Social Security and the Rise in Health Spending: A Macroeconomic Analysis *

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Abstract

In this paper, I develop a quantitative macroeconomic model of health spending and use it as a framework to evaluate potential explanations for the dramatic rise in US health spending as a share of GDP over the last half century, i.e. from 4% of GDP in 1950 to 13% of GDP in 2000. I find that the main existing explanations, expanded health insurance coverage and income growth, only account for 48% of the rise in US health spending from 1950 to 2000. I propose and evaluate a new explanation for the rise in health spending: the expansion of US Social Security. 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 whole economy. Furthermore, by raising people’s expected future utility, Social Security increases the marginal benefit from investing in health and thus induces more health spending. I find that the expansion of US Social Security can account for a significant portion of the rise in health spending (21%). This finding suggests that another recently popular hypothesis for the unexplained residual, health technological progress, may be less important than what existing studies suggest (e.g. Newhouse (1992) and CBO (2008)). It also suggests that Social Security policies have a significant spill-over effect on public health care policies via the impact of Social Security on health spending, that future studies on Social Security policies should take into account.

Keywords: Health Care Spending, Social Security, Medicare, Life Expectancy.

JEL Classifications:

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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). Why has US health spending as a share of GDP risen so much? This question has attracted growing attention in the literature (e.g. Newhouse (1992), Finkelstein (2007), Hall and Jones (2007) and CBO(2008)). Several explanations have been proposed, e.g. increased health insurance and income growth. According to CBO (2008), however, existing explanations together only account for around half of the rise in US health spending over the last half century, suggesting that there is still a large residual left unexplained. The main purpose of this paper is to account for this large residual by proposing and evaluating a new explanation for the rise in health spending: the expansion of US Social Security since 1950.

As shown in Figure 2, the size of the US Social Security program has also dramatically expanded since 1950. Total Social Security expenditures were only 0.3 % of GDP in 1950, and jumped to 4.2% in 2000. I argue that the expansion of US Social Security is another important cause of the rise in health spending. 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 the aggregate health care spending. For example, if the young’s marginal propensity to spend on health care is 0.09, and the elderly’s marginal propensity to spend on health care is 0.4, then transferring one dollar from the young to the elderly would increase the aggregate health care spending by 31 cents. Follette and Sheiner (2005) find that elderly households spend a much larger share of their

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1For 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

2Note 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.

3Marginal propensity to spend on health care is defined as follows: how many cents of health care spending would
income on health care than non-elderly households.\textsuperscript{4}

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 and thus induces people to invest more in health to increase their survival probability.\textsuperscript{5}

Some people may think that Social Security wealth crowds out the private savings of people 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 can transfer resources from the young to the elderly (e.g. Imrohoroglu et al. (1995), and Attanasio and Brugiavini (2003)). For instance, future Social Security wealth cannot crowd out savings motivated by precautionary reasons because it is not liquid and cannot be borrowed against. Social Security payments are usually larger than the private savings of the poor and people who live longer than expected. Furthermore, Social Security reduces the aggregate capital level and thus increases 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 proposed explanations for the rise in health spending, I develop an Overlapping-Generations (OLG), General Equilibrium (GE) model with endogenous longevity and endogenous health spending. Following Grossman (1972), I adopt the concept of health capital in the model. Health capital depreciates over the life cycle, and health care spending produces new health capital. In each period, agents face a survival probability which is an increase

\textsuperscript{4}For instance, they find that the elderly in the 3rd income quintile spend 40\% of their income on health care, while health care spending is only 9\% of income for the non-elderly in the 3rd income quintile in 1987 (see Table 1).

\textsuperscript{5}Here I assume that health care spending is positively correlated to longevity.
ing function of their health capital. Before retirement, agents earn labor income by inelastically supplying labor to the labor market. 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 care spending over time via private savings, but they do not have access to private annuity markets.6

First, I use the model to assess the quantitative importance of the main existing explanations and quantify the size of the unexplained residual. Then I study the expansion of US Social Security in the model and find out whether it can account for this residual. Here I consider two main existing explanations for the rise in health spending. One says that the increased health insurance over the last half century, e.g. the creation of Medicare and Medicaid, lowers the direct cost of health care for the consumer, thus encouraging more usage of health care services (e.g. Finkelstein (2007)). Another says that the rise in US health spending over the last half century is due to the economic growth over the same period. Assuming health care is a luxury good, health spending as a share of GDP rises as the economy grows (e.g. Hall and Jones (2007)). Other conventional explanations for the rise in health spending include population aging, rising health care price, etc. I do not consider them in this paper because these explanations have been found quantitatively not important by previous studies (e.g. Newhouse (1992), CBO(2008)).

