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Abstract

In this paper, I develop a quantitative macroeconomic model with endogenous health and endogenous longevity and use it to study the impact of Social Security on aggregate health spending. I find that Social Security increases the aggregate health spending of the economy via two channels. First, Social Security transfers resources from the young with low marginal propensity to spend on health care to the elderly (age 65+) with high marginal propensity to spend on health care. Second, Social Security raises people's expected future utility and thus increases the marginal benefit from investing in health to live longer. In the calibrated version of the model, I show that the positive impact of Social Security on aggregate health spending is quantitatively important. The expansion of US Social Security since 1950 can account for approximately 43% of the dramatic rise in US health spending as a share of GDP over the same period (i.e. from 4% of GDP in 1950 to 13% of GDP in 2000). I also find that this positive impact of Social Security has two interesting policy implications. First, the negative effect of Social Security on capital accumulation in this model is significantly smaller than what previous studies have found, because Social Security induces extra years of life via health spending and thus encourages private savings for retirement. Second, Social Security has a significant spillover effect on public health insurance programs (e.g. Medicare). As Social Security increases health spending and longevity, it also increases the insurance payments from these programs, thus raising their financial burden.

Keywords: Social Security, Health Spending, Savings, Longevity.
JEL Classifications: E20, E60, H30, I00.

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1 Introduction

Aggregate health care spending as a share of GDP has more than tripled since 1950 in the United States. It was approximately 4% in 1950, and jumped to 13% in 2000 (see Figure 1).[1] Why has US health spending as a share of GDP risen so much? This question has attracted growing attention in the literature.[2] Several explanations have been proposed, such as increased health insurance and income growth. According to CBO (2008), however, existing explanations *together* only account for approximately half of the rise in US health spending over the last half century, suggesting that there is still a large portion of the rise in health spending remaining unexplained. This paper is mainly motivated by this large unexplained residual.

Over the last several decades, the size of the US Social Security program has also dramatically expanded (as shown in Figure 2). Total Social Security expenditures were only 0.3% of GDP in 1950, and jumped to 4.2% of GDP in 2000.[3] Furthermore, several papers in the literature have shown that *theoretically* mortality-contingent claims, such as Social Security annuities, may have positive effects on health spending and longevity.[4] For instance, Davies and Kuhn (1992) argue that Social Security annuities provide people with an incentive to increase longevity through higher spending on longevity-inducing health care because the longer a person lives, the more Social Security payments she receives.

What are the effects of Social Security on *aggregate* health spending? Can the expansion of US Social Security account for the dramatic rise in US health spending over the last several decades? I ask these questions in this paper. To answer them, I develop an Overlapping Generations (OLG), General Equilibrium (GE) model with endogenous health spending and endogenous longevity. Following Grossman (1972), I adopt the concept of health capital in the model. Health capital depreciates over the life cycle, and health spending produces new health capital. In each period, agents face a survival probability which is an increasing function of their health capital. Before retirement, agents earn labor income by inelastically supplying labor to the labor market.

[1]For 1929-1960, the data is from Worthington (1975), and after 1960, the data is from http://www.cms.hhs.gov/NationalHealthExpendData. Health care spending includes spending on hospital care, physician service, prescription drugs, and dentist and other professional services. It excludes the following items: spending on structures and equipment, public health activity, and public spending on research

[2]Newhouse (1992), Finkelstein (2007), Hall and Jones (2007) and CBO (2008), etc.

[3]Note that these changes do not simply reflect the population structure changes over this period. The average Social Security expenditure (per elderly person) also increased significantly, from 3.7 % of GDP per capita in 1950 to 33.7% of GDP per capita in 2000.

[4]Davies and Kuhn (1992), Philipson and Becker (1998).

After the mandatory retirement age, they live on Social Security annuities and private savings. Social Security annuities are financed by a payroll tax on working agents. In the model, agents spend their resources either on consumption, which gives them a utility flow in the current period, or on health care, which increases their health capital and survival probability to the next period. Agents can smooth consumption or health spending over time via private savings, but they do not have access to private annuity markets.[5]

In the model, Social Security increases aggregate health spending as a share of GDP via two channels. First, Social Security transfers resources from the young to the elderly (age 65+), whose marginal propensity to spend on health care is much higher than the young, thus raising aggregate health spending. For example, if the marginal propensities to spend on health care for the young and for the elderly are 0.09 and 0.4 respectively, then transferring one dollar from the young to the elderly would increase aggregate health spending by 31 cents.[6] Follette and Sheiner (2005) find that elderly households spend a much larger share of their income on health care than non-elderly households.[7] Second, Social Security raises expected future utility by providing annuities in the later stage of life and insuring for uncertain lifetime. As a result, it increases the marginal benefit from investing in health to increase longevity, and thus induces people to spend more on health care.

Some people may think that Social Security wealth crowds out the private savings of agents with rational expectation, which can offset the impact of the above-described mechanisms. This is not exactly true. It has been well argued in the literature that Social Security in a model with frictions can transfer resources from the young to the elderly (e.g. Imrohoroglu et al. (1995), and Attanasio and Brugiavini (2003)). For instance, Social Security payments are usually larger than the private savings of poor people and people who live longer than expected. Future Social Security wealth cannot crowd out savings motivated by precautionary reasons because it is not liquid and cannot be borrowed against. Furthermore, Social Security reduces the aggregate capital level and

[5] The data shows that the US private annuity markets were very thin over the last several decades. According to Warshawsky (1988), only approximately 2% - 4% of the elderly population owned private annuities from the 1930s to the 1980s. A common explanation for the lack of private annuity markets is that the adverse-selection problem in private annuity markets reduces the yield on these annuities.

[6] Marginal propensity to spend on health care is defined as follows: how many cents of health spending would be induced by one extra dollar of disposable income. In this example, if the government transfers one dollar from the young to the elderly, then the elderly would spend 40 cents more on health care and the young would spend 9 cents less on health care.

[7] For instance, they find that the elderly in the 3rd income quintile spend 40% of their income on health care, while health spending is only 9% of income for the non-elderly in the 3rd income quintile in 1987 (see Table 1).

thus increases the interest rate, which also induces people to allocate more resources to the later stage of life. In fact, several empirical studies have suggested that the substitutability between private savings and Social Security wealth can be as low as 0.2, which means one dollar Social Security wealth only crowds out 20 cents private savings (Diamond and Hausman (1984), Samwick (1997)).

To evaluate the quantitative importance of the impact of Social Security on aggregate health spending, I conduct the following quantitative exercise in the calibrated version of the model. I exogenously change the size of Social Security and then study how this change affects agents' health spending behavior in the model. I find that an increase in the size of Social Security which is similar in magnitude to the expansion of US Social Security from 1950 to 2000 can generate a significant rise in health spending as a share of GDP in the model, which accounts for 43% of the rise in US health spending as a share of GDP from 1950 to 2000. Furthermore, I find that the expansion of Social Security is very important in accounting for another relevant empirical observation over the same period: the change in life-cycle profile of average health spending (per person). Meara, White, and Cutler (2004) find that health spending growth was much faster among the elderly than among the non-elderly from 1963 to 2000. As a result, the life-cycle profile of health spending has become much steeper over the last several decades (see Figure 3). I find that the expansion of Social Security can also generate the changing life-cycle profile of health spending in the model.

