From the data we observe that a small fraction of the population is responsible for a large amount of total health expenditures e.g. 1 percent of the population is responsible for 22 percent of total health expenditures. The model matches the high concentration of health care expenditures well but slightly understates the concentration of the 1 percent of highest spenders (17.9 percent in the model vs. 22 percent reported in the data). The model then over-predicts the concentration of 5 and 10 percent of the population but matches closely again at 50 percent.

Number of insured workers Panel one in Figure 2 shows the fraction of privately insured workers. We overlay the information from the data with proportion of insured workers 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 closely tracks the proportion of insured workers over the life cycle.

We calibrate the fraction of agents buying health insurance to be the 60.3 percent where 99.5 percent of this group buys the low deductible insurance and the remaining agents buy the high deductible insurance. According to MEPS data of 2005, 86.1 percent of the population under age 65 do have health insurance (70.1 percent is private and 16 percent is public), so that roughly 60.2 percent of workers are privately insured.

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 percent and that only 1 percent is currently holding HSAs.[27] In the benchmark

[27]Other surveys find slightly larger numbers for the prevalence of high deductible health insurances (e.g. www.eHealthinsurance.com or Claxton et al. (2006)).

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 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. The model does not match the wealth and income distributions accurately. Two of the main reasons are the lack of additional income shocks and 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.

5 Results

In this section we first explain the economic mechanism underlying our model. We then systematically explore the effect of savings and the effect of health productivity. In addition, we show evidence for the importance of accounting for the full general equilibrium effects when analyzing tax sheltered savings vehicles like HSAs. 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.

5.1 The savings and insurance effect

In our first policy experiment we concentrate on the savings and the insurance effect of HSAs and turn off any influence of health on the formation of human capital by setting tuning parameter θ in the human capital production function equal to zero and recalibrating the model to the U.S. economy, circa 2004/2005.

We report the results of this policy experiment in Table 7. The first column shows the benchmark outcomes without HSAs. Most entries are normalized to 100 to facilitate the comparison with the steady state general equilibrium outcomes after HSAs are fully implemented in the second column. In the third column we provide the outcomes of a partial equilibrium version of the model where we abstract from any general equilibrium price adjustments by holding wages, the interest rate, the insurance premiums for low and high deductible insurances, and the premium for Medicare constant at their respective initial steady state levels.

General equilibrium effects. The introduction of HSAs makes high deductible health insurances more attractive so that workers in the long run switch from low to high deductible health insurance in order to fully benefit from the tax savings. This switch triggers increases in savings as agents start shifting their assets into the tax free savings accounts that they can roll over from one period to the next. In the new steady state agents hold more than fifty percent of their assets in the HSAs which supports the argument made in Aaron, Healy and Khitatrakun (2008) that it is optimal to keep funds in the HSAs as long as possible since they also accumulate tax free. Steady state capital increases by almost 3 percent and triggers a growth effect of output of almost a percent. This income effect dominates the reduction of moral hazard via the high deductible health insurance so that despite the relatively higher effective price for health care services, spending on health care services increases by more than 1 percent of GDP. The latter is definitely not a goal of HSAs but an inevitable by-product of the general equilibrium effects triggered by tax free savings accounts and the expansion of insurance.

The increase of income triggers increases in consumption and health spending. The latter improves the health of individuals. Increases in consumption and health are both welfare improving. A rudimentary welfare analysis suggests that the average lifetime utility of a newborn generation increases significantly in the long run.[28]

It is interesting to note that as the health of the working age population increases, health care spending of the older generation decreases so that the Medicare premium can be lowered. This does not alleviate the pressure on the government budget though, as the government forgoes massive tax income by offering tax free savings on a large scale. Since government spending is a residual variable in our analysis that balances the difference of tax income and spending on the social insurance program, we find that HSAs will force the government to severely cut its spending into other programs as can be seen by the over 5 percent decrease in the ratio of government spending to private sector output G/Y.[29]

In conclusion we find that the savings effect generates massive positive income effects, so that individuals end up spending more on health care despite the prevalence of high deductible health insurances. On the other hand, HSAs achieve almost full coverage of the entire working age population.

Partial equilibrium effects. Many micro simulations rely on partial equilibrium analyses. In this subsection we would therefore like to point out the importance of the general equilibrium analysis presented above by contrasting our outcomes with a partial equilibrium analysis of an otherwise identical policy experiment, i.e. the introduction of HSAs. In the partial equilibrium analysis we hold all market prices constant (i.e. wages, interest rates, and insurance premiums) and let agents react optimally to the introduction of HSAs. From the last column in Table 7 we see that the effects change dramatically, compared the general equilibrium effects in column 2.[30]

First, since insurance premiums do not adjust, we find that the swap from low to high deductible health insurances is not as complete as before as agents can only benefit from the tax free savings but not from any premium reductions that would follow the reduction of adverse selection. Now only 36.9 percent of workers switch into high deductible plans, whereas 38.4 percent stay in low deductible plans. In absolute numbers this amounts to a rather moderate increase in the number of newly insured workers. The asset split into standard assets vs. tax free holdings in HSAs is also not as extreme as before as agents only hold about 25 percent of their assets in HSAs. Due to the extra income from the tax free savings, agents also end up spending more on health care services which increases aggregate health minimally and leads to small welfare improvements. Overall, the results highlight the importance of a general equilibrium analysis of such a comprehensive reform as the adjustment of prices changes the results

[28]It should be noted that for a complete welfare analysis, measured in compensating consumption units, solutions for the transition path from the old to the new steady state would be required. However, since transitions are not feasible due to computational constraints, we cannot provide a thorough welfare analysis.

