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Social security and the rise in health spending

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ABSTRACT

In a quantitative model of Social Security with endogenous health, I argue that Social Security increases the aggregate health spending of the economy because it redistributes resources to the elderly whose marginal propensity to spend on health is high. I show by using computational experiments that the expansion of US Social Security can account for over a third of the dramatic rise in US health spending from 1950 to 2000. In addition, Social Security has a spill-over effect on Medicare. As Social Security increases health spending, it also increases the payments from Medicare, thus raising its financial burden.

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 Fig. 1).[1] Why has US health spending as a share of GDP risen so much? This question has attracted growing attention in the literature (Newhouse, 1992; Finkelstein, 2007; Hall and Jones, 2007, among others). Several explanations have been proposed, such as increased health insurance and economic growth. However, these existing explanations *together* only account for up to 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 (e.g., Newhouse, 1992; CBO, 2008). 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 Fig. 2). Total Social Security expenditures were only 0.3% of GDP in 1950, and jumped to 4.2% of GDP in 2000.[2] 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 (Davies and Kuhn, 1992; Philipson and Becker, 1998). For

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[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] 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.

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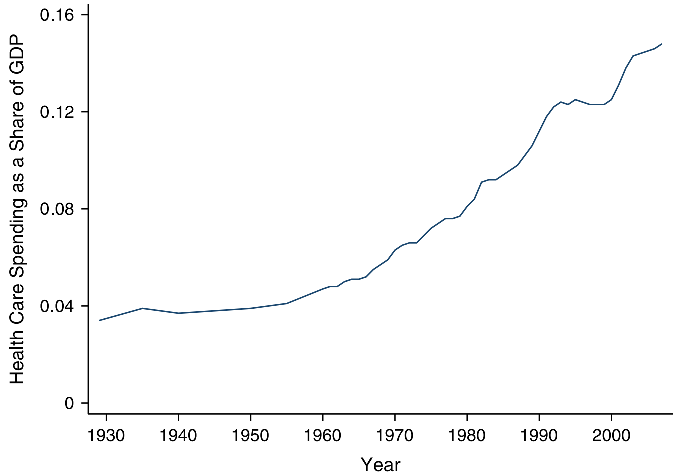

Fig. 1. Health spending (as a share of GDP) in the United States: 1929–2005.

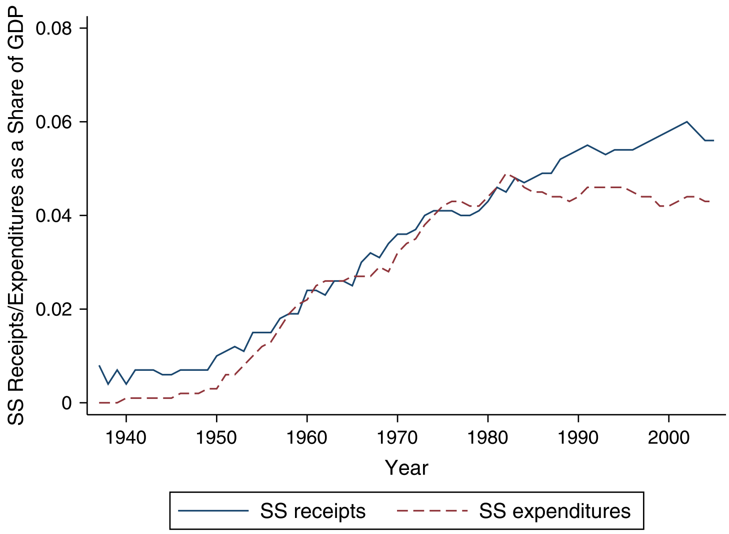

Fig. 2. US Social Security: total expenditures/receipts as a share of GDP.

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? To address these questions, I develop an Overlapping Generations (OLG), General Equilibrium (GE) model with endogenous health spending and endogenous longevity. Following Grossman (1972), the concept of health capital is adopted 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. After retirement, 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.[3] Agents also have a warm-glow bequest motive.

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

[3] 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.

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.[4] Follette and Sheiner (2005) find that elderly households spend a much larger share of their income on health care than non-elderly households.[5] 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; 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 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, the following quantitative exercise is conducted 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. The quantitative exercise shows 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 aggregate health spending, which accounts for 35% of the rise in US health spending as a share of GDP from 1950 to 2000. Furthermore, 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 et al. (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 Fig. 3). The quantitative exercise shows 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 (e.g., Auerbach and Kotlikoff, 1987; Imrohoroglu et al., 1995; Conesa and Krueger, 1999; Fuster et al., 2007). 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. This negative impact has been found quantitatively important. I show by using computational experiments that existing studies may have exaggerated this negative effect since they all assume exogenous longevity and health spending. When health spending and longevity are endogenous, this negative saving effect may be partially offset by the extra longevity induced by Social Security (via increasing health spending). For instance, the capital stock would be 29% higher if Social Security were eliminated in the benchmark model. But when the health spending decisions are fixed in the model, the capital stock would be 39% higher if Social Security were eliminated. These quantitative results suggest 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. Medicare covers a fixed fraction of health spending for the elderly. Therefore, as Social Security induces the elderly to spend more on health care, it also increases the insurance payments from Medicare, thus raising its financial burden. In the benchmark model, the payroll tax rate required to finance the Medicare program is 3.1%, but this rate would drop to 1.0% 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, such as increased health insurance (e.g. the introduction of Medicare), economic growth, population aging, and rising health care price. However, all the main existing explanations together only account for up to half of the rise in health spending, suggesting that there is still a large portion of the rise in health spending remaining unexplained (see Newhouse, 1992; CBO, 2008). The findings of this paper suggest that the residual may be due to the expansion of Social Security. In particular, when the model is extended to include all the main existing

[4] 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.

[5] For instance, they find that the elderly in the 3rd income quintile spends 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.

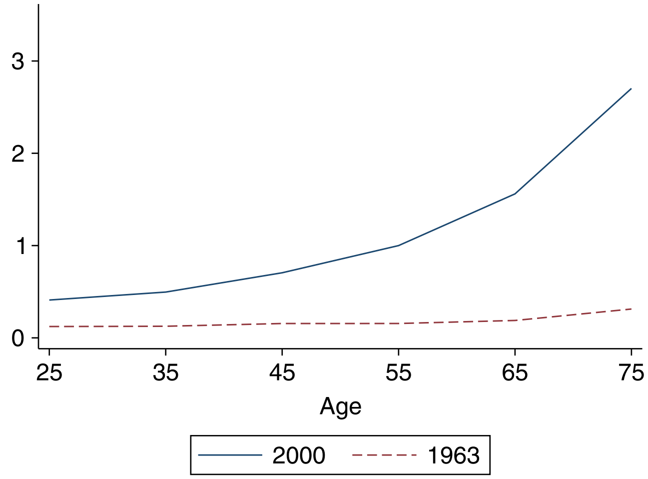

Fig. 3. Health spending (per capita) by age. (The age group 55–64 in 2000 is normalized to one.) (Data source: Meara et al., 2004.)

explanations in Section 4.3, it is shown that the extended model can account for most of the rise in US health spending from 1950 to 2000.