I find that increased health insurance is quantitatively more important than income growth in accounting for the rise in US health spending as a share of GDP from 1950 to 2000 (36% VS 8%). When considered simultaneously, these two changes account for 48% of the rise in health spending, which suggests that there is still around a half of the rise in health spending left unexplained. The expansion of Social Security can account for a significant portion of the unexplained residual.

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6According 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.
When these three changes are considered simultaneously, they account for 69% of the rise in health spending. This suggests that the expansion of US Social Security is quantitatively important in accounting for the rise in health spending over the last half century.

It is worth mentioning that there is another recently popular hypothesis for the unexplained residual, i.e. health technological progress. This hypothesis says that the invention and adoption of new and expensive health technologies over the past several decades is an important cause of the rise in US health care spending (e.g. Newhouse (1992), CBO (2008)). Since health technological progress is hard to measure, previous studies usually use the residual method to estimate its impact on health spending, that is, simply attributing the unexplained residual to health technological progress. As a result, these studies usually suggest that health technological progress is responsible for more than a half of the rise in health spending. Using the residual method of estimation, I find that the impact of health technological progress in the model is significantly smaller than what previous studies suggest (at most 31% of the rise in health spending). The intuition behind this result is simple: a portion of the residual is already attributed to the expansion of Social Security.

Finally, I check whether the proposed explanations of the rise in health spending are also consistent with another important empirical observation related to the rise in health spending: the simultaneous 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 when all four changes are considered simultaneously, the model can also match the changing life-cycle profile of health spending very well. Furthermore, a decomposition exercise shows that the expansion of Social Security plays a key role in accounting for the changing life-cycle profile of health spending while other explanations do not have significant effects on the shape of the life-cycle profile of health spending. The intuition for this result is straightforward: the impact of Social Security on health spending is much larger for the elderly than the young, thus significantly increasing the steepness of the health spending
The rest of the paper is organized as follows. In the second section, I set up the benchmark model. I calibrate the model in the third section, and provide the main results in the fourth section. I provide more results and further discussions in the fifth section, and conclude in the sixth 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:

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

(1)

Here $\beta$ 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, $c_j$. Let $u(\cdot)$ take the CRRA form,

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma},$$

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, $\chi$, which is drawn from a finite set $\{\chi_1, \chi_2, ..., \chi_z\}$. The probability of drawing $\chi_i$ is represented by $\Delta_i$ for all $i \in \{1, 2, ..., z\}$. Denote the exogenous mandatory retirement age by $R < T$. Before retirement, agent $i$ (agents with $\chi_i$) 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 $\epsilon_j$ is the (deterministic) age-specific component of labor efficiency, which is the same for all agents within
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 \( \chi_i \), which reflects the benefit-defined feature of the US Social Security system.

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

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

where \( c \) is consumption, \( m \) is health care spending, and \( b \) is the transfer from accidental bequests. Here \( \tau_{ss} \) and \( \tau_m \) 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.\(^8\) The set of budget constraints facing retired agents are,

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

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

\[
h_{j+1} = \gamma_j(1 - \delta^j_h)h_j + I_j(m_j), \forall j.
\]

Here \( \delta^j_h \) is the health capital depreciation rate, which is age-specific and deterministic, and \( \gamma_j \) 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, \( \gamma^b \), at age \( j \) is represented by \( \Lambda_j \) for all \( js \). Note that \( I_j(m_j) \) is the production of new health capital, in which the health care spending, \( m_j \), is an input. The new-born agents start with the initial health capital: \( h_1 = \bar{h} \).

At each age, agent \( i \)'s state can be represented by a vector \((s, h, \gamma)\). The individual’s problem

\(^7\)Note that both \( \chi_i \) and \( \epsilon_j \) are deterministic, which means that we do not consider the earnings uncertainty over the life-cycle in this paper.

\(^8\)Here the health insurance program is an artificial program that is designed to capture all the health insurance policies available to the consumer.
facing agent \( i \) at age \( j \) can be written as a Bellman Equation,

\[(P1)\]

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

subject to

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

and

\[
h' = \gamma_j(1 - \delta^j_h)h + I_j(m),
\]

\[
c \geq 0,
\]

\[
s' \geq 0,
\]

\[
m \geq 0.
\]

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 \((s, h, \gamma)\), 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 \( \chi \), and health shock \( \gamma \).