[29]We later provide an estimate of how much the government would have to tax agents in order to keep the government spending to GDP ratio constant to pre-HSAs levels.

[30]We do not report values for output, aggregate capital stock and prices, since the latter have been fixed and the former are outcomes of the production process. Since this is a partial equilibrium exercise, we have to abstract from production as firm first order conditions are not satisfied anymore due to the fixing of all prices.

significantly.

5.2 Health productivity and the human capital effect

If one believes the argument that households only forgo unnecessary treatment after buying high deductible health insurances (e.g. Manning et al. (1987) or Matisson (2002)), then parameter θ in expression (17) should be close to zero. Setting $\theta = 0$ 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. We have presented the outcome of the introduction of HSAs under this assumption in the section above.

If, on other hand, one believes in Grossman's argument (Grossman (1972)) that health is also 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. We therefore repeat the exercise above by setting health productivity parameter $\theta = 1$. Results are reported in Table 8.

The mechanism is very similar to what we presented before. HSAs make the high deductible health insurance option more attractive so agents switch to it. This lowers the premium of high deductible health insurances and increases the premium of low deductible insurances which reinforces the take up of high deductible insurances. Second, HSAs provide a tax free savings vehicle so that agents start to accumulate more physical capital. The steady state capital stock increases by 2.7 percent. The positive income effect on health care spending balances the negative insurance effect, so that aggregate health capital in the economy increases. This increase is small and is triggered by higher health capital holdings of the older working population which has lower labor productivity. Since the health improvements are concentrated on the population with lower productivity, the aggregate human capital measure drops slightly. Hence, incorporating the human capital effect, the model reports slightly smaller growth effects than without productive health.

We were careful to not overstate the impact of health on productivity which is a reasonable assumption for a developed country like the U.S. We therefore only observe very small changes that can be attributed to the human capital effect. The qualitative results are identical to the results with the human capital effect turned off. Partial equilibrium effects do again significantly differ from general equilibrium outcomes.

5.3 Contribution limits and tax free savings

There has been a lot of discussion about 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 like Fronstin (2010) have questioned whether this savings limit is too low and therefore does not allow agents to save enough for their health spending. In a general equilibrium framework the annual contribution limit to HSAs is critical in determining the size of the savings effect, which in return influences the demand for health insurance and health care.

In this policy experiment we isolate the quantitative importance of the contribution limit to HSAs. To do so, we vary the annual savings limit in from $\$100$ to $\$5,500$. We plot the steady state results of this analysis in Figures 3 and 4. In addition, we overlay the graph with steady state values from the benchmark economy without HSAs and with results from a partial equilibrium analysis where appropriate.

The tax stimulus associated with HSAs induces households to save more. This positive effect on the accumulation of physical capital will increase output and therefore household income if the annual savings limit is chosen high enough (i.e. an annual savings limit between $\$2,400$ and $\$2,500$ will make HSAs operative). If the annual savings limit is below $\$2,400$, then HSAs do not provide a large enough incentive to trigger a switch to high deductible insurances and the economy stays in its status quo state as can be seen from panel 2 in Figure 3. Once the critical threshold is reached, agents start purchasing more high deductible health insurance contracts which will increase the effective price of health care. However, they also start to save more in the tax free accounts (see panel 3 in Figure 3), which triggers positive output and therefore positive income effects (see panel 1 in Figure 4). The additional income outweighs the price effect from the high deductible insurances, so that overall, households will spend more on their health care after HSAs are introduced (see panel 1 in Figure 3). In addition, there is a large number of previously uninsured workers, that now has high deductible health insurance. The additional moral hazard also contributes to increases in total health expenditures.

If we 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 again observe substantial differences between the general equilibrium and the partial equilibrium outcomes in panel 1 of Figure 3 and panel 2 of Figure 4.

We conclude that HSAs can increase the number of insured individuals but they also increase total health expenditures in the economy, which runs counter to one of the main goals of HSAs. 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 in the next section in order to address this issue.

5.4 Taxpayer liability from Health Savings Accounts

In order to determine the tax revenue loss i.e. the cost of HSAs for tax payers, we run the following experiment. We introduce HSAs into the benchmark economy, holding the government spending to output ratio (G/Y) constant to the original ratio in the first steady state without HSAs. 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 with a savings limit of $\bar{s}^m = \$2.850$. We find that if the government were to hold its spending as a fraction of GDP constant, then the introduction of HSAs requires additional tax revenues of 5.16 percent of GDP (raised by this lump sum tax on all surviving households).