This paper also contributes to the quantitative literature on Social Security that was started 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. It shows 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 terms of modeling, this paper is closely related to a recent macroeconomic literature that studies a quantitative macroeconomic model with endogenous health (Suen, 2006; Hall and Jones, 2007; Yogo, 2007; Jung and Tran, 2008; Halliday et al., 2009, among others).

The rest of the paper is organized as follows. The benchmark model is set up in the second section and calibrated in the third section. The main quantitative results are provided in the fourth section. The implications of endogenous health for other macroeconomic effects of Social Security are discussed in the fifth section. I provide further discussions in the sixth section and conclude in the seventh section.

2. The benchmark model

The structure of the benchmark model is as follows.

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:

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

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 derived from consumption at age j is denoted by $u(c_j)$. If an agent at age j does not survive to age $j+1$, she leaves her savings s_{j+1} as bequest and derives utility from it, i.e. $\theta_b\nu(s_{j+1})$. Here θ_b represents the intensity of the bequest motive, and the bequests are assumed to be equally transferred to the working agents in the next period.

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 $\{\chi_1,\chi_2,\ldots,\chi_z\}$. The probability of drawing χ_i is represented by Δ_i for all $i\in\{1,2,\ldots,z\}$. Denote the exogenous mandatory retirement age by $R<T$.[6] 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

[6] I relax the assumption of exogenous retirement in Section 6 and show that the main results are robust to this assumption.

labor efficiency, which is the same for all agents within the cohort.[7] The interest rate is denoted by r. After retirement, the agent only lives on her own savings, s, and the Social Security payments, $\mathrm{Tr}(\chi_i)$ (if there are any). Note that $\mathrm{Tr}(\chi_i)$ 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:

$$s_{j+1}+c_j+(1-k_e I_{d>0})qm_j=(w\chi_i\epsilon_j-p_d)(1-\tau_{ss}-\tau_m)+s_j(1+r)+b, \quad \forall j\in\{1,\ldots,R-1\}, \tag{2}$$

where c is consumption, and qm is health spending with m as the quantity of health care and q as the relative price of health care. b is the transfer from bequests. Here d represents the type of employment-based health insurance held by agents, and $I_{d>0}$ is the indicator function for having employment-based health insurance before retirement ($I_{d>0}=1$ if $d>0$, otherwise $I_{d>0}=0$). The payroll tax rates for financing Social Security and Medicare are by denoted by τ_{ss} and τ_m respectively.

The set of budget constraints facing retired agents are

$$s_{j+1}+c_j+(1-k_m-k_{ret}I_{d>1})qm_j+p_m=s_j(1+r)+\mathrm{Tr}(\chi_i), \quad \forall j\in\{R,\ldots,T\}. \tag{3}$$

Here $I_{d>1}$ is the indicator function for having employment-based health insurance after retirement ($I_{d>1}=1$ if $d>1$, otherwise $I_{d>1}=0$).

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

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

Here δ_h^j is the health capital depreciation rate, which is age-specific and deterministic. Note that $I_j(m_j)$ is the new health capital produced, which is a function of health spending at that age, m_j. The new-born agents start with the initial health capital: $h_1=\overline{h}$.

At each age, agents choose consumption, saving, and spending on health care to maximize their expected lifetime utility. The utility maximizing problem facing agent i with state (s,h,d) at age j can be written as a Bellman equation,

$$V_j^i(s,h,d)=\max_{c,s',m} u(c)+\beta P_j(h')V_{j+1}(s',h',d)+(1-P_j(h'))\theta_b\nu(s') \tag{P1}$$

subject to Eqs. (2)–(4),

$c\ge 0,$

$s'\ge 0,$

and $m\ge 0$.

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 $S_j^i(s,h,d)$ be the policy rule for savings for agent i at age j with (s,h,d), and $M_j^i(s,h,d)$ be the policy rule for health spending. 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 the type of health insurance d.[8]

There are two forms of health insurance: employment-based health insurance and Medicare.[9] Before retirement, some agents have employment-based health insurance that pays a k_e portion of total health spending. After retirement, a subgroup of these agents continue to have employment-based health insurance that pays a k_{ret} portion of total health spending. The type of health insurance held by agents is represented by $d\in\{0,1,2\}$ with $d=0$ representing no employment-based health insurance, $d=1$ representing employment-based insurance only before retirement, and $d=2$ representing employment-based insurance throughout the whole life. The value of d for each agent is determined at birth by a random draw with the probability of drawing d equal to Ω_{d}. Employment-based health insurance is administered by competitive insurance companies and financed by premiums paid by workers, p_d.[10] Medicare pays a k_m portion of total health spending for every agent after retirement. It is administered by the government and financed by a payroll tax τ_m and premiums paid by retirees, p_m.

[7] 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.

[8] Note that for simplicity, the model abstracts from health shocks and earnings shocks over the life cycle. These shocks are important for understanding insurance problems and issues related to cross-sectional distributions. However, they may be less relevant in this paper as the focus of the paper is on the aggregate effects of Social Security.

[9] I do not consider Medicaid here for technical reasons. That is, in the model with endogenous health spending, agents enrolled in Medicaid would choose an infinite amount of health expenditures as Medicaid does not require co-payments. In reality, this would not happen because Medicaid puts tight restrictions on what types of health care services and what physicians and hospitals can be used by its enrollees.

[10] Note that the employment-based health insurance premiums are exempted from taxation in the US, which will be reflected in the model. By definition, p_0 is equal to zero.

2.2. The production technology

On the production side, the economy consists of two sectors: the consumption goods sector and the health care sector. The production in the two sectors is governed by the same (Cobb–Douglas) production function but with sector-specific total productivity factor (TFP). Assuming that the production is taken in competitive firms and factors can move freely between the two sectors, it is easy to obtain that the model can be aggregated into a one-sector economy, and that the relative price of health care is inversely related to the relative TFPs in the two sectors.[11] Let the aggregate production function take the following form:

$$Y = AK^{\alpha}L^{1-\alpha}. \tag{6}$$

Here α is the capital share, A is the TFP, K is the capital, and L is the labor. Assuming capital depreciates at a rate of δ, the firm chooses K and L by maximizing profits $Y - wL - (r+\delta)K$. The profit-maximizing behaviors of the firm imply

$$w = (1-\alpha)A\left(\frac{K}{L}\right)^{\alpha}$$

$$r = \alpha A\left(\frac{K}{L}\right)^{\alpha-1} - \delta$$

Note that if the two sectors have differential TFP growth, the relative price of health care would change over time. This possibility and its implication for health spending are considered in Section 6.