2.2 The Firm

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

\[
Y = K^\alpha(AL)^{1-\alpha}.
\]
Here the capital share $\alpha \in (0, 1)$, and capital depreciates at a rate of $\delta$. 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 $(s, h, \gamma_j)$. The law of motion for $\Phi(\cdot, \cdot, \cdot, \cdot, \cdot)$ can be written as follows,

$$\Phi'(j + 1, \chi_i, s', h', \gamma^b) = \Lambda_{j+1} \sum_{j=1}^{T} \sum_{i=1}^{z} \sum_{l=g,b} \int_{0}^{\infty} \int_{0}^{\infty} P_j(h') \Phi(j, \chi_i, s, h, \gamma^l) I_h ds dh,$$

with

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

where $I_h$ and $I_s$ are indicator functions that $I_h = 1$, if $h' = \gamma^l(1 - \delta^j)h + I_j(M^j(s, h, \gamma^l)), otherwise, I_h = 0; and I_s = 1$, if $s' = S^j(s, h, \gamma^l), otherwise, I_s = 0$. 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 $V^i_j(\cdot, \cdot, \cdot)$, individual policy rules $S^i_j(\cdot, \cdot, \cdot)$ and $M^i_j(\cdot, \cdot, \cdot)$, 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 $\{r, w, k_m, Tr(\cdot), \tau_{ss}, \tau_m, b\}$, $\{S^i_j(\cdot, \cdot, \cdot), M^i_j(\cdot, \cdot, \cdot), V^i_j(\cdot, \cdot, \cdot)\}$ solves the individual’s dynamic programming problem (P1).
2. aggregate factor inputs are generated by decision rules of the agents:

\[ K = \sum_{i=1}^{z} \sum_{j=1}^{T} \sum_{l=g,b} \int_{0}^{s} \int_{0}^{h} s \Phi(j, \chi_i, s, h, \gamma^l) ds dh, \]

\[ L = \sum_{i=1}^{z} \sum_{j=1}^{T} \sum_{l=g,b} \int_{0}^{s} \int_{0}^{h} \chi_i \epsilon_j \Phi(j, \chi_i, s, h, \gamma^l) ds dh. \]

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:

\[ \sum_{j=1}^{z} \sum_{i=1}^{T} \sum_{l=g,b} \int_{0}^{s} \int_{0}^{h} s \Phi(j, \chi_i, s, h, \gamma^l) ds dh = \sum_{j=1}^{z} \sum_{i=1}^{T} \sum_{l=g,b} \int_{0}^{s} \int_{0}^{h} b \Phi(j, \chi_i, s, h, \gamma^l) ds dh. \]

5. the population measure, \( \Phi \), 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

\[ (1 + p_g) \sum_{j=1}^{z} \sum_{i=1}^{T} \sum_{l=g,b} \int_{0}^{s} \int_{0}^{h} b \Phi(j, \chi_i, s, h, \gamma^l) ds dh = \sum_{i=1}^{z} \sum_{j=1}^{T} \sum_{l=g,b} \int_{0}^{s} \int_{0}^{h} S_j^i(s, h, \gamma^l)(1 - P_j(h')) \Phi(j, \chi_i, s, h, \gamma^l) ds dh, \]

where \( h' = \gamma^l(1 - \delta^l_h)h + M_j^i(s, h, \gamma^l) \).

Since the model cannot be solved analytically, numerical methods are used in the rest of the paper.

### 3 Calibration

The plan of the rest of the paper is as follows. I calibrate the model in this section. Then I use the calibrated model to assess the quantitative importance of potential explanations for the rise
in US health spending with special emphasis on the new explanation proposed in this paper: the expansion of US Social Security.

The calibration strategy adopted here is as follows: the values of the model parameters are chosen so that the model economy (at steady state) matches some key moments in the US economy in 1950.

### 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 longevity, such as the one addressed in this paper, the level of utility has to be positive so that people would not prefer a shorter life. In a standard CRRA utility function, the coefficient of relative risk aversion, \( \sigma \), needs to be less than 1 to have a positive period utility flow. In the benchmark calibration, the value of \( \sigma \) is set to 0.9. In the fifth section, I also explore values above one for \( \sigma \) as sensitivity analysis and find that the main results remain. When \( \sigma \) is set to be above one, I follow Hall and Jones (2007) and add a positive constant term into the utility function to avoid the problem of negative utility. The subjective discount factor \( \beta \) is set to \( 0.985 = 0.904 \).