The logic behind the sharp decline in the government's tax revenues is the following. The introduction of HSAs is indeed a tax cut for capital income, which has a number of fiscal implications on the government budget. First, a zero tax rate on savings in HSAs directly lowers the income tax base and therefore tax revenues. Furthermore, a zero capital income tax for specific investments affects the investment portfolios of U.S. households as they rationally re-allocate their savings from highly taxed to tax free savings accounts. This in turn decreases the tax base and further lowers tax revenue.

6 Conclusion

We study the macroeconomic effects of HSAs that have been introduced in the U.S. in 2003. This reform couples a health insurance reform with a capital income tax reform. We develop a general equilibrium model with health and a health care sector and demonstrate that general equilibrium channels play an important role in determining the success or failure of HSAs. Particularly, we find that HSAs are successful in insuring more individuals but fail to decrease health care spending. The magnitude of the increases in health expenditures depends on the annual contribution limits to HSAs and the interplay of general equilibrium effects. A rudimentary welfare analysis points towards long run welfare gains from HSAs.

However, the effects on tax revenue losses are large. After the introduction of HSAs, government revenue drops, so that government spending (the residual of tax revenue after the 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 to insure more people. Especially since we 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 more than 5 percent 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[31], and (*iii*) no alternative tax free 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 implications more carefully. 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.

[31] GAO (2006) report that participants in their survey were initially unaware of a monthly $3 administrative bank fee for maintaining the HSA and felt that it diminished any potential gains from interest earned on their HSA balance. If one included this feature in the model, the take-up rate of HSAs and high deductible insurance is likely to be lower.

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7 Appendix

7.1 Definition of equilibrium with HSAs

1 *Given the exogenous government policies* $\left\{\tilde{\tau}\left(\tilde{y}\left(x_j\right)\right), \tau^K\right\}_{j=1}^J$, *a competitive equilibrium* ***with health savings accounts*** *is a collection of sequences of distributions* $\left\{\mu_j, \Lambda_j\left(x_j\right)\right\}_{j=1}^J$ *of individual household decisions*
$\left\{c\left(x_j\right),\ a\left(x_j\right),\ a^m\left(x_j\right),\ m\left(x_j\right),\ in\left(x_j\right)\right\}_{j=1}^J$, *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) $\left\{c\left(x_j\right), a\left(x_j\right), a^m\left(x_j\right), m\left(x_j\right), in\left(x_j\right)\right\}_{j=1}^J$ *solves the consumer problem* (6),

(b) *the firm first order conditions hold*

$$\begin{aligned} w &= F_L\left(K, L\right), \\ q &= F_K\left(K, L\right), \\ R &= q + 1 - \delta, \end{aligned}$$

(c) *markets clear*

$$
\begin{aligned}
A &= \sum_{j=1}^{J} \mu_j \int \left(a\left(x_j\right) + a^m\left(x_j\right)\right) d\Lambda\left(x_j\right) \\
T^{Beq} &= \sum_{j=1}^{J} v_j \int \left(a\left(x_j\right) + a^m\left(x_j\right)\right) d\Lambda\left(x_j\right), \\
K &= A + T^{Beq} + \sum_{j=1}^{J} \mu_j \int \left(1_{\{in_j(x_j)=1\}} p_j + 1_{\{in_j(x_j)=2\}} p_j'\right) d\Lambda\left(x_j\right), \\
L &= \sum_{j=1}^{J_1} \mu_j \int e(j, x_j) d\Lambda\left(x_j\right),
\end{aligned}
$$

(d) *the aggregate resource constraint holds*

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

(e) *the government programs clear so that* (14), (15), (16), *and* (13) *hold,*

(f) *the budget constraints of insurance companies* (10) *and* (11) *hold*

(g) *the distribution is stationary*

$$
\left(\mu_{j+1}, \Lambda\left(x_{j+1}\right)\right) = T_{\mu,\Lambda}\left(\mu_j, \Lambda\left(x_j\right)\right),
$$

where $T_{\mu,\Lambda}$ *is a one period transition operator on the distribution.*

7.2 Tables and Figures

Parameters:		Explanation/Source:
- Periods working	$J_1 = 6$	
- Periods retired	$J_2 = 3$	
- Population growth rate	$n = 1.2\%$	U.S. Census 2006
- Years modeled	$years = 72$	from age 20 to 92
- Human capital profile	$\left\{\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2\right\} = \{8.12, 0.14, -0.0015\}$	
- 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	$p_{m,Ins} = 1.20$	U.S. Census 2004
- Price for medical care for uninsured	$p_{m,nIns} = 1.45$	U.S. Census 2004
- Capital share in production	$\alpha = 0.33$	Standard value
- Capital depreciation	$\delta = 8.5\%$	Kydland and Prescott (1982) Nadiri and Prucha (1996)
- Total factor productivity	$A = 1$	Normalization
- Health depreciation	$\delta_j = \{0.001, ..., 0.08\}$	MEPS 2004/2005
- High deductible	$\gamma' = 0.75$	- to match $\frac{\rho}{\rho'} = 0.13$ according to Fronstin and Collins (2006)
- Medicare deductible	$\gamma^{Med} = 0.02$	- 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	$\rho = 0.24$	0.25 in Suen (2006)
- Coinsurance rate, Medicare	$\rho^{Med} = 0.30$	- Center for Medicare and Medicaid Services (2005)
- Maximum contribution to HSAs	$\bar{s}^m = \$2,850$	- Revenue procedure 2006-53 and Fronstin and Collins (2006)
- Asset grid	$a_{Grid} = [0, ..., 3]_{1\times 90}$	
- HSA asset grid	$a^m_{Grid} = [0, ..., 1.5]_{1\times 20}$	
- Health grid	$h_{jGrid} = [0.02, ..., 4]_{1\times 15}$	