2.3. Stationary equilibrium

Let $\Phi(j, \chi_i, d)$ represent the population measure for agent i at age j with health insurance type d in a stationary equilibrium.[12] The law of motion for $\Phi(\cdot,\cdot,\cdot)$ can be written as follows:

$$\Phi'(j+1, \chi_i, d) = P_j(h_{j+1}(j, \chi_i, d))\Phi(j, \chi_i, d), \tag{7}$$

with

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

Since the two state variables, $\{s, h\}$, can be completely determined by $\{j, \chi_i, d\}$ at steady state, I simplify the notations for the value function and individual policy rules to $V_j^i(d), S_j^i(d), M_j^i(d)$ when defining the stationary equilibrium. For a given set of government parameters $\{\mathrm{Tr}(\cdot), k_m, p_m\}$, a stationary equilibrium can be defined as follows.

Definition. A *stationary equilibrium* for a given set of government parameters $\{\mathrm{Tr}(\cdot), k_m, p_m\}$, is a collection of value functions $V_j^i(\cdot)$, individual policy rules $S_j^i(\cdot)$ and $M_j^i(\cdot)$, population measures $\Phi(\cdot,\cdot,\cdot)$, prices $\{r, w, q\}$, payroll tax rates $\{\tau_{ss}, \tau_m\}$, employment-based health insurance policy parameters $\{k_e, k_{ret}, p_1, p_2\}$, and transfer from bequests b, such that,

1. Given $\{r, w, q, k_m, p_m, \mathrm{Tr}(\cdot), \tau_{ss}, \tau_m, b, k_e, k_{ret}, p_1, p_2\}$, $\{S_j^i(\cdot),\ M_j^i(\cdot),\ V_j^i(\cdot)\}$ solves the individual's dynamic programming problem (P1).
2. Aggregate factor inputs are generated by decision rules of the agents:

$$K = \frac{1}{1+p_g}\sum_{i=1}^{z}\sum_{j=1}^{T}\sum_{d=0}^{2} S_j^i(d)\Phi(j, \chi_i, d),$$

$$L = \sum_{i=1}^{z}\sum_{j=1}^{T}\sum_{d=0}^{2} \chi_i \epsilon_j \Phi(j, \chi_i, d).$$

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 Medicare are self-financing:

$$\sum_{j=R}^{T}\sum_{i=1}^{z}\sum_{d=0}^{2} \mathrm{Tr}(\chi_i)\Phi(j, \chi_i, d) = \sum_{j=1}^{R-1}\sum_{i=1}^{z}\sum_{d=0}^{2} \tau_{ss}(w\chi_i\epsilon_j - p_d)\Phi(j, \chi_i, d).$$

$$\sum_{j=R}^{T}\sum_{i=1}^{z}\sum_{d=0}^{2} k_m q M_j^i(d)\Phi(j, \chi_i, d) = \sum_{j=1}^{R-1}\sum_{i=1}^{z}\sum_{d=0}^{2} \tau_m(w\chi_i\epsilon_j - p_d)\Phi(j, \chi_i, d).$$

5. The population measure, Φ, evolves over time according to Eq. (7), and satisfies the stationary equilibrium condition: $\Phi' = (1+p_g)\Phi$.

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[11] Specifically, the relative price of health care q is equal to A_c/A_m, where A_c and A_m are the sector-specific TFPs.

[12] Note that the other two state variables, $\{s, h\}$, are endogenous and can be completely determined by $\{j, \chi_i, d\}$ in a stationary equilibrium.

6. Employment-based health insurance policies are self-financing,

$$\sum_{j=1}^{R-1}\sum_{i=1}^{z} k_e q M_j^i(1)\Phi(j,\chi_i,1) = \sum_{i=1}^{z}\sum_{j=1}^{R-1} p_1\Phi(j,\chi_i,1),$$

$$\sum_{j=1}^{R-1}\sum_{i=1}^{z} k_e q M_j^i(2)\Phi(j,\chi_i,2) + \sum_{j=R}^{T}\sum_{i=1}^{z} k_{ret} q M_j^i(2)\Phi(j,\chi_i,2) = \sum_{i=1}^{z}\sum_{j=1}^{R-1} p_2\Phi(j,\chi_i,2),$$

7. The transfer from bequests, b, satisfies

$$(1+p_g)\sum_{j=1}^{R-1}\sum_{i=1}^{z}\sum_{d=0}^{2} b\Phi(j,\chi_i,d) = \sum_{i=1}^{z}\sum_{j=1}^{T}\sum_{d=0}^{2}(1+r)S_j^i(d)[1-P_j(h_{j+1}(j,\chi_i,d))]\Phi(j,\chi_i,d).$$

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

3. Calibration

The benchmark model is calibrated here, and the calibrated model is used in the next section 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.

The benchmark model is calibrated to match the US economy in 2000. The calibration strategy adopted here is the following. The values of some standard parameters are predetermined based on previous studies, and the values of the rest of the parameters are then *simultaneously* chosen 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, and can live up to age 100 (i.e. $T=16$). The mandatory retirement age, R, is set to 65. The population growth rate in the model, p_g, is calibrated to match the elderly share of the US population (25+) in 2000, that is, 19.5% according to the Census data.

3.2. Preference parameters

In many standard model environments, the level of period utility flow 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, the utility function for consumption, $u(c)$, 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. The value of π_c is chosen so that the model-implied value of a statistical life (VSL) is consistent with its empirical estimates in the literature.[13] The empirical estimates of VSL in the literature range from approximately 1 million dollars to values near 20 million dollars. 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, \$7 million is used in the benchmark calibration. The value of σ is set to 1.5, which is in the middle of the range of values used in the standard macro literature.[14]

The subjective discount factor β is chosen to match the capital-output ratio in the US, that is, 3.0 according to Auerbach and Kotlikoff (1995). The resulting value of β is 0.88 (i.e. $0.975^5=0.88$). As for the bequest motive, the bequest utility function takes the standard CRRA form, i.e. $\nu(s)=s^{1-\sigma}/(1-\sigma)$. The intensity of the bequest motive, θ_b, affects how fast the elderly dissave in the model. Thus, its value is chosen to match the average wealth profile after retirement. Specifically, it is calibrated to the ratio between the average wealth in the 60–64 age group and the 85–89 age group, that is, 1.9 according to the PSID data.[15]

[13] 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, $q/(\partial P/\partial m)$.

[14] As robustness check, I also explore other values for σ (i.e. 1.01, 2, 2.5, 3) and find that the main quantitative results do not significantly change. That is, the expansion of Social Security can account for from 34% to 37% of the rise in health spending in these robustness check exercises. The detailed results of these exercises are available from the author upon request.