It is worth mentioning that the model also has several interesting implications about the macroeconomic effects of Social Security. First, the negative effect of Social Security on capital accumulation in the model is significantly smaller than what has been found in previous studies.[8] It is well known that pay-as-you-go Social Security crowds out private savings because as people expect to receive Social Security payments after retirement, they save less than in the economy without social security. Previous studies found that this negative impact is quantitatively large. The capital stock would increase by approximately a third if Social Security were eliminated. However, these studies may have exaggerated this negative effect since they all assume exogenous longevity and health spending. When health spending and longevity are endogenous, Social Security also has a positive effect on savings: as Social Security increases longevity via health spending, people would save more for retirement than in the economy without Social Security. I find that this positive effect is quantitatively significant. In the benchmark model, the capital stock would be 25% higher if Social Security were eliminated. But when the health spending decisions are fixed in the model,

[8] Auerbach and Kotlikoff (1987), Imrohoroglu et al. (1995), etc.

the capital stock would be 31% higher if Social Security were eliminated. This suggests that models assuming exogenous longevity and health may have significantly exaggerated the negative effect of Social Security on savings.

Second, Social Security has a significant spill-over effect on public health insurance programs (e.g. the US Medicare) via its impact on health spending. Public health insurance programs usually provide coinsurance for health spending. As a result, as Social Security increases health spending, it also increases the insurance payments from these programs, thus raising their financial burden. In the benchmark model, the payroll tax rate required to finance the health insurance payments for the whole population is 10.7%, but this rate would drop to 6.9% (by 36%) if Social Security were eliminated. This spill-over effect can be even larger for programs that only target the elderly, such as the US Medicare program. In the benchmark model, the payroll tax rate required to finance the health insurance payments for the elderly is 5.4%, and this rate would drop to 2.1% (by 61%) if Social Security were eliminated. This finding is particularly interesting because Social Security and Medicare are the two largest public programs in the United States and both are currently under discussion for reforms. It suggests that the spill-over effect of Social Security on Medicare may be large, and thus should be taken into account by future studies on policy reforms.

This paper contributes to the literature that studies the causes of the rise in US health spending over the last several decades. Several explanations have been proposed. Among them, increased health insurance and income growth have received the most attention in the literature. One says that the increased health insurance over the last several decades (e.g. the introduction of Medicare) reduces price to the consumer and increases the demand for health care services.[9] The other says that the income growth over the last half century is an important cause of the rise in health spending as a share of GDP because health care is a luxury good.[10] Other conventional explanations for the rise in health spending include population aging, rising health care price, etc. According to CBO (2008), however, all these explanations together only account for approximately half of the rise in US health spending over the last half century, suggesting that there is still a large portion of the rise in health spending remaining unexplained.[11]

This paper also contributes to the quantitative literature on Social Security that was started

[9] Feldstein (1971,1977), Manning et al. (1987), and Newhouse et al. (1992), and Finkelstein (2007), etc.

[10] See Hall and Jones (2007).

[11] It is worth mentioning that several studies have suggested that the unexplained residual may be due to health technological progress. That is, the invention and adoption of new and expensive health technologies over the past several decades increased health spending (e.g. Newhouse (1992), CBO (2008)). I will provide further discussion on this issue in the sixth section.

by Auerbach and Kotlikoff (1987). Most existing studies in the literature either assume exogenous health or no health at all. To the best of my knowledge, this paper is the first study to include endogenous health into a quantitative model of Social Security. I show in this paper that endogenous health does significantly change the answer to a key question in this literature, i.e. the effect of Social Security on capital accumulation.

In term of modeling, this paper is closely related to a recent macroeconomic literature that studies a quantitative macroeconomic model with endogenous health. For instance, Hall and Jones (2007), Suen (2006), Yogo (2007), Halliday, He, and Zhang (2009), Jung and Tran (2008), etc.

The rest of the paper is organized as follows. I set up the benchmark model in the second section and calibrate the model in the third section. In the fourth section, I provide the main results, i.e. the quantitative importance of the effects of Social Security on health spending. I show the relationship between endogenous health and the macroeconomic effects of Social Security in the fifth section and provide some further discussions in the sixth section. I conclude in the seventh section.

2 The Benchmark Model

2.1 The Individual

Consider an economy inhabited by overlapping generations of agents whose maximum possible lifetime is T periods. Agents are *ex ante* identical and face the following expected lifetime utility:

$$E\sum_{j=1}^{T}\beta^{j-1}\left[\prod_{k=2}^{j}P_{k-1}(h_k)\right]u(c_j). \tag{1}$$

Here β is the subjective discount factor, $P_{k-1}(\cdot)$ is the conditional survival probability from age $k-1$ to k, which is an increasing function of h_k, the health capital at age k. The utility flow at age j, $u(c_j)$, is determined by the consumption at that age, c_j. Note that it is assumed here that agents do not directly derive utility from health. Health is only useful for increasing survival probabilities.

In each period, a new cohort of agents is born into the economy. For simplicity, the population growth rate, p_g, is assumed to be constant in the benchmark model. Agents face a permanent earnings shock at birth, χ, which is drawn from a finite set $\{\chi_1, \chi_2, ..., \chi_z\}$. The probability of drawing χ_i is represented by Δ_i for all $i \in \{1, 2, ..., z\}$. Denote the exogenous mandatory retirement age by $R < T$. Before retirement, agent i (agents with χ_i) gets labor income $w\chi_i\epsilon_j$ in each period (by exogenously supplies one unit of labor in the market). Here w is the wage rate, and ϵ_j is the (deterministic) age-specific component of labor efficiency, which is the same for all agents within the cohort.[12] The interest rate is denoted by r. After retirement, the agent only lives on his own savings, s, and the Social Security payments, $Tr(\chi_i)$ (if there are any). Note that $Tr(\chi_i)$ is an increasing function of χ_i, which reflects the benefit-defined feature of the US Social Security system.

The set of budget constraints facing working agents are as follows:

$$s_{j+1} + c_j + (1 - k_m)m_j = w\chi_i\epsilon_j(1 - \tau_{ss} - \tau_m) + s_j(1 + r) + b, \forall j \in \{1, ..., R - 1\}, \tag{2}$$

where c is consumption, m is health spending, and b is the transfer from accidental bequests. Here τ_{ss} and τ_m are the payroll tax rates for financing Social Security and the health insurance program respectively, and k_m is the coinsurance rate offered by the health insurance program, which means that a k_m portion of spending on health care is reimbursed by the health insurance program.[13] The set of budget constraints facing retired agents are,

$$s_{j+1} + c_j + (1 - k_m)m_j = s_j(1 + r) + Tr(\chi_i), \forall j \in \{R, ..., T\}. \tag{3}$$

Agents' health capital evolves over time according to the following equation,

$$h_{j+1} = (1 - \delta_h^j)h_j + I_j(m_j) + \gamma_j, \forall j. \tag{4}$$

Here δ_h^j is the health capital depreciation rate, which is age-specific and deterministic, and γ_j is the age-specific health shock, which is serially independent. At the beginning of each period, agents receive a health shock $\gamma_j \in \{\gamma^g, \gamma^b\}$. The probability of receiving a bad shock, γ^b, at age j is represented by Λ_j for all js. Note that $I_j(m_j)$ is the production of new health capital, in which the health spending, m_j, is an input. The new-born agents start with the initial health capital: $h_1 = \overline{h}$.

At each age, agent i's state can be represented by a vector (s, h, γ). The individual's problem facing agent i at age j can be written as a Bellman Equation,

[12] Note that both χ_i and ϵ_j are deterministic, which means that we do not consider the earnings uncertainty over the life-cycle in this paper.

[13] Here the health insurance program is an artificial program that is designed to capture all the health insurance policies available to the consumer.