Table 1: **Exogenous Parameters**
Estimated independently from the model or provided by other studies.

Parameters:		Explanation/Source:	Free Paras
- Relative risk aversion	$\sigma = 3.11$	to match $\frac{K}{Y}$ and R	1
- Preference on consumption	$\eta = 0.9$	to match $\frac{p\times M}{Y}$	1
- Discount factor	$\beta = 0.98$	to match $\frac{K}{Y}$ and R	1
- Health production productivity	$\phi_j = \{0.65,\ 0.9,\ 1,\ 1, ..., 1\}$	to match $\frac{p\times M}{Y}$	3
- Production parameter of health	$\xi = 0.27$	to match $\frac{p\times M}{Y}$	1
- Human capital production	$\chi = 0.85$	to match income distribution	1
- Health productivity	$\theta = [0, 1]$	used for sensitivity analysis	1
- Health Shocks	see Table 3		20
- Pension replacement rate	$\Psi = 0.48$	to match size of Social Security	1
- Payroll tax Medicare:	$\tau^{Med} = 2.92\%$	to match size of Medicare	1
- Low deductible	$\gamma = 0.015$	- to match percentage of insured to be close to 80%	1
- Coinsurance rate, high deductible	$\rho' = 0.22$	to match insurance take-up rate	1
-Total number of free parameters			33

Table 2: **Endogenous Parameters used to Match Moments in U.S. Data**

	Shock 1	Shock 2	Shock 3	Shock 4	Shock 5
Age					
18-25:	0.00	0.05	0.40	1.05	2.20
26-33:	0.00	0.05	0.40	1.05	2.20
34-41:	0.00	0.05	0.40	1.05	2.20
42-49:	0.00	0.05	0.44	1.10	2.40
50-57:	0.00	0.05	0.45	1.13	2.50
58-65:	0.00	0.05	0.45	1.24	2.65
66-74:	0.00	0.05	0.45	1.25	2.65
75-81:	0.00	0.09	0.47	1.30	2.70
72-89:	0.00	0.09	0.50	1.37	3.00

Table 3: **Health Shocks by 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.

	to	Shock 1	Shock 2	Shock 3	Shock 4	Shock 5
18 to 26	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.214	0.519	0.235	0.031	0.002
Shock 2	.	0.201	0.513	0.249	0.035	0.003
Shock 3	.	0.184	0.503	0.267	0.043	0.004
Shock 4	.	0.164	0.485	0.287	0.056	0.008
Shock 5	.	0.129	0.444	0.320	0.089	0.018
26 to 34	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.247	0.481	0.245	0.028	0.001
Shock 2	.	0.222	0.471	0.272	0.034	0.001
Shock 3	.	0.189	0.452	0.312	0.046	0.002
Shock 4	.	0.160	0.428	0.349	0.061	0.003
Shock 5	.	0.118	0.378	0.398	0.098	0.009
34 to 42	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.235	0.451	0.259	0.050	0.005
Shock 2	.	0.185	0.433	0.303	0.069	0.010
Shock 3	.	0.149	0.410	0.336	0.089	0.016
Shock 4	.	0.120	0.375	0.356	0.116	0.032
Shock 5	.	0.075	0.290	0.369	0.182	0.084
42 to 50	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.146	0.383	0.361	0.101	0.009
Shock 2	.	0.110	0.346	0.392	0.137	0.015
Shock 3	.	0.078	0.300	0.412	0.185	0.025
Shock 4	.	0.051	0.240	0.411	0.253	0.045
Shock 5	.	0.032	0.187	0.394	0.318	0.070
50 to 58	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.185	0.418	0.298	0.086	0.013
Shock 2	.	0.149	0.394	0.327	0.111	0.020
Shock 3	.	0.118	0.366	0.350	0.137	0.029
Shock 4	.	0.086	0.319	0.364	0.174	0.057
Shock 5	.	0.041	0.204	0.329	0.245	0.181
58 to 66	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.099	0.437	0.330	0.105	0.029
Shock 2	.	0.091	0.416	0.334	0.122	0.037
Shock 3	.	0.079	0.385	0.336	0.149	0.051
Shock 4	.	0.059	0.320	0.330	0.207	0.084
Shock 5	.	0.045	0.272	0.321	0.250	0.112
66 to 74	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.103	0.357	0.384	0.143	0.012
Shock 2	.	0.083	0.325	0.407	0.168	0.018
Shock 3	.	0.066	0.295	0.425	0.190	0.024
Shock 4	.	0.044	0.235	0.428	0.245	0.048
Shock 5	.	0.027	0.169	0.390	0.301	0.113
74 to 82	.	.	.	.	.	.
from	.	.	.	.	.	.
Shock 1	.	0.063	0.248	0.426	0.216	0.047