[15] Here I truncate the wealth profile by age 90 because the data points after age 90 are limited in the dataset.

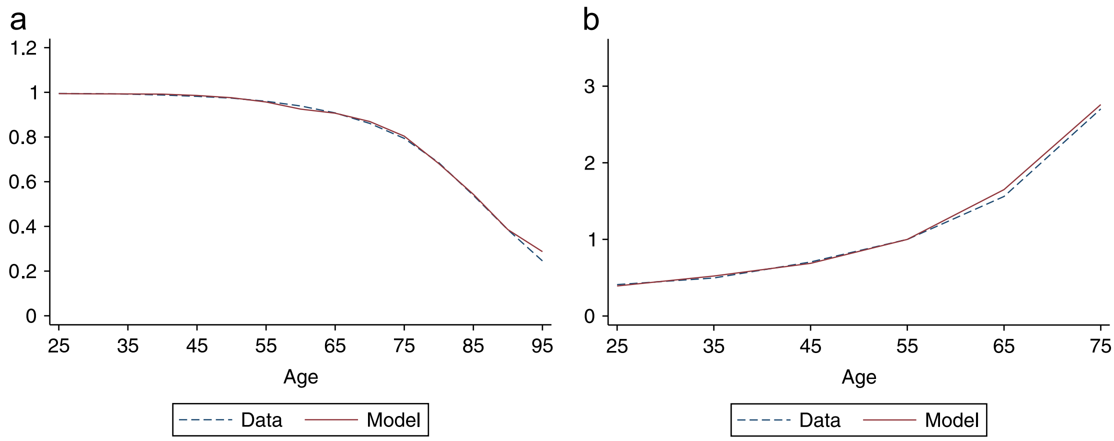

Fig. 4. Survival prob. and health spending over the life cycle. (a) Cond. survival probability. (b) Average health spending.

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 TFP parameter, A, is chosen to match the GDP per capita in the US economy in 2000: \$35,081 (in \$2000). The sector-specific TFPs in the two sectors are normalized to be the same in the benchmark model, implying that the relative price of health care, q, is equal to one. Note that the value of q would change when the two sectors have differential TFP growth, and this possibility will be studied in Section 6.

3.4. Survival probability function and health technology

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

$$\begin{cases} P(h)=1-\frac{1}{e^{a(h-\underline{h})}} & \text{if } h \geq \underline{h} \\ P(h)=0 & \text{if } h<\underline{h} \end{cases}$$

Here $a>0$, so that the value of $P(\cdot)$ is always between zero and one, and $P(h)$ is concave and increasing in h (when $h \geq \underline{h}$). Note that $\underline{h}$ is the minimum level of health capital required to survive to the next period with a positive probability.

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 Fig. 4(a)). To capture this feature in the model, it is assumed 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 $\overline{h}$, $\underline{h}$, and $\{\delta_h^j\}_{j=2}^{T-2}$ are calibrated to match the conditional survival probabilities over the life cycle, while δ_h^1 is normalized to zero and δ_h^{T-1} is normalized to be equal to δ_h^{T-2}. Fig. 4(a) plots both the model results and the data on survival probabilities over the life cycle.

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. It suggests that the value of a should be related to the level of aggregate health spending. Therefore, the value of a is calibrated 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:

$$I_j(m_j)=\lambda_j m_j^{\theta}, \quad \forall j$$

where $\theta \in (0,1)$ and $\{\lambda_j\}_{j=1}^{T-1}$ are positive. The value of λ_j before retirement is assumed to be age-invariant and is normalized to one. The rest of the parameters in the health production function is calibrated to match the life cycle profile of health spending (per capita).[16] In specific, the value of the curvature parameter, θ, is chosen to match the shape of the health spending profile before retirement, that is, the average health spending ratio between age 25 and age 64. The values of λ_j after retirement are chosen to match the average health spending (per capita) by age during retirement. Since the data is only available for six age groups: {25–34, 35–44, 45–54, 55–64, 65–74, 75+}, it is assumed: $\lambda_9=\lambda_{10}$, $\lambda_{11}=\lambda_{12}=\ldots=\lambda_{15}$. The model results and the data on the health spending (per capita) profile are plotted in Fig. 4(b), and the calibrated values for θ and λs are reported in Table 2.

[16] The data is from Meara et al. (2004), who document the relative health spending (per capita) by age from 1963 to 2000. The data in 2000 is used in calibration.

3.5. Earnings and employment-based health insurance

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

The logarithm of the individual-specific permanent earnings shock, $\ln \chi_i$, is assumed to follow the normal distribution: $N \sim (0, \sigma_\chi^2)$. The distribution is discretized into five states using the method introduced in Tauchen (1986). Transforming the values back from the logarithms, a finite set of $\{\chi_1, \chi_2, \ldots, \chi_5\}$ can be obtained 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 0.65 such that it is consistent with the empirical estimates of the variance of log annual earnings of men in Heathcote et al. (2010).

The coverage rates provided by employment-based health insurance, k_e and k_{ret}, are set to be 0.7 and 0.3 respectively based on the estimation in Attanasio et al. (2011). According to the health insurance data from US Census Bureau, there are approximately 30% of working age Americans who do not have employment-based health insurance while there are approximately 35% of the elderly who still have employment-based health insurance. Therefore, the values of $\{\Omega_0, \Omega_1, \Omega_2\}$ are set to $\{0.3, 0.35, 0.35\}$.

3.6. Social security and medicare

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 Administration) data in 2000. Following Fuster et al. (2007), the values of $\mathrm{Tr}(\cdot)$ in 2000 are chosen so that the Social Security program has the marginal replacement rates listed in Table 1. Then every beneficiary's benefits are rescaled so that the Social Security program is self-financing.

In 2000, total US Medicare expenditures were approximately 2.3% of GDP, and the annual Medicare premium per elderly was $546. Thus, the value of p_m is set to 546, and then the value of k_m is chosen such that the Medicare expenditures in the model match 2.3% of GDP. The Medicare payroll tax rate τ_m is endogenously determined by Medicare's self-financing budget constraint.

Table 1
The social security benefit formula.

Lifetime earnings	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

Note: y is the lifetime earnings of the agent and $\overline{y}$ is the average lifetime earnings.

Table 2
Benchmark calibration.