As argued before, I assume that agents do not directly derive utility from health capital. This assumption implies that the model misses an important feature of health capital: health increases the quality of life. I do not include this feature since it is less relevant to the mechanisms that this paper emphasizes and modeling it greatly complicates the model. However, taking into account the
impact of health on the quality of life is surely important for understanding people’s health-related behaviors, and is left for future research.

3.3 Production Technology

The capital share in the production function, $\alpha$, is set to 0.3. The depreciation rate $\delta$ is set to $1 - (1 - 0.07)^5 = 0.304$. The value of the labor-augmented technology, $A$, is chosen so that the 1950 steady state matches the GDP per capita in the US economy in 1950: $1937$ (in current dollars).

3.4 Survival Probability Function and Health Technology

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

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

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 99.2% in 1950, 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 ($h$) at age 25 ($j = 1$), and then their health capital depreciates over time (via the health depreciation rates, $\{\delta_{hj}^{T-1}\}$), which lowers their survival probabilities over the life cycle. Therefore, the values of $\bar{h}$ and $\{\delta_{hj}^{T-1}\}$ are calibrated to match the conditional survival probabilities over the life cycle, and $\delta_{h2}^{T-1}$ is normalized to 0. Figure 4 plots both the model results and the data on survival probabilities over the life cycle. The calibrated values of $\bar{h}$ and $\{\delta_{hj}^{T-1}\}$ 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 care 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 care spending as a share of GDP in 1950: 3.9%.

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 care spending by age over the life cycle. I calibrate these parameters to match the relative health care spending (per capita) by age. Since the data is only available for six age groups: \{25 – 34, 35 – 44, 45 – 54, 55 – 64, 65 – 74, 75+\}, I assume: $\lambda_1 = \lambda_2$, $\lambda_3 = \lambda_4$, $\lambda_5 = \lambda_6$, $\lambda_7 = \lambda_8$, $\lambda_9 = \lambda_{10}$, $\lambda_{11} = \lambda_{12} = \ldots = \lambda_{15}$. Since it is relative health care spending (per capita), one of the six age groups needs to be normalized. I normalize $\lambda_3$ and $\lambda_4$ 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 care spending (per capita) by age are plotted in Figure 5.

The curvature in the health production function, $\theta$, directly controls how fast the marginal product of health spending diminishes as health spending increases, and should be related to the income elasticity of health care spending. I set the value of $\theta$ to be 0.15. The implied income elasticity of health spending in the benchmark model is 1.17, which is consistent with the previous empirical estimates on income elasticity of health spending (e.g. Gerdtham and Jonsson (2000), and OECD (2006)). I also explore other two values of $\theta$, 0.1 and 0.2, as sensitivity analysis. As can be seen in Table 9, the main qualitative results remain as the value of $\theta$ changes. However, the quantitative importance of each explanation rises as the value of $\theta$ increases. The intuition for that is that a higher value of $\theta$ implies higher income and price elasticities of health spending, thus increasing the quantitative importance of each explanation.

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9The data is from Meara, White and Cutler (2004), who document the relative health care 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.
3.5 Earnings and the Health Shock

The age-specific labor efficiencies, \( \{ \epsilon_j \}_{j=1}^{R-1} \), are calculated from the earnings data from the IPUMS 1950 (see Table 4).

The logarithm of the individual-specific permanent earnings shock, \( \ln \chi_i \), is assumed to follow the normal distribution: \( \mathcal{N} \sim (0, \sigma^2_{\chi}) \). 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, \( \sigma^2_{\chi} \), is set to 0.2 based on the estimation of Moffitt and Gottschalk (2002).

The probabilities of receiving a bad health shock, \( \{ \Lambda_j \}_{j=1}^{T} \), are taken from the health status data in PSID from 1968 to 1983. There is little information in the literature on the magnitudes of the health shock. Therefore, the values of \( \gamma \) are chosen arbitrarily here: \( \gamma^g \) is normalized to one and \( \gamma^b = 0.8 \). I tried different values for \( \gamma^b \) as robustness check and find the results do not significantly change (see Table 9).