(P1)

$$V_j^i(s,h,\gamma) = \max_{s',m} u(c) + \beta P_j(h')E_j[V_{j+1}^i(s',h',\gamma')]$$

subject to

$$\begin{cases} s' + c + (1-k_m)m = w\chi_i\epsilon_j(1-\tau_{ss}-\tau_m) + s(1+r) + b & \text{if} \quad j < R \\ s' + c + (1-k_m)m = s(1+r) + Tr(\chi_i) & \text{if} \quad j \geq R \end{cases}$$

and

$$h' = (1-\delta_h^j)h + I_j(m) + \gamma_j,$$
$$c \geq 0,$$
$$s' \geq 0,$$
$$m \geq 0.$$

Here $V_j^i(\cdot,\cdot,\cdot)$ is the value function of agent i at age j. Since agents can only live up to T periods, the dynamic programming problem can be solved by iterating backwards from the last period. Let $S_j^i(s,h,\gamma)$ be the policy rule for savings for agent i at age j with (s,h,γ), and $M_j^i(s,h,\gamma)$ be the policy rule for health spending. There exist accidental bequests in the economy, since agents face mortality risks in each period. I assume that accidental bequests are equally transferred to the working agents in the next period. Note that there are in total five dimensions of individual heterogeneity in this economy: age j, savings s, health status h, permanent earnings shock χ, and health shock γ.

2.2 The Firm

The production technology is described by a standard Cobb-Douglas production function,

$$Y = K^\alpha (AL)^{1-\alpha}. \tag{5}$$

Here the capital share $\alpha \in (0,1)$, and capital depreciates at a rate of δ. Production is undertaken in a competitive firm. The firm chooses capital K and labor L by maximizing profits $Y - wL - (r+\delta)K$. Note that A is the labor-augmented technology. The profit-maximizing behaviors of the firm imply,

$$w = (1-\alpha)A(\frac{K}{AL})^\alpha$$

$$r = \alpha(\frac{K}{AL})^{\alpha-1} - \delta$$

2.3 Stationary Equilibrium

Let $\Phi(j, \chi_i, s, h, \gamma_j)$ represent the population measure for agent i at age j with (s, h, γ_j). The law of motion for $\Phi(\cdot,\cdot,\cdot,\cdot,\cdot)$ can be written as follows,

$$\Phi'(j+1, \chi_i, s', h', \gamma^b) = \Lambda_{j+1} \sum_{j=1}^{T} \sum_{i=1}^{z} \sum_{l=g,b} \int_0 \int_0 P_j(h')\Phi(j, \chi_i, s, h, \gamma^l) I_s I_h ds dh, \tag{6}$$

with

$$\Phi'(1,\cdot,\cdot,\cdot,\cdot) = (1+p_g)\Phi(1,\cdot,\cdot,\cdot,\cdot),$$

where I_h and I_s are indicator functions that $I_h = 1$, if $h' = \gamma^l(1-\delta_h^j)h + I_j(M_j^i(s, h, \gamma^l))$, otherwise, $I_h = 0$; and $I_s = 1$, if $s' = S_j^i(s, h, \gamma^l)$, otherwise, $I_s = 0$. In a stationary equilibrium, the distribution satisfies the condition: $\Phi' = (1+p_g)\Phi$.

A stationary equilibrium for a given set of government parameters $\{Tr(\cdot), k_m\}$, is defined as follows,

Definition: A **stationary equilibrium** for a given set of government parameters $\{Tr(\cdot), k_m\}$, is a collection of value functions $V_j^i(\cdot,\cdot,\cdot)$, individual policy rules $S_j^i(\cdot,\cdot,\cdot)$ and $M_j^i(\cdot,\cdot,\cdot)$, population measures $\Phi(\cdot,\cdot,\cdot,\cdot,\cdot)$, prices $\{r, w\}$, payroll tax rates $\{\tau_{ss}, \tau_m\}$, and transfer from accidental bequests b, such that,

1. given $\{r, w, k_m, Tr(\cdot), \tau_{ss}, \tau_m, b\}$, $\{S_j^i(\cdot,\cdot,\cdot),\ M_j^i(\cdot,\cdot,\cdot),\ V_j^i(\cdot,\cdot,\cdot)\}$ solves the individual's dynamic programming problem (P1).

2. aggregate factor inputs are generated by decision rules of the agents:

$$K = \sum_{i=1}^{z} \sum_{j=1}^{T} \sum_{l=g,b} \int_0 \int_0 s\Phi(j, \chi_i, s, h, \gamma^l) ds dh,$$

$$L = \sum_{i=1}^{z} \sum_{j=1}^{T} \sum_{l=g,b} \int_0 \int_0 \chi_i \epsilon_j \Phi(j, \chi_i, s, h, \gamma^l) ds dh.$$

3. given prices $\{r, w\}$, K and L solve the firm's profit maximization problem.

4. the values of $\{\tau_{ss}, \tau_m\}$ are determined so that Social Security and the health insurance program are self-financing:

$$\sum_{j=R}^{T}\sum_{i=1}^{z}\sum_{l=g,b}\int_0\int_0 Tr(\chi_i)\Phi(j,\chi_i,s,h,\gamma^l)dsdh = \sum_{j=1}^{R-1}\sum_{i=1}^{z}\sum_{l=g,b}\int_0\int_0 \tau_{ss} w\chi_i\epsilon_j\Phi(j,\chi_i,s,h,\gamma^l)dsdh.$$

$$\sum_{j=R}^{T}\sum_{i=1}^{z}\sum_{l=g,b}\int_0\int_0 \Theta(M_j^i(s,h,\gamma^l))\Phi(j,\chi_i,s,h,\gamma^l)dsdh = \sum_{j=1}^{R-1}\sum_{i=1}^{z}\sum_{l=g,b}\int_0\int_0 \tau_m w\chi_i\epsilon_j\Phi(j,\chi_i,s,h,\gamma^l)dsdh.$$

5. the population measure, Φ, evolves over time according to equation (6), and satisfies the stationary equilibrium condition: $\Phi' = (1+p_g)\Phi$.

6. the transfer from accidental bequests, b, satisfies

$$(1+p_g)\sum_{j=1}^{R-1}\sum_{i=1}^{z}\sum_{l=g,b}\int_0\int_0 b\Phi(j,\chi_i,s,h,\gamma^l)dsdh = \sum_{i=1}^{z}\sum_{j=1}^{T}\sum_{l=g,b}\int_0\int_0 S_j^i(s,h,\gamma^l)(1-P_j(h'))\Phi(j,\chi_i,s,h,\gamma^l)dsdh,$$

where $h' = \gamma^l(1-\delta_h^j)h + M_j^i(s,h,\gamma^l)$.

I focus on stationary equilibrium analysis in the rest of the paper. Since analytical results are not obtainable, numerical methods are used to solve the model.

3 Calibration

I calibrate the model here and then in the next section I use the calibrated model to assess the quantitative importance of the effects of Social Security on health spending. Specifically, I answer the quantitative question: to what extent does the expansion of US Social Security account for the rise in US health spending as a share of GDP from 1950 to 2000.

I calibrate the benchmark model to match the US economy in 2000. The calibration strategy adopted here is the following. I predetermine the values of some standard parameters based on previous studies, and then *simultaneously* choose the values of the rest parameters to match some key moments in the US economy in 2000.

3.1 Demography

Each period in the model corresponds to 5 years. Agents are born at age 25. The maximum possible lifetime is 100 years, so $T = 16$. The mandatory retirement age, R, is set to 65. According to the US Census Bureau, the average US population growth rate between 1950 to 2000 was 0.8%, so I set $p_g = 0.8\%$.