Parameter	Description	Value
α	Capital share	0.3
δ	Capital depreciation rate	$1-(1-0.07)^5$
σ	CRRA utility parameter	1.5
Parameter	Description	Moments to match
$\beta = 0.975^5$	Subjective discount factor	Capital-output ratio: 3.0 (annual)
$\pi_c = 0.034$	Constant in the utility function	VSL: $7 million
$\tau_{ss} = 10.6\%$	Social Security replacement rate	SSA data
$k_e = 0.7$, $k_{ret} = 0.3$	Health coinsurance rates	Attanasio et al. (2011)
$\{\Omega_{hi}\}_{hi=0}^2$	Distribution of health ins. type	US Census Bureau health ins. data
$\{\epsilon_j\}_{j=1}^{R-1}$	Age-efficiency profile	CPS earnings data
$\{\delta_h^j\}_{j=2}^{14}$	Health depreciation rates	Conditional surv. prob. data
$a = 0.064$	Parameter in surv. prob. function	HS in 2000: 12.5% of GDP
$p_g = 1.8\%$	Population growth rate	The elderly population share
$\sigma_\chi^2 = 0.65$	Permanent earning shock parameter	Heathcote et al. (2010)
$\theta_b = 0.75$	The intensity of the bequest motive	Wealth ratio (age 60–64/age 85–89)
$\overline{h} = 91$, $\underline{h} = 13$	Initial health capital and death capital	Conditional surv. prob. data
$\lambda_1 = \cdots = \lambda_8 = 1$	Health production coefficient	Normalization
$\lambda_9 = \lambda_{10} = 1.85$	–	Relative HS in age 65–74
$\lambda_{11} = \cdots = \lambda_T = 2.75$	–	Relative HS in age 75+
$\theta = 0.16$	Health production curvature	HS ratio (age 25–34/age 55–64)

Table 3
Benchmark model statistics.

Name	Model	Data
Capital-output ratio (annual)	3.0	3.0
Aggregate health spending (% of GDP) in 2000	12.5%	12.5%
Life expectancy	75.7	76.9
GDP per capita (in $)	35,263	35,081
Value of a Statistical Life	$6.9 million	$7.0 million
Medicare payroll tax rate, τ_m	3.1%	2.9%
Medicare coinsurance rate, k_m	0.4	–
Medicare payments (% of GDP)	2.3%	2.3%
Wealth ratio (age 60–64/age 85–89)	1.9	1.9
HS ratio (age 25–34/age 55–64)	2.5	2.4
Elderly population share	19.6%	19.5%

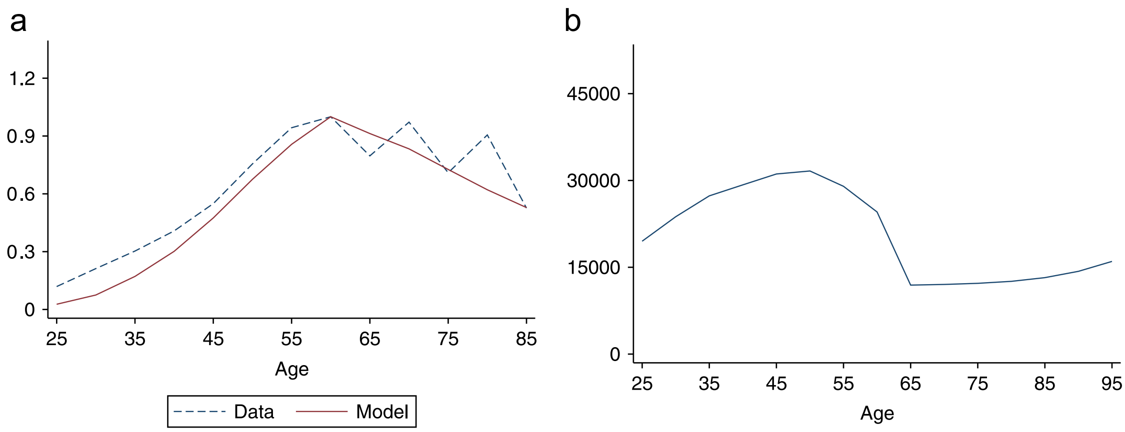

Fig. 5. Wealth and income over the life cycle. (a) Average wealth. (b) Average earnings. (Wealth profile: the data source is PSID, and the age group 60–64 is normalized to one.)

Table 2 summarizes the results of the benchmark calibration. This calibration delivers an annual interest rate of 3.0%. Table 3 contains some key statistics of the benchmark economy. Fig. 5(a) and (b) plots the average wealth and the income over the life cycle in the benchmark economy.

It is worth mentioning that the shape of the life-cycle wealth profile is relevant in this study, because a main effect of Social Security on aggregate health spending works through the reallocation of resources over the life cycle.[17] Therefore, it is important that the wealth profile in the model is consistent with the data. It is a well-observed fact that the elderly does not dissave as quickly as the simple life-cycle model predicts. As seen in Fig. 5(a), the benchmark model matches the wealth profile in the data fairly well, particularly, the wealth profile after retirement. In the model, agents do not run down their wealth quickly after retirement.[18]

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, the calibrated model is used to assess the quantitative importance of these mechanisms. Specifically, the following thought experiment is conducted: I exogenously reduce the Social Security payroll rate in the model and then investigate how this change affects the health spending behavior. Note that when the payroll tax rate is changed, the corresponding Social Security payments are also adjusted so that the Social Security program is always self-financing.

[17] Thanks to the anonymous referee for this point.

[18] This result is mainly due to the bequest motive. Remember that the calibration strategy for the intensity parameter for the bequest motive is to match the average wealth ratio between age group 60–64 and age group 85–89.

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 and in the benchmark equilibrium. The quantitative results suggest 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 12.5% to 9.5%, which is in magnitude 35% of the change in US health spending as a share of GDP between 1950 and 2000 (see Table 4).

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 3.0% to 2.0%). This result is consistent with what previous studies have found (e.g., Auerbach and Kotlikoff, 1987; Imrohoroglu et al., 1995). 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 75.7 years to 74.4 years. This change in life expectancy in the model accounts for 15% 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 35% of the rise in health spending, but only accounts for 15% 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 (e.g., Chay and Greenstone, 2003; Grossman, 2005). There is a large literature on the relationship between health spending and survival probability/mortality rate (see Cutler et al., 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 et al. (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 Fig. 3).

It is important that the potential explanations of the rise in US aggregate health spending are also consistent with the related empirical observation: the simultaneous change in life-cycle profile of health spending (per person). Fig. 6(a) plots 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 plays a key role in matching the change in life-cycle profile of health spending over the last several decades.

4.2. *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. Fig. 6(b) plots the total available resources over the life cycle, i.e. the sum of wealth, earnings, and bequest transfers. As can be seen, Social Security significantly raises the total resources

Table 4
Results from the main thought experiments.