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. Following Fuster, Imrohoroglu, Imrohoroglu(2007), the values of \( T r(\cdot) \) 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 \( \bar{y} \) is the average lifetime earnings. Then I rescale every beneficiary’s benefits so that the average replacement rate of the Social Security program is 40% (SSA (2001)). The payroll tax rate, \( \tau_{ss} \), is then determined so that Social Security is self-Financing. I do the same exercise for the 1950 Social Security program except that the replacement rate is 4% in 1950. \(^{10}\) The resulting payroll tax rates are 1% and 11%. The coinsurance rate of the health

\(^{10}\)The size of Social Security in 1950 was approximately one tenth of that in 2000 (see Figure 2). Therefore, I assume that the replacement rate in 1950 is 4% = 40% \times 0.1.
insurance program, \( k_m \), is normalized to zero in the benchmark model.

Table 6 summarizes the results of the benchmark calibration.

4 Quantitative Analysis

I use the calibrated model to assess the quantitative importance of the proposed explanations for the rise in US health spending. Here four stories are considered: the rise in health insurance coverage, income growth, health technological progress and the new explanation: the expansion of Social Security. Since I calibrate the benchmark model to the year 1950, I run forward experiments in the model to find out whether these four changes can replicate the rise in health spending as a share of GDP. I also evaluate the ability of these explanations to match the simultaneous shift in the life-cycle profile of health spending (per person).

The main findings are: 1) two main existing explanations, increased health insurance coverage and income growth, together account for 48% of the rise in US health spending as a share of GDP from 1950 to 2000, suggesting there is around half of the rise in health spending left as the unexplained residual. 2) The new explanation proposed in this paper, the expansion of Social Security, can account for another 21% of the rise, which is a significant part of the residual (40%). 3) The upper bound on the impact of health technological progress in this model is much smaller than what existing studies suggest (e.g. Newhouse (1992) and CBO (2008)). 4) The expansion of Social Security plays a key role in matching the simultaneous change in life-cycle profile of health spending.

4.1 Existing explanations

Among the existing explanations, increased health insurance and income growth have received the most attention. One says that the increased health insurance over the last several decades reduces price to the consumer and increases the demand for health care services (e.g. Feldstein (1971,1977), Manning et al. (1987), and Newhouse et al. (1992), and Finkelstein (2007)). 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 (e.g. Hall and Jones). In this section, I use the calibrated model to assess the quantitative importance of these stories. Between 1950 and 2000, the average health coinsurance rate increased by 45 percentage points (CMS data), the real GDP per capita increased by a factor of 2.97. In Experiment 4, I find that adding these two changes simultaneously in the model can increase health spending from 3.9% of GDP to 8.2% of GDP, which accounts for 48% of the entire rise in US health spending as a share of GDP from 1950 to 2000. In Experiment 1 and 2, I add these two changes independently and find that they account for 36% and 8% respectively (see Table 7).

4.2 The expansion of Social Security

The US Social Security program has dramatically expanded since 1950. The average Social Security expenditures was only 3.7% of GDP per capita in 1950, and it has jumped to 33.7% in 2000. As argued before, Social Security increases health spending via two mechanisms. First, it transfers resources from the young to the elderly who have a higher marginal propensity to spend on health care than the young, thus increasing the aggregate health spending. Second, by providing annuities in the later stage of life and insuring for uncertain longevity, Social Security increases people’ expected future utility. As a result, it raises the marginal benefit from investing in health and thus induces people to invest more in health.

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

In Experiment 3, I find that the expansion of Social Security in the model increases health spending from 3.9% of GDP to 4.8% of GDP, which is 10% of the entire rise in US health spending as a share of GDP from 1950 to 2000 (see Table 7). In Experiment 5, I add the expansion of Social Security simultaneously with the above-described two changes in the model, and find that they can account for 69% of the rise in US health spending. This suggests that the expansion of Social Security and its interaction with the other causes can account for 21% of the rise in health spending, a significant part of the unexplained residual (40%).

### 4.3 Health technological progress

Several studies have suggested that health technological progress may be an important cause of the rise in US health spending, and is responsible for the large residual left unexplained in the literature (e.g. Newhouse (1992), CBO (2008)). However, since health technological progress is hard to measure, these studies usually use the residual method to estimate the impact of health technological progress on health spending. In Experiment 6, I apply the same method and find that health technological progress is much smaller in this model than what previous studies suggest. The estimated health technological progress is only 0.5% (annual). That is, when this health technological progress is added simultaneously with the other three changes in the model, it can account for the entire rise in health spending. When this technological progress is studied alone, it only accounts for 14% of the rise in health spending (see Experiment 7 in Table 7). The intuition for this result is straightforward: a significant portion of the residual has been accounted for by the expansion of Social Security.
4.4 Life-cycle profile of health care spending

Meara, White, and Cutler (2004) have documented an interesting empirical observation that is closely related to the rise in health spending over the last several decades: 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). I argue that the potential explanations of the rise in 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).