3.2 Preference Parameters

In many standard model environments, the level of period utility flow, $u(\cdot)$, does not matter. However, when it comes to a question of life and death, such as the one addressed in this paper, the level of utility is not irrelevant anymore. For instance, people would prefer a shorter life if the level of utility is negative. Note that in a standard CRRA utility function, the level of utility would be negative when the coefficient of relative risk aversion is larger than one. To avoid this problem, I follow Hall and Jones (2007) and add a positive constant term into the utility function, that is, I assume the utility function, $u(c)$, takes the following form,

$$\pi_c + \frac{c^{1-\sigma}}{1-\sigma},$$

where π_c is the positive constant term and σ is the coefficient of relative risk aversion. I set the value of σ to 1.01 (near-log utility), and choose the value of π_c so that the model-implied value of a statistical life (VSL) is consistent with its empirical estimates in the literature. VSL is the most commonly-used measure for the value of life in the literature, which means how much health spending is needed to (statistically) save a life in the population. In the model it is measured by the inverse of the marginal effect of health spending on survival probability, $\frac{1}{\partial P/\partial m}$. The empirical estimates of VSL in the literature range from approximately 1 million dollars to values near 20 million dollars.[14] After reviewing the literature, Viscusi and Aldy (2003) find that the value of a statistical life for prime-aged workers has a median value of about $7 million in the United States, though this value may vary significantly across studies. Therefore, I target at 7 million dollars in the benchmark calibration. The subjective discount factor β is set to $0.98^5 = 0.904$.

As argued before, I assume that agents do not directly derive utility from health capital, thus the model does not capture another feature of health capital: health increases the quality of life. I do so because this feature is less relevant to the mechanisms that this paper emphasizes and modeling it greatly complicates the model.

[14]See Viscusi and Aldy (2003) for a detailed introduction of this literature

3.3 Production Technology

The capital share in the production function, α, is set to 0.3. The depreciation rate δ is set to $1-(1-0.07)^5 = 0.304$. The value of the labor-augmented technology, A, is chosen to match the GDP per capita in the US economy in 2000: \$35081 (in \$2000).

3.4 Survival Probability Function and Health Technology

The survival probability function, $P(\cdot)$, is assumed to take the form,

$$P(h) = 1 - \frac{1}{e^{ah}}, \tag{7}$$

where $a > 0$, so that the value of $P(\cdot)$ is always between zero and one, and $P(h)$ is concave and increasing in h.

According to the National Vital Statistics Reports (2007), the conditional survival probability to the next period (age 30) at age 25 is 99.5% in 2000, and continues to decline over the life cycle (see Table 2). To capture this feature in the model, I assume that agents start with a high initial level of health capital ($\overline{h}$) at age 25 ($j = 1$), and then their health capital depreciates over time (via the health depreciation rates, $\{\delta_h^j\}_{j=1}^{T-1}$), which lowers their survival probabilities over the life cycle. Therefore, the values of $\overline{h}$ and $\{\delta_h^j\}_{j=2}^{T-1}$ are calibrated to match the conditional survival probabilities over the life cycle, while δ_h^1 is normalized to 0. Figure 4 (a) plots both the model results and the data on survival probabilities over the life cycle. The calibrated values of $\overline{h}$ and $\{\delta_h^j\}_{j=0}^{T-1}$ are presented in Table 2.

Note that the scale parameter, a, directly controls the health capital levels needed to match the survival probabilities in the data, thus affecting the effectiveness of health spending in increasing the survival probability by producing new health capital. Therefore, the value of a should be related to the level of aggregate health spending. I calibrate the value of a to match the health spending as a share of GDP in 2000: 12.5%.

The technology for producing new health capital takes the following form,

$$I_j(m_j) = \lambda_j m_j^\theta,$$

where $\theta \in (0, 1)$ and $\{\lambda_j\}_{j=1}^{T-1}$ are positive. Since the values of $\{\lambda_j\}_{j=1}^{T-1}$ control the effectiveness of producing new health capital at different ages, they directly determine the relative health spending by age over the life cycle. I calibrate these parameters to match the relative health spending (per capita) by age.[15] Since the data is only available for six age groups: $\{25-34, 35-44, 45-54, 55-64, 65-74, 75+\}$, I assume: $\lambda_1 = \lambda_2$, $\lambda_3 = \lambda_4$, $\lambda_5 = \lambda_6$, $\lambda_7 = \lambda_8$, $\lambda_9 = \lambda_{10}$, $\lambda_{11} = \lambda_{12} = ... = \lambda_{15}$. Since it is relative health spending (per capita), one of the six age groups needs to be normalized. I normalize λ_3 and λ_4 to one, because the age group of 35-44 is normalized in the data. The calibrated values are presented in Table 3. The model results and the data on the relative health spending (per capita) by age are plotted in Figure 4(b).

The curvature in the health production function, θ, is a key parameter in this model, but there exists little information in the literature on its value. Thus, I set the value of θ to be 0.15 in the benchmark calibration and also explore other values (0.1, 0.2, and 0.25) in the section of sensitivity analysis.

3.5 Earnings and the Health Shock

The age-specific labor efficiencies, $\{\epsilon_j\}_{j=1}^{R-1}$, are calculated from the earnings data in the Current Population Surveys (see Table 4).

The logarithm of the individual-specific permanent earnings shock, $\ln \chi_i$, is assumed to follow the normal distribution: $N \sim (0, \sigma_\chi^2)$. I discretize the distribution into 5 states using the method introduced in Tauchen (1986). Transforming the values back from the logarithms, I get a finite set of $\{\chi_1, \chi_2, ..., \chi_5\}$, with the corresponding probabilities $\{\Delta_i\}_{i=1}^5$. The variance of the log of the permanent earnings shock, σ_χ^2, is set to 0.2 based on the estimation of Moffitt and Gottschalk (2002).

The probabilities of receiving a bad health shock, $\{\Lambda_j\}_1^T$, are mapped to the fraction of people in bad health status by age in PSID from 1968 to 1983. There is little information in the literature on the magnitudes of the health shock. Therefore, in the benchmark calibration I normalize γ^g to zero and set γ^b to -10.2, that is 10% of the initial health capital level ($\overline{h}$). I also explore other values for γ^b (0 and -20.4), as robustness check and find the results do not significantly change (see Table 11).

3.6 Social Security and the Health Insurance Program

Social Security in the model is designed to capture the main features of the US Social Security program. The Social Security payroll tax rate is set to 10.6%, according to the SSA (Social Security

[15] The data is from Meara, White and Cutler (2004), who document the relative health spending (per capita) by age from 1963 to 2000. The data in 1963 is used to calibrate $\{\lambda_j\}_{j=1}^{T-1}$, since there is no data earlier than 1963 available.

Administration) data in 2000. Following Fuster, Imrohoroglu, Imrohoroglu (2007), the values of $Tr(\cdot)$ in 2000 are chosen so that the Social Security program has the marginal replacement rates listed in Table 5. Here y is the agent's lifetime earnings, and $\overline{y}$ is the average lifetime earnings. Then I rescale every beneficiary's benefits so that the Social Security program is self-financing. The health insurance program in the model is an artificial program that is designed to capture all the health insurance policies available to the consumer in the US. The CMS (Centers for Medicare & Medicaid Services) data shows that the out of pocket spending is approximately 25% of total health spending in 2000. Therefore, I set the coinsurance rate of the health insurance program, k_m, to 75%.

Table 6 summarizes the results of the benchmark calibration, and Table 7 contains some key statistics of the benchmark economy. Figures 4(c) and 4(d) plot the saving and consumption life-cycle profiles in the benchmark economy.

4 The Effects of Social Security on Health Spending

As argued before, Social Security increases *aggregate* health spending via two channels. First, it transfers resources from the young with low marginal propensity to spend on health care to the elderly with high marginal propensity to spend on health care, thus increasing the aggregate health spending of the economy. Second, by providing annuities in the later stage of life and insuring for uncertain longevity, Social Security increases people's expected future utility. As a result, it raises the marginal benefit from investing in health and thus induces people to spend more on health are.