Parameters	Model	Data	Source	Nr. of Moments
- Medical expenses per GDP:	14.77%	15-6%	Baicker (2006) and Fang and Gavazza (2007)	1
- Fraction of insured workers: (private insurance)	60.3%	-Employment based 59.8%) public: 19%	- MEPS 2005 and U.S. Census Bureau 2006	1
- Ratio of average low vs. high deductible premium	0.44	0.6 to 1.2	- Fronstin and Collins (2006) and Claxton et al. (2006)	1
- Ratio of low deductible vs. Medicare premium	1.79	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	0.09	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: $\frac{\gamma}{\sum_j \mu_j p_j}$	0.12	0.07 to 0.23	- Fronstin and Collins (2006), Claxton et al. (2006), and U.S. Department of Health 2006	1
- High deductible plan: $\frac{\gamma'}{\sum_j \mu_j p'_j}$	0.27	0.66 to 1.15	- same source as above,	1
- Medicare: $\frac{\gamma^{Med}}{\sum_j \mu_j p_j^{med}}$	0.3	1	U.S. Department of Health 2006	1
Ratio deductible vs. median income				
- Low deductible plan: $\frac{\gamma}{med(income)}$	0.018	0.017	- Fronstin and Collins (2006) and U.S. Census 2005	1
- High deductible plan: $\frac{\gamma'}{med(income)}$	0.09	0.13	- Fronstin and Collins (2006) and U.S. Census 2005	1
- Medicare: $\frac{\gamma^{Med}}{med(income)}$	0.024	0.06	U.S. Department of Health 2006 and U.S. Census 2005	1
- Capital output ratio: K/Y	3.05	3	NIPA	1
- Interest rate	3.88%	4%	NIPA	1
- Residual Government spending: G/Y	19.8%	20.2%	Castaneda et al. (2003)	1
- Size of Social Security: SocSec/Y	5.06%	5%	Social Security Administration 2002	1
- Size of Medicare: Medicare/Y	3.43%	3.1%	U.S. Department of Health 2002	1
- Fraction over 65	13.97%	12.4%	U.S. Census 2005	
- Payroll tax Social Security: τ^{Soc}	8.3%	6%-10%	IRS [32]	1
- Average marginal income tax	28%	21.5% to 32.1%	- Stephenson (1998) and Barro and Sahasakul (1986)	1
- Income and savings profile		see Figure 2		9
- Insurance take-up ratios		see Figure 2		6
Total number of Moments				33

Table 5: **Data vs. Model**

Total Health Care Expenditure:	Data (in %)	Model (in %)
Percent of Total Population		
1%	22.000	17.940
5%	49.000	52.823
10%	64.000	74.950
50%	97.000	99.900

Table 6: **Distribution of Health Expenditures in the U.S. Economy**.
Data is from MEPS 2002 as summarized in Yu and Ezzati-Rice (2005).

	Benchmark No HSA	HSA G.E.	HSA P.E.
Output: Y	100.000	100.980	
Capital stock: K	100.000	102.999	
Standard assets: a in %	100.000	43.700	75.004
Assets in HSAs: a^m in %	0.000	56.300	24.996
Health Capital: H	100.000	100.349	100.157
Medical spending: $p_m M$	100.000	107.474	102.572
Medical spending: $p_m M/Y$ in %	17.233	18.341	
Consumption: C	100.000	107.512	102.738
Human capital: Hk	100.000	100.000	100.000
Interest rate: r in %	3.377	3.235	
Wages: w	100.000	100.860	
Insured workers - low deduct. insurance in %	62.215	0.000	38.380
Insured workers - high deduct. insurance in %	0.000	99.168	36.917
Low deductible base premium	100.000	191.808	
High deductible base premium	115.055	80.758	
Medicare premium	100.000	85.861	
Government spending: G/Y in %	18.663	13.115	
Welfare	-100.000	-85.251	-93.951

Table 7: **Steady State Results without Human Capital Effect**, $\theta = 0$

	Benchmark No HSA	HSA G.E.	HSA P.E.
Output: Y	100.000	100.876	
Capital stock: K	100.000	102.710	
Standard assets: a in %	100.000	48.521	51.603
Assets in HSAs: a^m in %	0.000	51.479	48.397
Health Capital: H	100.000	100.144	100.120
Medical spending: $p_m M$	100.000	112.684	108.228
Medical spending: $p_m M/Y$ in %	14.774	16.503	
Consumption: C	100.000	105.556	102.095
Human capital: Hk	100.000	99.984	99.999
Interest rate: r in %	3.876	3.767	
Wages: w	100.000	100.678	
Insured workers - low deduct. insurance in %	60.319	0.000	11.301
Insured workers - high deduct. insurance in %	0.002	99.762	85.575
Low deductible base premium	100.000	158.748	
High deductible base premium	192.242	85.805	
Medicare premium	100.000	86.242	
Government spending: G/Y in %	19.794	14.471	
Welfare	-100.000	-87.442	-93.373