In this section, I investigate the model’s ability of matching the changing life-cycle profile of health spending, which can be considered as a robustness check for the model. As shown in Figure 6, while the model matches very well the rise in aggregate health spending from 1950 to 2000, it also does an excellent job of matching the change in life-cycle profile of health spending. Furthermore, a decomposition exercise shows that among the four explanations considered here, the expansion of Social Security plays the key role in generating the steeper life-cycle profile of health spending. In the decomposition exercise, I shut down four stories one by one to find out how each explanation affects the life-cycle profile of health spending. As shown in Figure 7, shutting down the expansion of Social Security dramatically changes the health spending profile while the other changes do not significantly affect the profile.\footnote{There is one caveat: increased health insurance can also generate a steeper life-cycle profile of health spending if the increase in health insurance was larger among the elderly than the young over the last half century (such as the creation of Medicare). I do not explore this possibility here because I do not have data on health insurance by age for the last half century.} This result suggests that the expansion of Social Security plays a key role in matching the change in life-cycle profile of health spending over the last several decades. The intuition behind this result is simple: the impact of Social Security on health spending is much larger for the elderly than the young.
5 Further Discussion

5.1 The value of life

In models with endogenous longevity, such as the one studied in this paper, the value of life matters. This section asks whether the value of life implied in this model is reasonable compared to the data. Specifically, I look at the marginal cost of saving a life, which is defined as \( \frac{1}{\partial P/\partial m} \) in the model. It is the inverse of the marginal effect of health care spending on survival probability, and means how much health care spending is needed to (statistically) save a life in the population. The marginal cost of saving a life is also referred as the value of a statistical life (VSL), and it is the most commonly-used measure for the value of life in the literature.

The first column in Table 8 shows the marginal cost of saving a life at each age in the benchmark model. I compare these numbers to the empirical estimates of VSL in literature, which range from approximately 2 million to 9 million.\(^{12}\) The marginal cost of saving an average person in the benchmark model is 3.4 million (in 2000 $), which is in the range of these empirical estimates.

It is also interesting to see how income growth affects the value of life in the model. Many empirical studies have suggested that the value of life is positively related to income, and the empirical estimates of the income elasticity of VSL range from 0.5 to 1.0 (see Viscusi and Aldy (2003) for the details). This model provides a natural framework to test this hypothesis. As shown under the third column in Table 8, income growth significantly increases the value of life in the model. When income increases by a factor of 2.97 (from 1950 to 2000), the value of an average person’s life increases from 3.4 million $ to 10.0 million $. The implied income elasticity of VSL in the model is 0.99, which is consistent with what the empirical studies suggest. The second column in Table 8 shows the impact of Social Security on the value of life. Here one thing is worth mentioning: while Social Security does not increases the value of life on average, it significantly

\(^{12}\)Viscusi and Aldy (2003), Ashenfelter and Greenstone (2004), and Murphy and Topel (2005), Hall and Jones (2007).
increases the value of life for the elderly.\(^\text{13}\)

### 5.2 The Hall-Jones utility function and \(\sigma\)

As argued before, the utility function, \(u(\cdot)\), has to be positive so that agents would not prefer a shorter life in the model.\(^\text{14}\) This restriction implies that in the standard CRRA utility function, \(c^{1-\sigma}/1-\sigma\), the value of \(\sigma\) has to be below one. However, most empirical estimates of this parameter in the literature suggest that the value of \(\sigma\) should be one (log utility) or above. In the benchmark calibration, I choose the value of \(\sigma\) to be 0.9, which is close to one but also implies a positive utility function. Hall and Jones (2007) propose an alternative solution to this problem. They add a positive constant term into the CRRA utility function, which allow them to study cases with the value of \(\sigma\) above one. The Hall-Jones utility function is specified as follows,

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

where \(\pi_c\) is a positive constant term. By choosing a proper value of \(\pi_c\), the utility function can be positive for cases with \(\sigma\) above one.

Here I replicate the main quantitative analysis under the Hall-Jones utility function, in which I recalibrate the model to the same moments used in the benchmark calibration and choose the value of \(\pi_c\) so that the value of life is also consistent with the benchmark calibration. I explore the case when \(\sigma = 1.1\). The results are reported in Table 9. As can be seen, the main qualitative results do not change significantly when \(\sigma\) is set to be above one and the Hall-Jones utility function is used. However, the quantitative importance of income growth in this scenario is much larger than in the benchmark model. The intuition for this result is simple. As pointed out in Hall and Jones (2007), adding a constant positive term in the CRRA utility function increases the income elasticity of health spending (see Hall and Jones(2007) for detailed analysis of the properties of this

\(^{13}\)The impacts of health insurance and health technological progress on the value of life are not of particular interest. Here I do not report them to save some space.