In this section, I use the calibrated model to assess the quantitative importance of these mechanisms. Specifically, I run the following thought experiment: I exogenously reduce the size of Social Security in the benchmark economy and then investigate how this change affects the health spending behavior in the model. Here I only focus on stationary equilibria comparisons. To reduce the size of Social Security, I lower the Social Security payroll tax rate and then adjust the Social Security payments to make the Social Security program self-financing again.

The US Social Security program was invented in the mid of 1930s, and since then its payroll tax rate had stayed at 2% until 1949. After that, the Social Security payroll tax rate started to rise gradually to 10.6% in 2000. To answer the question: to what extent does the expansion of US Social Security account for the rise in US health spending as a share of GDP from 1950 to 2000, I simply reduce the Social Security payroll tax rate from 10.6% to 2% in the model and then compare the aggregate health spending as a share of GDP in the new stationary equilibrium to that in the benchmark economy. I find that the change in Social Security dramatically reduces the aggregate health spending. That is, as the Social Security payroll tax rate decreases from 10.6% to 2%, aggregate health spending as a share of GDP in the model drops from 12.4% in to 8.7%, which is in magnitude 43% of the change in US health spending as a share of GDP between 1950 and 2000 (see Table 8).

Social Security also has significant effects on other statistics in the model. As the Social Security payroll tax rate is reduced from 10.6% to 2%, the model interest rate decreases significantly (from 3.7% to 2.9%). This result is consistent with what previous studies have found.[16] The intuition behind is simple: Social Security reduces capital accumulation and thus increases the market interest rate through general equilibrium effects. Social Security also has a significant impact on life expectancy (via health spending). As the size of Social Security is reduced to the 1950 level, life expectancy in the model drops from 75.2 years to 73.4 years. This change in life expectancy in the model accounts for 21% of the change in life expectancy in the US data from 1950 to 2000, i.e. from 68.2 years in 1950 to 76.8 years in 2000. The reason why the model accounts for 43% of the rise in health spending, but only accounts for 21% of the change in life expectancy may be because the increase in life expectancy over 1950-2000 in the US is not solely due to the rise in health spending during the same period. For instance, other factors, such as increased education, behavioral changes, technological changes, and declines in pollution, may also have caused the increase in survival probability (Chay and Greenstone (2003), Grossman (2005), Hall and Jones (2007), etc.). There is a large literature on the relationship between health spending and survival probability/mortality rate (see Cutler, Deaton, and Lleras-Muney (2006) for a survey of the literature). While most studies find that health spending has a positive effect on survival probability, there is no consensus on the magnitude of the effect so far in the literature.

4.1 Life-cycle Profile of health Spending

Meara, White, and Cutler (2004) have documented an interesting empirical observation that is closely related to the rise in aggregate health spending over the last several decades, that is, the simultaneous change in life-cycle profile of health spending (per person). They find that health spending growth was much faster among the elderly than among the young. As a result, the life-cycle profile of health spending (per person) has become much steeper over time (see Figure 3).

[16] Auerbach and Kotlikoff (1987), Imrohoroglu et al. (1995), etc.

I argue that the potential explanations of the rise in US health spending should be consistent not only with the rise in *aggregate* health spending as a share of GDP, but also with this related empirical observation: the simultaneous change in life-cycle profile of health spending (per person). To investigate the model's ability to match the changing life-cycle profile of health spending, in Figure 5 I plot the life cycle profiles of health spending in both model economies (with 10.6% and 2% Social Security tax rates respectively). As can be seen, the effects of Social Security are highly unequal across the age distribution. The change in the size of Social Security affects the elderly much more than the young. As a result, the life-cycle profile of health spending in the model economy with 1950 Social Security (the dash line) becomes much flatter than the one in the benchmark economy, and thus has a similar shape with the life-cycle profile of health spending in 1950 in the data. This result suggests that the expansion of Social Security does not only account for a large portion of the rise in aggregate US health spending from 1950 to 2000, but also play a key role in matching the change in life-cycle profile of health spending over the last several decades.

4.2 The Impact of Social Security on Other Life-cycle Profiles

To better understand the intuition behind the effects of Social Security on health spending, it is useful to look at how Social Security affects other life-cycle profiles in the model. Figure 6(a) plots the (after-tax) earnings profiles. As can be seen, Social Security decreases the earnings for the young by taxing them and increases the earnings for the elderly by providing them annuities. The change in the earnings profile reflects an important reason why Social Security increases the elderly's health spending, that is the income effect. Social Security increases the elderly's income and thus induce more spending on health care. This argument holds true even after taking into account the adjustment of private savings. Figure 6(b) plots the total available resources over the life cycle, i.e. the sum of savings and earnings. As can be seen, Social Security significantly raises the total resources available to the elderly. This is consistent with previous studies on the impact of Social Security on elderly poverty. These studies find that Social Security plays a key role in reducing the poverty rate among the US elderly over the last several decades.[17]

Figures 6(c) and 6(d) plot the life-cycle profiles of consumption and savings in the benchmark economy and the economy with 1950 Social Security. There are a few things to note. First, the model generates hump-shaped consumption profiles. The hump-shaped consumption profile is a well-observed fact in the data, but standard life-cycle models usually have difficulty generating it

[17] Atkinson (1989), Engelhardt and Gruber (2004), etc.

(Hansen and Imrohoroglu (2008)). Hansen and Imrohoroglu (2008) find that the missing private annuity market is an important reason for the hump-shaped consumption profile. Their finding is reconfirmed in this paper. Second, the savings profiles are hump-shaped and agents in the 2000 economy save relatively less for the retirement than in the 1950 economy. This reconfirms the well-known finding in the Social Security literature, i.e. Social Security has a negative effect on private savings for retirement. However, it is worth noting that the magnitude of this negative effect in the model is smaller than what previous studies have found. I will provide further discussion on this issue in the next section.

5 Macroeconomic Effects of Social Security and Endogenous Health

5.1 The Negative Effect of Social Security on Capital Accumulation

It is well-known that pay-as-you-go Social Security discourages private savings as it transfers resources from the young with high marginal propensity to save to the elderly with low marginal propensity to save. As capital accumulation is a key determinant of the long-run performance of the economy, the negative effect on capital accumulation has become one of the main reasons for economists to propose the privatization of Social Security. Started by Auerbach and Kotlikoff (1987), most quantitative studies on Social Security have found that this negative effect of Social Security on capital accumulation is quantitatively important, i.e. the capital stock would be approximately a third higher if Social Security were eliminated.[18] However, all these studies assume either exogenous health spending or no health spending at all.

Does endogenous health spending change the impact of Social Security on capita accumulation? I answer this question in this section. The standard exercise to quantify the negative impact of Social Security on capital accumulation in the literature is to assess how much higher the capital stock would be if Social Security were eliminated in the the model. To understand whether endogenous health matters for the negative impact of Social Security on capital accumulation, I first replicate this exercise in the benchmark economy (with endogenous health spending). Then I fix agents' health spending behavior and conduct this exercise again. Comparing the results from these two exercise, I find that the negative impact of Social Security on capital accumulation is significantly smaller in the model with endogenous health. As shown in Table 9, in the model

[18]Imrohoroglu et al.(1995), Conesa and Krueger (1999), etc. The exceptions are papers by Fuster et al. (2003, 2007), who argue that the negative effect would be much smaller if there exists intergenerational altruism.

with endogenous health spending, the capital stock would be 25% higher if Social Security were eliminated. However, when health spending is fixed, the capital stock would be 31% higher if Social Security were eliminated. The intuition behind this result is as follows. When health spending and longevity are endogenous, Social Security also has a positive effect on savings: as Social Security increases longevity via health spending, people would save more for retirement than in the economy without Social Security.