Table 8: **Steady State Results with Human Capital Effect**, $\theta = 1$

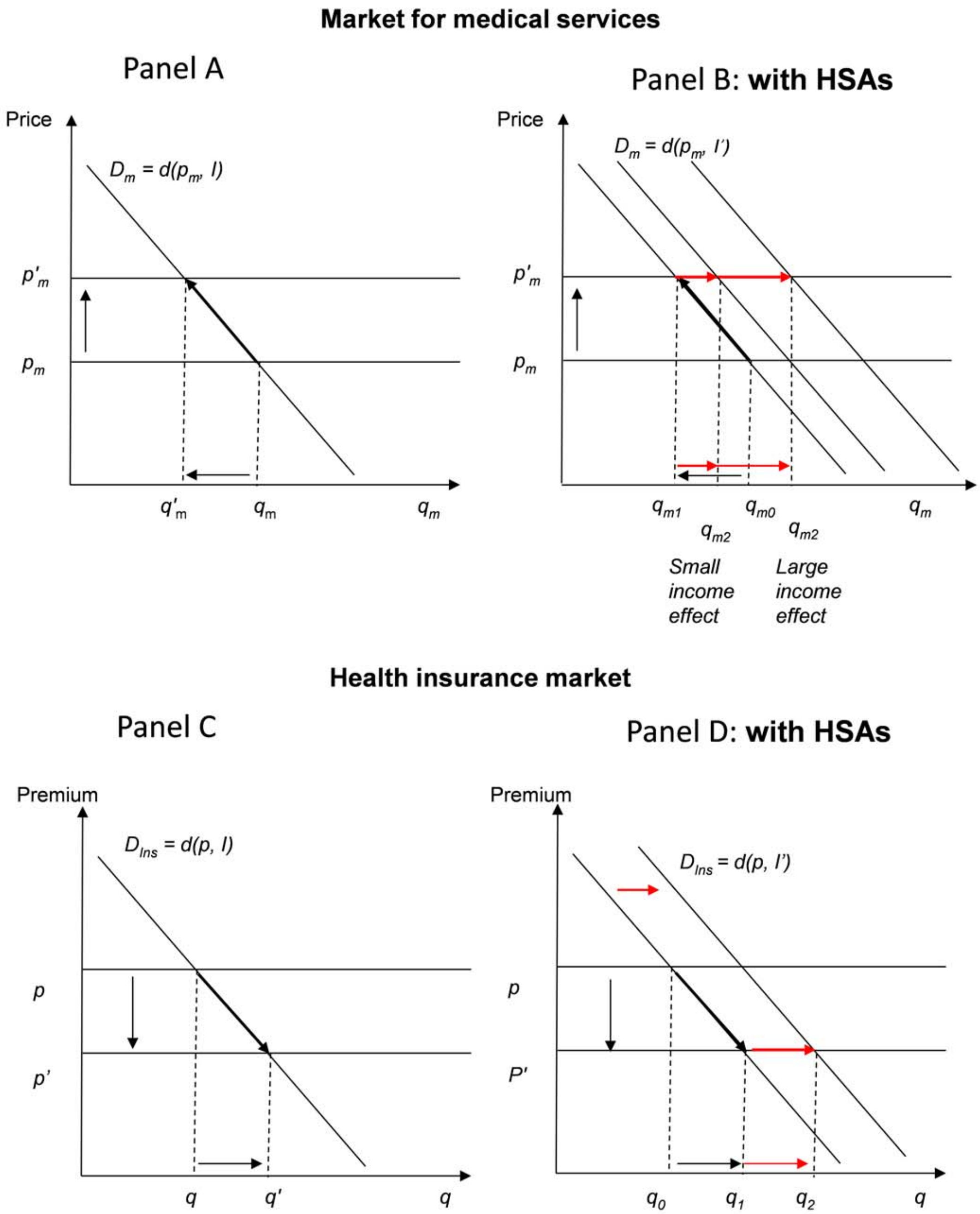

Figure 1: **Economic Mechanism of HSAs**