\(^{14}\)Note that a similar problem also appears in the fertility literature (see Jones and Schoonbroodt (2009) for a detailed discussion).
utility function). The implied income elasticity of health spending in this scenario is 1.48, much larger than in the benchmark model and also well above the empirical estimates.\textsuperscript{15} As a result, income growth has a larger impact on health spending.

5.3 Social Security and public health insurance

An interesting implication of the model is that, by changing health spending, Social Security indirectly affects the financial burden on the health insurance program. As shown in Table 10, in the model economy in 2000, the health insurance program is financed by a payroll tax of 5.8%. However, the same health insurance program only needs a payroll tax of 4.7% when there is no Social Security co-existing in the economy. The intuition for this result is the following. The expenses of the health insurance program are largely dependent on the level of spending on health care. When Social Security increases health spending, it also raises the financial burden on the health insurance program.

The policy implication of this result is very important. The solvency problem is often at the center of the debates on both public health policy reform and Social Security policy reform in developed countries.\textsuperscript{16} Ignoring the interaction between these two policies may lead us to wrong policy decisions. Thus, future policy studies should take into account this spill-over effect of Social Security on public health insurance.

6 Conclusion

In this paper, I propose and evaluate a new explanation for the rise in US health spending over the last several decades: the expansion of US Social Security. I emphasize the following mechanisms. 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

\textsuperscript{15}See Gerdtham and Jonsson (2000) and OECD (2006) for detailed review of the empirical literature.
\textsuperscript{16}Such as the debates on Medicare and Social Security in the United States.
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 and thus induces people to invest more in health to increase their survival probability to the future.

I find that the expansion of Social Security can account for a significant portion of the rise in health spending. Furthermore, I find that the expansion of Social Security plays a key role in matching an important related empirical observation: the simultaneous change in life-cycle profile of average health spending (per person). The finding of this paper has several interesting implications. First, it implies that another recently popular hypothesis for the rise in health spending, health technological progress, is less important than what previous studies suggest (e.g. Newhouse (1992), CBO (2008)). Second, this paper’s finding suggests that Social Security may have a significant spill-over effect on the solvency of health insurance policy (such as Medicare) via its impact on health spending. This should be taken into account in future policy studies.
References


7 Appendix: A Panel Study Among OECD Countries

In this appendix, I present evidence from a panel of 14 OECD countries over the period 1980-2005 on the relationship between the size of public pension and health care spending.\(^{17}\) The 14 countries include: Australia, Canada, Denmark, Finland, Germany, Ireland, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, United Kingdom, and United States. I run the following panel regression,

\[
h_{i,t} = \alpha_0 + \alpha_1 PP_{i,t} + \alpha_2 y_{i,t} + \alpha_3 P65_{i,t} + \alpha_4 PH_{i,t} + c_i + \mu_{i,t},
\]

where \(h_{i,t}\) is the log of health care spending per capita (in real terms), and \(y_{i,t}\) is the log of GDP per capita (in real terms). The key variable of interest here is \(PP_{i,t}\), the size of public pension, which is measured by the total public pension payments as a share of GDP. The other control variables include \(P65\), the population share of the people above age 65, and \(PH\), the size of public health policy, which is measured by public health spending as a share of total health spending. Note that \(i\) is the country index, \(t\) is the year index, and \(c_i\) is the country-specific fixed effect.

The regression results are shown in Table 11.\(^{18}\) The main finding of this panel regression is that the size of public pension has a significant effect on health care spending per capita. The estimated coefficient for the size of public pension is 2.99 (as highlighted in the column of Regression 1 in Table 9), which means that when the size of public pension (as a share of GDP) increases by 0.01, health care spending per capita increases by 2.99\%. Note that this panel regression also generates an income elasticity of health spending: 1.149, the estimated coefficient for the log of GDP per capita. This value is consistent with the previous panel studies among OECD countries (see Gerdtham and Jonsson (2000), and OECD (2006), etc.).