5.2 Social Security and Public Health Insurance

Another interesting implication of the model is that, by changing health spending, Social Security indirectly affects the financial burden of the health insurance program. As shown in Table 9, in the benchmark economy, the health insurance program is financed by a payroll tax of 10.7%. However, the same health insurance program would only need to be financed by a payroll tax of 6.9% if Social Security were eliminated. This spill-over effect can be even larger for programs that only target the elderly, such as the US Medicare program. In the benchmark model, the payroll tax rate required to finance the health insurance payments for the elderly is 5.4%, and this rate would drop to 2.1% (by 61%) if Social Security were eliminated. The intuition for this result is the following. As the health insurance program provides coinsurance for health spending, its payments are largely dependent on the total health spending, which is an individual choice. As Social Security encourages people to spend more on health care, it also raises the financial burden of the health insurance program.

This finding is particularly interesting given that Social Security and Medicare are the two largest public programs in the United States and both are currently under discussion for reforms. As shown here, the spill-over effect of Social Security on Medicare may be quantitatively important. Hence, any future policy studies should take into account this spill-over effect.

6 Further Discussion

6.1 Health Technological Progress

It is worth mentioning that several studies have suggested that the unexplained residual may be due to the health technological progress over the last several decades (e.g. Newhouse (1992), CBO (2008)). That is, the invention and adoption of new and expensive health technologies over the past several decades increased health spending. However, since health technological progress is hard to measure, previous studies simply attribute the large unexplained residual to health technological progress. As a result, these studies usually suggest that health technological progress may be responsible for approximately a half of the rise in US health spending. However, the results of this paper suggest that the impact of health technological progress may be significantly smaller than what previous studies suggest, because a large portion of the residual is already attributed to the expansion of Social Security.

In the following section, I will present some empirical evidence on the rise in health spending by income to shed further light on the relative importance of health technological progress compared to the expansion of Social Security.

6.2 Health Spending by Income

The theory proposed in this paper also has interesting implications about the rise in health spending by income. An implicit assumption of this theory is that people were financially constrained in their old age when there was no Social Security. Social Security affects health spending by loosening people's old-age budget constraint. Therefore, a direct implication of this theory is that the impact of Social Security on health spending should be larger for the poor than the rich.[19] However, the health technological progress hypothesis has the opposite implication about the relationship between health spending growth and income. The fundamental assumption in the health technological progress hypothesis is that people were constrained by technology, but not by money. When there are new health technologies available, people will choose to use them. As a result, this hypothesis implies that the rise in health spending should be larger for the rich, since newly-invented technologies are usually very expensive and the rich are more likely to be able to afford them.

Follette and Sheiner (2005) document the relationship between health spending growth and household income in the data. They find that the health spending growth rate is negatively correlated to household income among the majority of elderly households. As shown in Table 10, health spending per household (in real terms) increased by a factor of 6.3 for elderly households in the first (poorest) income quintile from 1970 to 2002. It only increased by a factor of 4.9 for the second income quintile, and by a factor of 4.1 and 3.6 respectively for the third and fourth income quintile. However, the negative relationship between health spending growth and household income is reversed at the top of the income distribution: households in the fifth income quintile experienced a bigger increase in health spending than those in the fourth quintile.

[19] This implication is amplified by the redistributive feature of Social Security.

The non-monotone relationship between household income and health spending growth provides us information about the relative importance of the technological progress hypothesis and the Social Security hypothesis. As health spending growth is negatively related with household income among most of elderly households (from the 1st to the 4th income quintile), the expansion of Social Security should be the key reason for the rise in health spending among these households. For the very rich households (the top income quintile), the health technological advance may be the driving force of the rise in their health spending.

6.3 Sensitivity Analysis

In the benchmark calibration, the values of θ and γ^b are chosen arbitrarily because of the lack of the data. In this section, I investigate whether the main results of this paper are sensitive to these parameter values.

Note that θ is the curvature parameter in the health production function, which is a key parameter in the model. It affects the effectiveness of health spending in producing new health capital, and also controls how fast the marginal effect of health spending diminishes as health spending increases. As can be seen in Table 11, the main qualitative results remain as the value of θ changes. However, the effects of Social Security on health spending become quantitatively more important as the value of θ increases. When the value of θ is set to 0.25, the change in Social Security in the model can reduce the aggregate health spending as a share of GDP from 12.4% to 8.0% which accounts for 51% of the rise in US health spending from 1950 to 2000. When the value of θ is set to 0.1, the expansion of Social Security in the model accounts for 38% of the rise in US health spending from 1950 to 2000.

The other parameter, γ^b, represents the magnitude of a bad health shock. In the benchmark calibration, its value is set to -10.2, that is equivalent to 10% of the initial health capital. As robustness check, I explore two other values of γ^b: 0 and -20.4. As shown in Table 11, the main results of the paper remain qualitatively true. But quantitatively, the effects of Social Security on health spending become larger as the magnitude of the health shock increases. When γ^b is equal to 0, i.e. the health shock is completely assumed away, the expansion of Social Security in the model accounts for 36% of the rise in US health spending from 1950 to 2000. When the value of γ^b is set to -20.4 (that means the magnitude of the health shock is doubled), the expansion of Social Security accounts for 54% of the rise in US health spending. The reason why the effect of Social Security on health spending is positively correlated with the magnitude of the health shock may be because Social Security provides partial insurance against the health shock.

7 Conclusion

In this paper, I show that Social Security significantly increases the aggregate health spending of the economy via two channels. First, Social Security transfers resources from the young to the elderly (age 65+) whose marginal propensity to spend on health care is much higher than the young, thus raising the aggregate health spending of the economy. Second, Social Security raises people's expected future utility by providing annuities in the later stage of life and insuring for uncertain longevity. As a result, it increases the marginal benefit from investing in health to live longer.

Using numerical simulation techniques, I show that the impact of Social Security on aggregate health spending is quantitatively important. The quantitative results suggest that the expansion of US Social Security can account for a significant portion of the rise in US health spending as a share of GDP from 1950 to 2000. Furthermore, I show that the expansion of Social Security plays a key role in matching an important related empirical observation over the same period: the simultaneous change in life-cycle profile of average health spending (per person).

Finally, I show that the effects of Social Security on aggregate health spending has two interesting implications for the macroeconomic effects of Social Security. First, once the effects of Social Security on health spending is taken into account, the negative effect of Social Security on capital accumulation is smaller than what previous studies have found. Second, Social Security may have a significant spill-over effect on public health insurance programs (such as US Medicare): Social Security may increase the financial burden of these programs because it encourages people to spend more on health care and thus increases the health insurance payments from these programs. Given that Social Security and Medicare are the two largest public programs in the US and both are currently under the discussions for reforms, I argue that this spill-over effect from Social Security on Medicare is particularly interesting and should be taken into account in future policy studies.

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Table 1: Household health Spending by Quintile (% of mean household income).

Income Quintile	1970	1977	1987	1996	2002
Non-elderly Households					
1	18%	30%	43%	40%	46%
2	9%	11%	15%	15%	18%
3	7%	8%	9%	10%	11%
4	7%	5%	7%	7%	8%
5	3%	3%	4%	4%	5%
Elderly Households					
1	35%	67%	92%	110%	132%
2	25%	39%	67%	50%	67%
3	18%	27%	40%	34%	40%
4	13%	15%	27%	24%	25%
5	4%	6%	11%	11%	12%

Note: 1st income quintile is the lowest quintile.