Economy	Agg. health spending (% of GDP)	Life expectancy (in years)
Data2000	12.5	76.8
Data1950	3.9	68.2
Benchmark model (2000SS)	12.5	75.7
Model (1950SS)	9.5	74.4
Experiment 1 (with main existing drivers)	4.5	70.2
Experiment 2	4.4	70.5
Endogenous retirement	**Agg. health spending (% of GDP)**	**Ave. retirement age**
Benchmark (2000SS)	12.5	62.8
Model (1950SS)	9.6	63.3

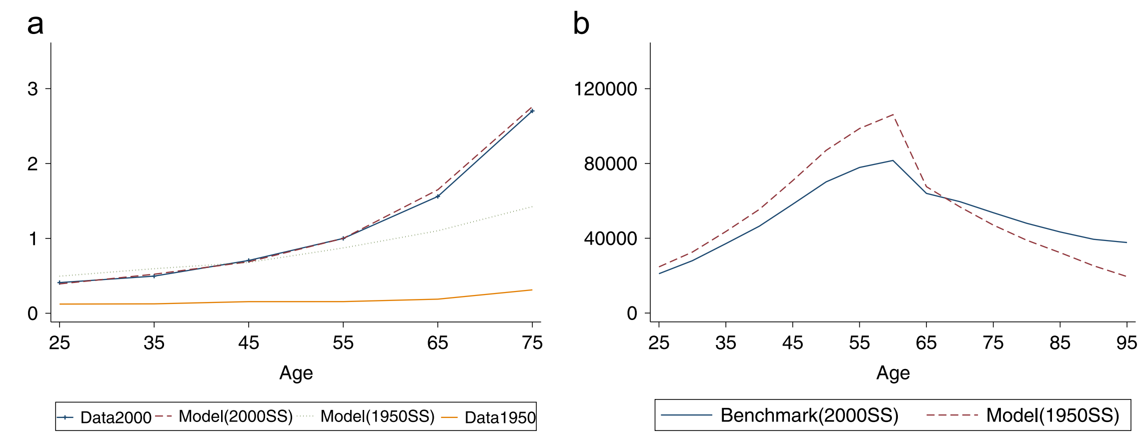

Fig. 6. Life cycle profiles: benchmark (2000SS) vs. counterfactual (1950SS). (a) Average health spending. (b) Average total resources available.

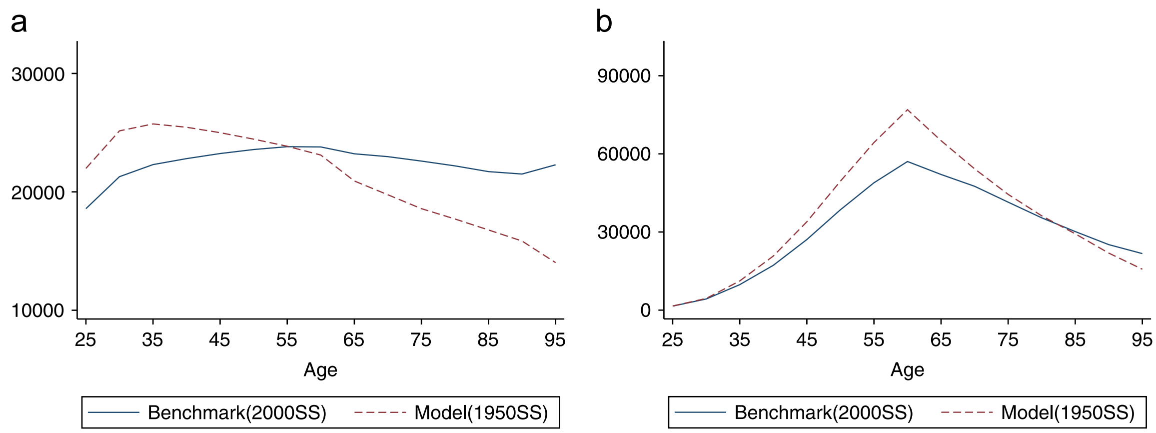

Fig. 7. Life cycle profiles: benchmark (2000SS) vs. counterfactual (1950SS) (continue). (a) Average consumption. (b) Average wealth.

available to the elderly. The change in the total resource profile reflects an important reason why Social Security increases aggregate health spending. Social Security reallocates more resources to the elderly who have the highest marginal propensity to spend on health care among the population, thus increasing aggregate health spending. This result is also consistent with previous studies on the impact of Social Security on elderly poverty (e.g., Atkinson, 1989; Engelhardt and Gruber, 2004). These studies find that Social Security has played a key role in reducing the poverty rate among the US elderly over the last several decades.

Fig. 7(a) and (b) plots the life-cycle profiles of consumption and wealth in the benchmark economy and the counterfactual economy with 1950 Social Security. There are a few things to note. First, Social Security significantly increases the consumption after retirement, which is consistent with the literature on the poverty alleviation effect of Social Security for the elderly. Second, agents save relatively less for the retirement in the benchmark economy than in the economy with 1950 Social Security. 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 is smaller than what previous studies have found. A detailed discussion on this issue will be provided in Section 5.

4.3. *Main existing explanations*

In this section, the model is extended to include the main existing hypotheses for the rise in health spending. The following quantitative question is asked. When these existing drivers are also included, can the extended model account for the entire rise in US health spending over 1950–2000? Specifically, the following thought experiment is conducted: I exogenously change the relevant dimensions of the model to mimic both the change in Social Security and the main existing drivers, and then investigate whether the health spending level in the new equilibrium matches the 1950 data on health spending.

As reviewed in the introduction section, several explanations have been provided in the existing literature for the rise in health spending. Among them, increased health insurance and economic growth have recently received the most attention in the literature. The former says that the increased health insurance over the last several decades (i.e. the expansion of Medicare and Medicaid) reduces price to the consumer and increases the demand for health care (Feldstein, 1977; Manning et al., 1987; Newhouse, 1992; Finkelstein, 2007). The latter suggests that since health care is a luxury good, people tend to spend a larger share of income on health care services as they get richer (see Hall and Jones, 2007). Medicare was implemented in the mid 1960s, and has been expanding ever since. To capture the change in Medicare over 1950–2000, the Medicare program is simply shut down in the benchmark model. To capture the growth from 1950 to 2000, the TFP level in the benchmark model is exogenously reduced by the amount that is consistent with the empirical estimation of TFP growth over this period in the US.[19] Note that Medicaid was not included in the benchmark model due to the technical reasons described in footnote 9. As a result, the model does not capture the effect of Medicaid on health spending.[20]

In a computational experiment (Experiment 1), I compute a version of the model that contains the 1950 Social Security program, no Medicare, and the 1950 TFP level. As shown in Table 4, aggregate health spending as a share of GDP in this version of the model drops to 4.5%. This result suggests that when the main existing explanations (i.e. the expansion of Medicare and economic growth) are also included, the model can account for a major portion (i.e. 93%) of the rise in health spending from 1950 to 2000.[21]

5. Other macroeconomic effects of social security

Does endogenous health matter for understanding other macroeconomic effects of Social Security? This question is addressed in the following.