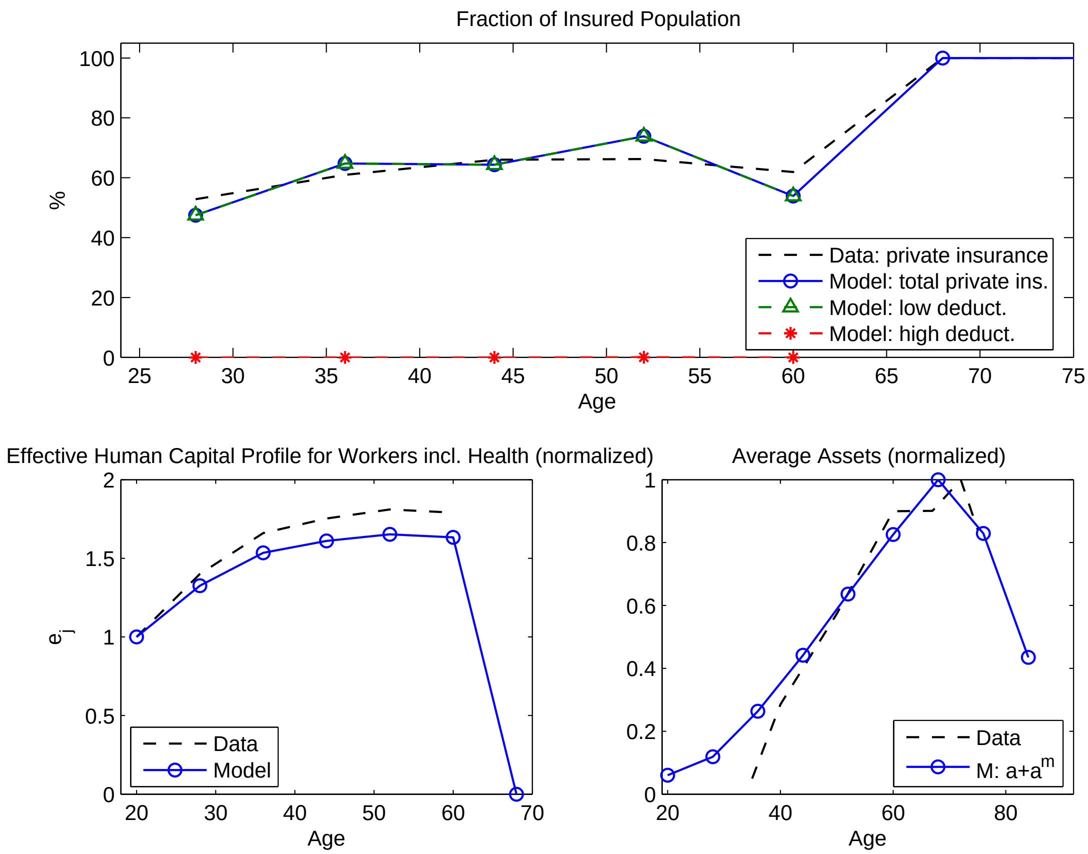

Figure 2: **Steady State Results without HSAs**

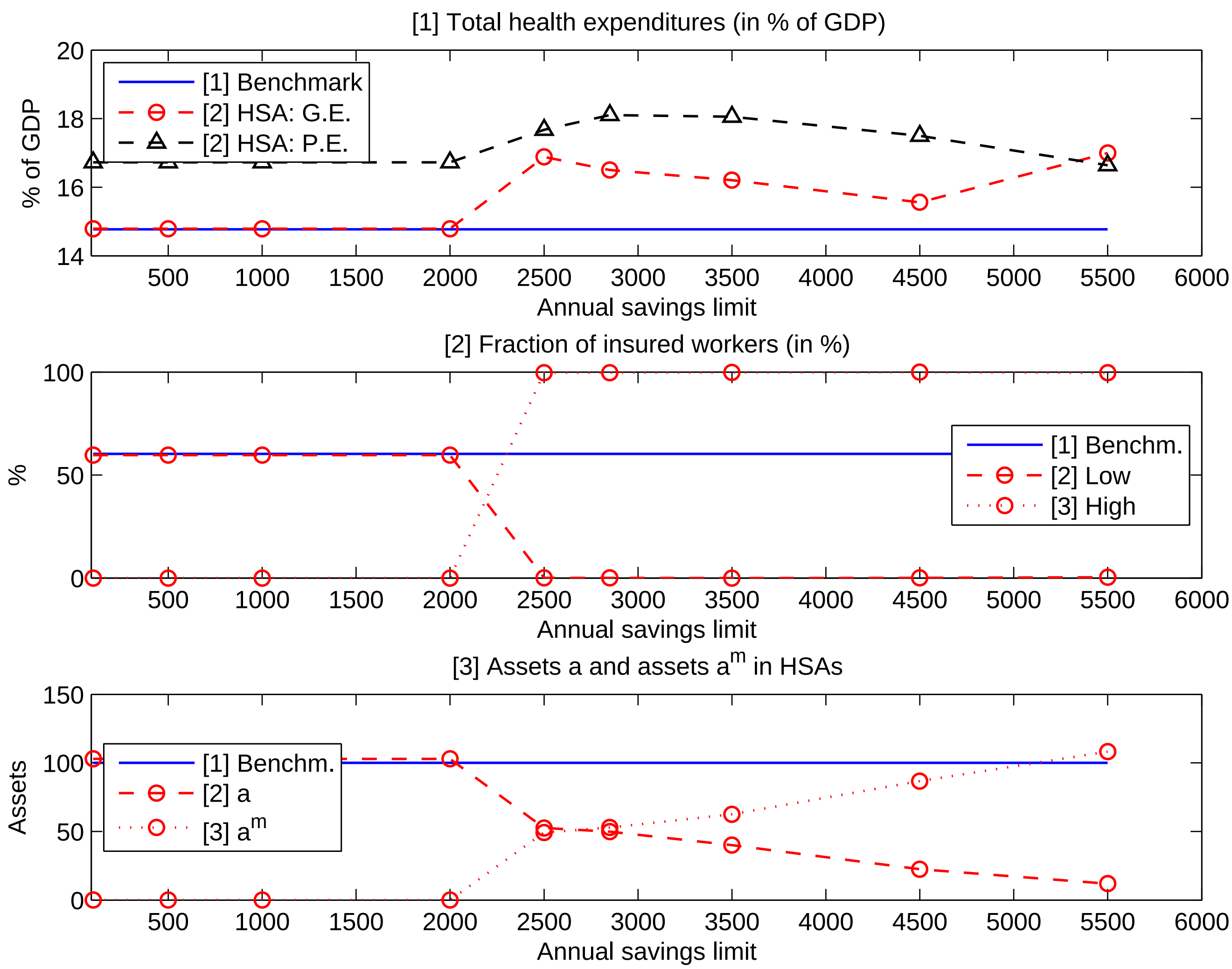

Figure 3: **Steady State Results with