(Data source: Follette and Sheiner (2005).)

Table 2: Survival probabilities (in 1950) and health depreciation rates

Age	SP-data	SP-model	Parameter	Value
25	0.995	0.995	$\bar{h}$	102
30	0.994	0.994	δ_h^2	5%
35	0.992	0.992	δ_h^3	8%
40	0.988	0.988	δ_h^4	10%
45	0.982	0.982	δ_h^5	11%
50	0.974	0.972	δ_h^6	12%
55	0.960	0.957	δ_h^7	13%
60	0.939	0.931	δ_h^8	15%
65	0.908	0.904	δ_h^9	16%
70	0.861	0.859	δ_h^{10}	18%
75	0.794	0.801	δ_h^{11}	45%
80	0.685	0.682	δ_h^{12}	58%
85	0.539	0.529	δ_h^{13}	70%
90	0.3855	0.396	δ_h^{14}	75%
95	0.246	0.229	δ_h^{15}	80%

Data source: National Vital Statistics Reports(2007). SP: survival probability.

Table 3: Health technology parameters: λs

Age	25-35	35-44	45-54	55-64	65-74	75+
Parameter	λ_1,λ_2	λ_3,λ_4	λ_5,λ_6	λ_7,λ_8	λ_9,λ_{10}	λ_{11}-λ_{15}
Value	1.15	1.0	1.0	1.05	1.6	4.0

Table 4: Labor efficiency by age, ϵs

Age	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Labor efficiency ϵ_j	1.0	1.23	1.34	1.41	1.46	1.43	1.51	1.39

(Source: calculated from CPS earnings data, with the labor efficiency of age 25-29 is normalized to one.)

Table 5: The Social Security Benefit Formula

	Marginal Replacement rates
$y \in [0, 0.2\overline{y})$	90%
$y \in [0.2\overline{y}, 1.25\overline{y})$	33%
$y \in [1.25\overline{y}, 2.46\overline{y})$	15%
$y \in [2.46\overline{y}, \infty)$	0

Table 6: Benchmark Calibration

Parameter	Description	Value
β	subjective discount factor	0.98^5
α	capital share	0.3
δ	capital depreciation rate	$1-(1-0.07)^5$
σ	CRRA utility parameter	1.01
θ	health production curvature	0.15
$\{\gamma^g, \gamma^b\}$	health shock	{0,-10.2}
Parameter	Description	Moments to match
$\pi_c = 92.0$	constant in the utility function	VSL: $7 million
$\tau_{ss} = 10.6\%$	Social Security replacement rate	SSA data
$\kappa_m = 75\%$	health coinsurance rate	CMS data
$\{\epsilon_j\}_{j=1}^{R-1}$	age-efficiency profile	CPS earnings data
$a = 0.05$	parameter in surv. prob. function	HS in 2000: 12.5% of GDP
$p_g = 0.8\%$	population growth rate	Census Bureau
$\sigma_\chi^2 = 0.2$	permanent earning shock parameter	Moffitt and Gottschalk (2002)
$\{\delta_h^j\}_{j=2}^{15}$ and $\overline{h}$	health depreciation rates and initial health capital	conditional surv. prob. data
$\{\lambda_j\}_{j=1}^{T-1}$	health production parameters	life-cycle HS profile data
$\{\Lambda_j\}_{j=1}^{T-1}$	health shock probabilities	health status data in PSID

Table 7: Benchmark Model Statistics

Name	Model	Data
Interest rate (annual)	3.7%	..
Aggregate health spending (% of GDP) in 2000	12.4%	12.5%
Life expectancy	75.2	76.9
GDP per capita (in $)	35902	35081
Value of a Statistical Life	$7.2 million	$7.0 million
Health insurance payroll tax rate, τ_m	10.7%	..

Table 8: Results from the Main Thought Experiment

	Model2000	Model1950	Data2000	Data1950
Aggregate Health Spending (% of GDP)	12.4	8.7	12.5	3.9
Life Expectancy	75.22	73.4	76.8	68.2
Interest Rate	3.7%	2.9%	..	..
Value of a Statistical Life(in $)	7.2 mil.	7.7 mil.	..	..

Table 9: Macroeconomic Effects of Social Security

	Benchmark Economy	Social Security Eliminated	Δ (in %)
The Capital Stock (in $) (endogenous health)	25802	32310	25%
The Capital Stock (in $) (health spending fixed)	25802	33836	31%
Health Insurance Tax Rate (for the whole population)	10.7%	6.9%	-36%
Health Insurance Tax Rate (for the elderly)	5.4%	2.1%	-61%

Table 10: Health Spending (per capita) by Income Quintile (in 2004 $).

Income Quintile	1970	1977	1987	1996	2002	$\frac{HS_{2002}}{HS_{1970}}$
Non-elderly Households						
1	716	1087	1944	1547	2088	2.92
2	751	990	1587	1541	2071	2.76
3	876	1056	1554	1687	2126	2.43
4	1191	1069	1827	1926	2341	1.97
5	1001	1289	1958	2100	2640	2.64
Elderly Households						
1	1190	2963	5058	5895	7525	6.32
2	1480	3001	6271	5005	7248	4.90
3	1506	2839	5402	4693	6234	4.14
4	1749	2388	5191	5022	6302	3.60
5	1378	2609	4972	4614	6337	4.60

Note: 1st income quintile is the lowest quintile.

(Data source: Follette and Sheiner (2005).)

Table 11: Sensitivity Analysis

	Model2000 HS (as a % of GDP)	Model1950 HS (as a % of GDP)
Benchmark		
θ=0.1	12.4	9.1
θ=0.2	12.4	8.2
θ=0.25	12.4	8.0
γ^b=0	12.4	9.3
γ^b=-20.4	12.4	7.8

Note: HS represents the aggregate health spending.