5.1. Social security and capital accumulation

It is well-known that pay-as-you-go Social Security discourages private saving 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 (Imrohoroglu et al., 1995; Conesa and Krueger, 1999; Fuster et al., 2007). 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 capital accumulation? 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 model. To understand whether endogenous health matters for the negative impact of Social Security on capital accumulation, I first conduct this exercise in the benchmark economy (with endogenous health spending), and then the same exercise is replicated in a counterfactual economy with fixed health spending decisions. Comparing the results from these two exercise, it can be seen that the negative impact of Social Security on capital accumulation is significantly smaller in the model with endogenous health. As shown in Table 5, in the model with endogenous health spending, the capital stock would be 29% higher if Social Security were eliminated. However, when health spending is fixed, the capital stock would be 39% higher if Social Security were eliminated. The intuition behind this result is as follows. When health spending and longevity are endogenous, the negative impact on saving is partially offset by the extra longevity induced by Social Security (via increasing health spending).

5.2. Social security and medicare

Another interesting implication of the model is that, by changing health spending, Social Security indirectly affects the financial burden of the Medicare program. As shown in Table 5, in the benchmark economy, the Medicare program is financed by a payroll tax of 3.1%. However, the same Medicare program would only need to be financed by a payroll tax of 1.0% if Social Security were eliminated. The intuition for this result is the following. As the Medicare program provides coinsurance for health spending, its payments are largely dependent on the total health spending of the elderly, which is an

[19] Greenwood et al. (2005) documented that TFP grew at an annual rate of 1.68% from 1950–1974, at 0.56% from 1975–1995, and at 1.2% from 1995–2000, which implies that TFP has grown by 178% in total from 1950–2000.

[20] In other words, the effect of Medicaid on health spending will be included in the residual left unexplained by the main drivers in the model. I argue that the effect of Medicaid may be significantly smaller than other types of health insurance because Medicaid puts tight restrictions on what types of health care services and what physicians and hospitals can be used by its enrollees. The empirical evidence has also shown that people have a strong aversion toward Medicaid (e.g., Ameriks et al., 2011).

[21] It is worth mentioning that the results from this computational experiment also imply that the expansion of Social Security interacts with the existing explanations. In particular, the effect of the expansion of Social Security on health spending may be amplified by Medicare in an interesting way. As Medicare only targets the elderly, it enlarges the young–elderly gap in marginal propensity to spend on health care. As a result, transferring resources from the young to the elderly (via Social Security) would have a larger effect on aggregate health spending.

Table 5
Macroeconomic effects of social security.

Statistic	Benchmark economy	Social Security eliminated	Δ (in%)
The capital stock (Endogenous health)	$22,813	$29,385	29
The capital stock (Health spending fixed)	$22,813	$31,805	39
Medicare tax rate	3.1%	1.0%	−68
Welfare (CEV)	–	−4.4%	

individual choice. As Social Security encourages the elderly to spend more on health care, it also raises the financial burden of the Medicare 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.

5.3. The welfare effect of social security

It is also interesting to look at the welfare implications of Social Security in the model. To do so, the following welfare measure is adopted: the compensating variation in consumption required to give the same expected lifetime utility to a new born. The quantitative results suggest that Social Security generates a net welfare loss in the benchmark model, i.e. 4.4% of consumption (see Table 5). That is, to obtain the same expected lifetime utility for a new born under the regime with Social Security, agents in the model without Social Security should reduce consumption in each period by 4.4%. The net welfare loss of Social Security suggests that the welfare gains from insuring against uncertain length of life may not be as large as the welfare loss created through other mechanisms, such as distorting health spending decisions, and reducing bequest transfers.[22] Note that the welfare result obtained here should be treated with caution, because the model does not include all the relevant elements for a complete welfare analysis of Social Security and thus may not capture all the potential welfare effects. For instance, the model may not fully capture the effects of Social Security on liquidity constraints and labor supply. In addition, because the model does not contain aggregate uncertainty, it does not capture the intergenerational risk sharing role of Social Security (see Krueger and Kubler, 2006; Ball and Mankiw, 2007). These elements are not modeled here because they are less relevant to the focus of this paper, i.e. the effects of Social Security on health spending, and modeling them greatly complicates the analysis.

6. Further discussion

I begin by discussing the implication for the rise in health spending by income.

6.1. Health spending by income

The theory proposed in this paper also has an interesting implication for the rise in health spending across the income distribution. 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.[23]

Table 6 presents the change in health spending for the elderly by lifetime income quintile in the benchmark exercise. As can be seen, as the size of Social Security expands from 1950 to 2000, the average health spending increases by the largest for the lowest income quintile, that is, by a factor of 3.78. This number declines as income rises, and it increases only by a factor of 1.68 for the highest income quintile. The negative relationship between health spending growth and income can also be found in the data. As documented by Follette and Sheiner (2005), the negative relationship between health spending growth and income holds true among the majority of the elderly population from 1970 to 2002. They find that the growth in health spending (per elderly household) from 1970 to 2002 was the fastest for households in the poorest income quintile, and the negative relationship between health spending growth and income held true through the whole population except the richest quintile.

[22] See Philipson and Becker (1998) for a detailed discussion on the negative effect of Social Security on welfare by distorting health spending decisions. Fehr and Habermann (2008) show that the negative effect of Social Security on bequest transfers is welfare-reducing.

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

Table 6
Health spending by income: benchmark (2000SS) vs. model (1950SS).

Income quintile	1	2	3	4	5
$\frac{HS_{2000SS}}{HS_{1950SS}}$	3.78	2.19	1.87	1.68	1.68

6.2. *Differential productivity growth in the health care sector*

The other conventional explanations for the rise in health spending include: differential productivity growth in the health care sector, population aging, and supply-induced demand, etc. These explanations have been found to be quantitatively less important by previous studies (e.g., Newhouse, 1992; CBO, 2008). The quantitative results in the previous section suggest that these explanations together may be responsible for a small portion of the rise in health spending, i.e. the residual left unexplained by the expansion of Social Security and Medicare, and economic growth.

Among them, the argument about differential productivity growth in health care is worth a discussion here. Conventional wisdom says that productivity growth in the health care sector may be slower than the rest of the economy because the relative price of health care has been increasing significantly over the last several decades. However, many studies in the literature have argued that this may not be true (e.g., Newhouse, 1992; Lawver, 2010). They argue that the rising relative price of health care may simply reflect changes in the quality of health care over time. For example, the treatment of heart attacks today is definitely much more effective than 30 years ago (see Heidenreich and McClellan, 2001). Indeed, after adjusting for quality changes, a recent study by Lawver (2010) finds that the relative price of health care has even slightly declined over 1996–2007, which suggests that productivity growth in the health care sector may not be slower than the rest of the economy. In fact, as argued in Newhouse (1992), the magnitude of productivity growth in the health care sector is extremely difficult to measure because new products and procedures are constantly introduced into this sector and it is difficult to measure the product. Based on this evidence, the existing literature concludes that it is hard to believe the differential productivity growth argument.