Varying Annual Contribution Limits to HSAs**

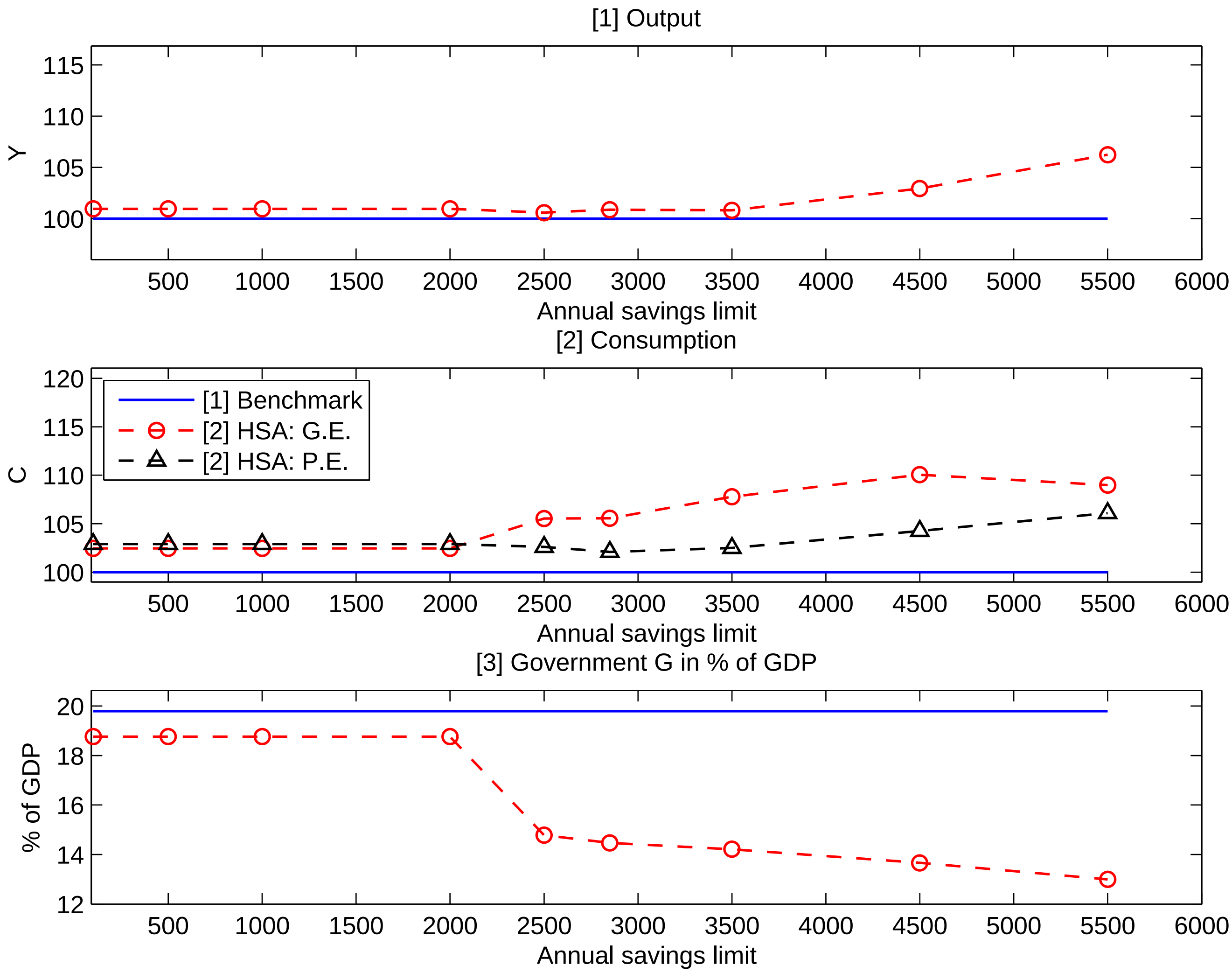

Figure 4: **Steady State Results with Varying Annual Contribution Limits to HSAs**