Figure 1: health Spending (as a share of GDP) in the United States: 1929-2005

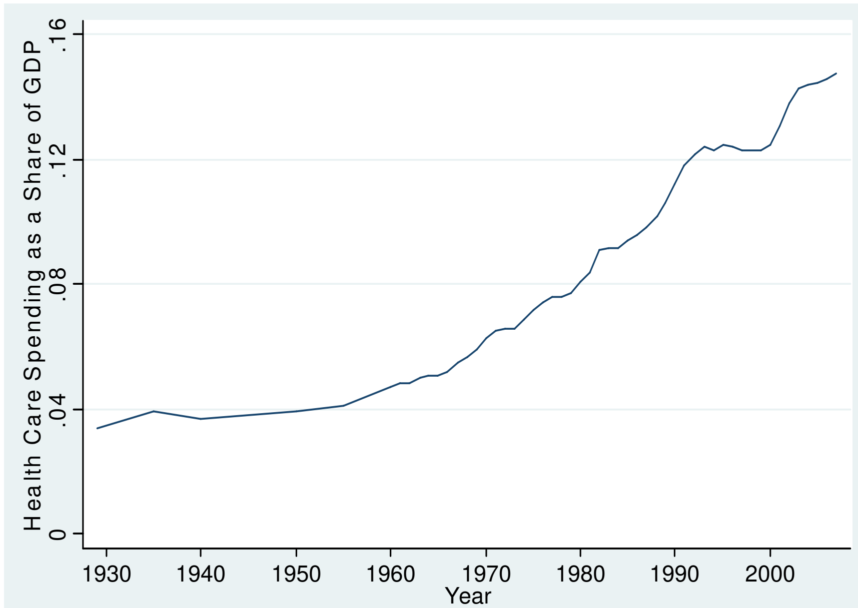


Figure 2: US Social Security: total expenditures/receipts as a share of GDP

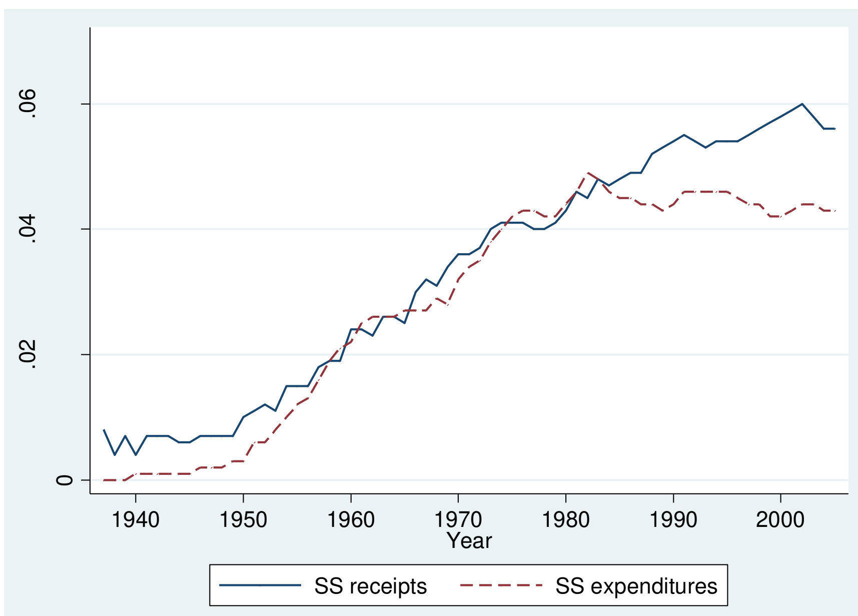
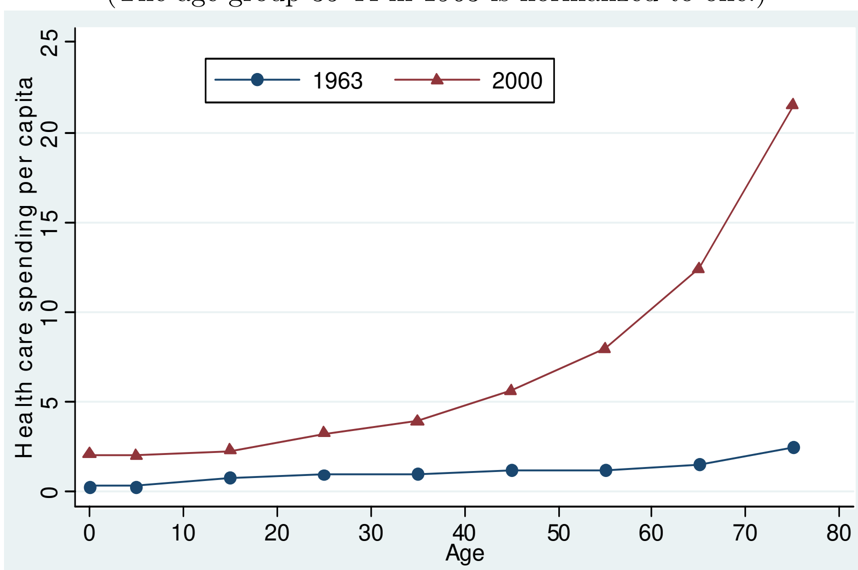
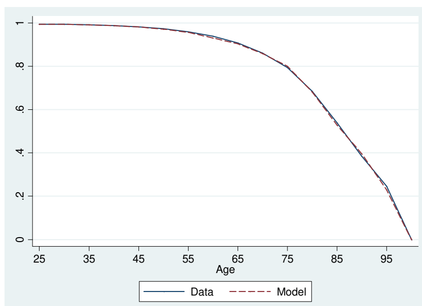


Figure 3: health Spending (per capita) By Age.
(The age group 35-44 in 1963 is normalized to one.)

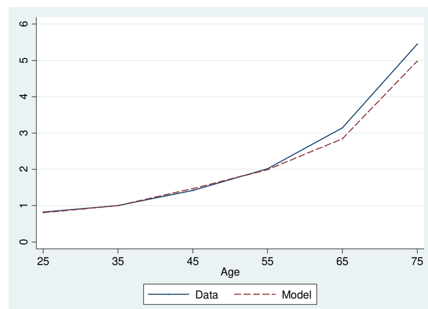


(Data source: Meara, White, and Cutler (2004).)

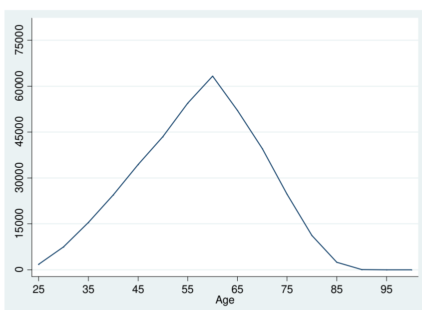
Figure 4: Life Cycle Features of the Benchmark Economy



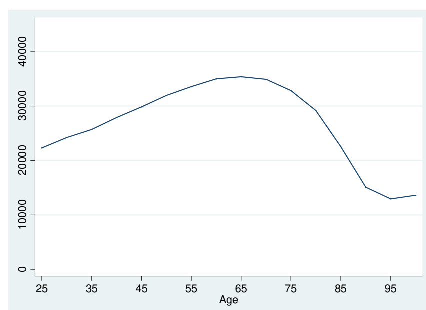
(a) Conditional survival probabilities



(b) Relative health spending by age

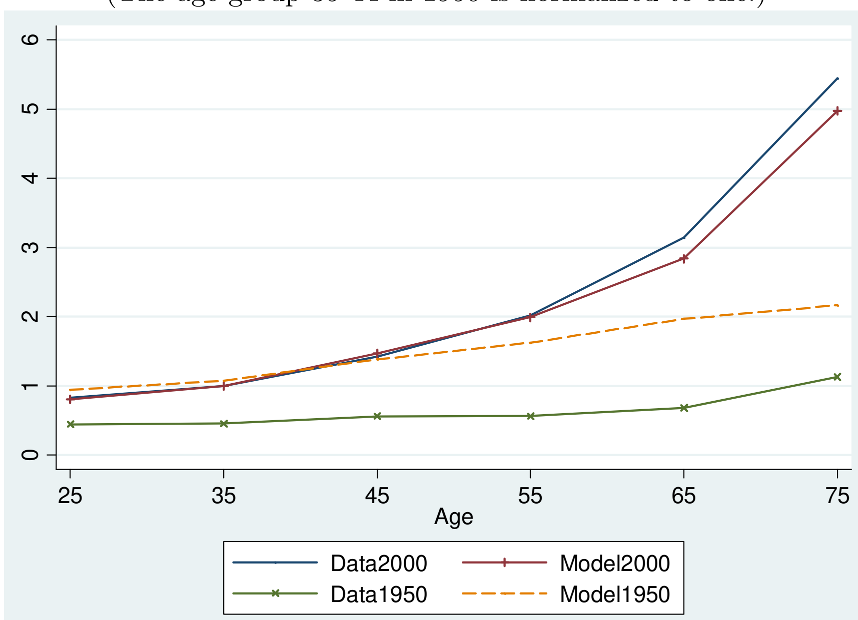


(c) Saving over the life cycle



(d) Consumption over the life cycle

Figure 5: Life-cycle profile of health spending (per capita): Model vs Data
(The age group 35-44 in 1950 is normalized to one.)



Data source: Meara, White, and Cutler (2004)

Figure 6: Life Cycle Profiles: Model2000 vs. Model1950

(a) Earning Profiles

(b) Earning+Saving Profiles

(c) Consumption Profiles

(d) Saving Profiles