To shed some light on the quantitative implications of the differential productivity growth story in the model, the following computational experiment (Experiment 2) is conducted. I arbitrarily assume that the TFP growth in the health care sector over 1950–2000 was only half of that in the rest of the economy, and then recompute the version of the model in Experiment 1, that is, a model with the 1950 (sector-specific) TFPs, no Medicare, and 1950 Social Security.[24] Specifically, the implied relative price of health care in 1950 is first calculated based on the argument in Section 3.3, and then the new equilibrium with 1950 values is computed. As shown in Table 4, aggregate health spending in this version of the model is 4.4% of GDP, that is only 0.1% lower than in the model computed in Experiment 1 which also captures the same mechanisms as in here except the change in the relative price of health care. This result suggests that an increase in the relative price of health care resulting from differential productivity growth in health care may not have a large effect on health spending. The intuition for this result is simple. In the model with endogenous health spending, a price increase also induces the consumer to consume less health care which partially offsets the effect of a higher price per unit of health care. Because a good measure of productivity growth in health care does not exist, it is impossible to precisely assess the quantitative importance of the differential productivity growth story. But the results in Experiment 2 suggest that this story may not be quantitatively important even if productivity growth in the health care sector is indeed significantly lower than the rest of the economy.

It is also worth mentioning that several studies have suggested a competing hypothesis for the large unexplained residual, that is, the health technological progress over the last several decades (e.g., Newhouse, 1992; Suen, 2006). This hypothesis says that the invention and adoption of new and expensive health technologies over the past several decades have driven the rise in health spending over the same period. However, since health technological progress is hard to measure, previous studies simply attribute the 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 over the last several decades. Based on this residual method, the results of this paper imply that the impact of health technological progress may be significantly smaller than what previous studies have suggested, because a large portion of the residual is already attributed to the expansion of Social Security.

6.3. *Endogenous retirement*

To check whether the main results of this paper are sensitive to the assumption of exogenous retirement, here I consider a version of the model in which agents are allowed to choose their retirement age endogenously. The analysis of this modified model suggests that the main results of the paper are robust to the assumption of exogenous retirement.

Agents derive utility from each period of leisure after retirement. In addition, agents have heterogenous preferences towards leisure so that the model can generate realistic retirement ages and a realistic effect of Social Security on

[24] Note that TFP growth in the consumption goods sector is assumed to be the same as the economy-wide TFP growth used in Experiment 1.

retirement.[25] The preference type for the agent is determined at birth by a random shock, ζ, with the probability of having $\zeta = \zeta_l$ equal to Λ_l for all $l \in \{1, 2, \ldots, n_l\}$. After all the shocks at birth are realized, an agent with permanent earning shock χ_i, health insurance type hi, and preference type ζ_l faces the following lifetime utility maximization problem.

$$\max_{R, \{c_j, m_j\}_1^T} \sum_{j=1}^{T} \beta^{j-1} \left[\prod_{k=2}^{j} P_{k-1}(h_k) \right] [u(c_j) + (1 - P_j(h_{j+1}))\theta_b \nu(s_{j+1})] + \sum_{j=R}^{T} \beta^{j-1} \left[\prod_{k=2}^{j} P_{k-1}(h_k) \right] \zeta_l \xi \tag{8}$$

subject to

$$\begin{cases} s_{j+1} + c_j + (1 - k_e I_{d>0}) q m_j = (w \chi_i \epsilon_j - p_d)(1 - \tau_{ss} - \tau_m) + s_j(1+r) + b & \text{if } j < R \\ s_{j+1} + c_j + (1 - k_m - k_{ret} I_{d>1}) q m_j + p_m = s_j(1+r) + \mathrm{Tr}(\chi_i, d, l) & \text{if } j \geq R \end{cases}$$

and

$$h_{j+1} = (1 - \delta_h^j) h_j + I_j(m_j), \quad c_j \geq 0, \ s_{j+1} \geq 0, \ m_j \geq 0, \ \forall j.$$

Here $\zeta_l \xi$ represents the utility flow from each period of leisure after retirement, which is determined by an individual-specific term, ζ_l, and a positive constant term, ξ.

To calibrate the model with endogenous retirement, the strategy adopted here is exactly the same as in the benchmark model. As for the new parameters, the logarithm of the individual-specific preference shock, $\ln \zeta_l$, is assumed to follow the normal distribution: $N \sim (0, \sigma_\zeta^2)$. The distribution is discretized into five states using the method introduced in Tauchen (1986). Transforming the values back from the logarithms, a finite set of $\{\zeta_1, \zeta_2, \ldots, \zeta_5\}$ can be obtained with the corresponding probabilities $\{\Lambda_i\}_{i=1}^5$. Therefore, there are two new parameters in this model, $\{\sigma_\zeta, \xi\}$. The value of ξ is calibrated to match the average retirement age in 2000, that is, 62.6 years according to Gendell (2001). The value of σ_ζ is calibrated to match the percentage of the population retired by age 60, that is, 38.4% according to Kopecky (2011). In addition, it is assumed that agents do not retire until 50 and do not work beyond age 70 because of the fact that most individuals retire within this age range.[26] The calibration results an average retirement age of 62.8 years, and the fraction of the population retired by 60 in the calibrated model is 38.4%.

As shown in Table 4, the effect of Social Security on health spending does not change significantly after the retirement decision is endogenized. When the Social Security payroll tax rate is reduced from 10.6% to 2%, aggregate health spending as a share of GDP in the model drops from 12.5% to 9.6%. It is worth noting that the change in Social Security does have a significant effect on the retirement age in the model. When the Social Security payroll tax rate is reduced from 10.6% to 2%, the average retirement age increases from 62.8 years to 63.3 years.[27]

7. Conclusion

A new explanation is proposed for the dramatic rise in US aggregate health spending, that is, the expansion of US Social Security program. Using numerical simulation techniques, I find 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, the expansion of Social Security also 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). When the model is extended to include the main existing explanations for the rise in health spending, the extended model can account for most of the rise in US health spending from 1950 to 2000.

The effect of Social Security on aggregate health spending has two other interesting implications. First, the negative effect of Social Security on capital accumulation is significantly smaller than what previous studies have found because the negative saving effect of Social Security is partially offset by the extra longevity it induces (via changing health spending). 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 Medicare because it encourages the elderly to spend more on health care and thus increases the insurance payments from Medicare.

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[25] Note that the benchmark model was not originally created for studying retirement and so it does not have enough heterogeneity to generate differential retirement decisions given one model period is 5 years.

[26] Note that it is also hard to estimate the labor efficiency beyond age 70 due to the selection bias in the data.

[27] The results on the effect of Social Security on retirement here should be treated with caution, because the model was originally created for studying health spending behavior and thus has some unfavorable features for studying retirement. For instance, the model abstracts from the intensive margin of labor supply and one model period is 5 years.

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