\(^{17}\)The data source is OECD health data (2009).
\(^{18}\)Note that it is not a strictly balanced panel. Several countries are missing data for 1-3 years.
Table 1: Household Health Care Spending by Quintile (% of mean household income).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-elderly Households</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>18%</td>
<td>30%</td>
<td>43%</td>
<td>40%</td>
<td>46%</td>
</tr>
<tr>
<td>2</td>
<td>9%</td>
<td>11%</td>
<td>15%</td>
<td>15%</td>
<td>18%</td>
</tr>
<tr>
<td>3</td>
<td>7%</td>
<td>8%</td>
<td>9%</td>
<td>10%</td>
<td>11%</td>
</tr>
<tr>
<td>4</td>
<td>7%</td>
<td>5%</td>
<td>7%</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>5</td>
<td>3%</td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>Elderly Households</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>35%</td>
<td>67%</td>
<td>92%</td>
<td>110%</td>
<td>132%</td>
</tr>
<tr>
<td>2</td>
<td>25%</td>
<td>39%</td>
<td>67%</td>
<td>50%</td>
<td>67%</td>
</tr>
<tr>
<td>3</td>
<td>18%</td>
<td>27%</td>
<td>40%</td>
<td>34%</td>
<td>40%</td>
</tr>
<tr>
<td>4</td>
<td>13%</td>
<td>15%</td>
<td>27%</td>
<td>24%</td>
<td>25%</td>
</tr>
<tr>
<td>5</td>
<td>4%</td>
<td>6%</td>
<td>11%</td>
<td>11%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Note: 1st income quintile is the lowest quintile.
(Data source: Follette and Sheiner (2005).)

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

<table>
<thead>
<tr>
<th>Age</th>
<th>SP-data</th>
<th>SP-model</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.99</td>
<td>0.99</td>
<td>$h$</td>
<td>214</td>
</tr>
<tr>
<td>30</td>
<td>0.99</td>
<td>0.99</td>
<td>$\delta_h^2$</td>
<td>3.5%</td>
</tr>
<tr>
<td>35</td>
<td>0.99</td>
<td>0.99</td>
<td>$\delta_h^3$</td>
<td>5.5%</td>
</tr>
<tr>
<td>40</td>
<td>0.98</td>
<td>0.98</td>
<td>$\delta_h^4$</td>
<td>7.5%</td>
</tr>
<tr>
<td>45</td>
<td>0.97</td>
<td>0.97</td>
<td>$\delta_h^5$</td>
<td>8.0%</td>
</tr>
<tr>
<td>50</td>
<td>0.95</td>
<td>0.95</td>
<td>$\delta_h^6$</td>
<td>9.0%</td>
</tr>
<tr>
<td>55</td>
<td>0.92</td>
<td>0.93</td>
<td>$\delta_h^7$</td>
<td>10.0%</td>
</tr>
<tr>
<td>60</td>
<td>0.89</td>
<td>0.89</td>
<td>$\delta_h^8$</td>
<td>11.0%</td>
</tr>
<tr>
<td>65</td>
<td>0.84</td>
<td>0.84</td>
<td>$\delta_h^9$</td>
<td>12.0%</td>
</tr>
<tr>
<td>70</td>
<td>0.77</td>
<td>0.76</td>
<td>$\delta_h^{10}$</td>
<td>15.0%</td>
</tr>
<tr>
<td>75</td>
<td>0.67</td>
<td>0.67</td>
<td>$\delta_h^{11}$</td>
<td>30.0%</td>
</tr>
<tr>
<td>80</td>
<td>0.54</td>
<td>0.55</td>
<td>$\delta_h^{12}$</td>
<td>37.0%</td>
</tr>
<tr>
<td>85</td>
<td>0.39</td>
<td>0.40</td>
<td>$\delta_h^{13}$</td>
<td>40.0%</td>
</tr>
<tr>
<td>90</td>
<td>0.25</td>
<td>0.26</td>
<td>$\delta_h^{14}$</td>
<td>55.0%</td>
</tr>
<tr>
<td>95</td>
<td>0.13</td>
<td>0.18</td>
<td>$\delta_h^{15}$</td>
<td>60.0%</td>
</tr>
</tbody>
</table>

Table 3: Health technology parameters: $\lambda$s

<table>
<thead>
<tr>
<th>Age</th>
<th>25-35</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65-74</th>
<th>75+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>$\lambda_1,\lambda_2$</td>
<td>$\lambda_3,\lambda_4$</td>
<td>$\lambda_5,\lambda_6$</td>
<td>$\lambda_7,\lambda_8$</td>
<td>$\lambda_9,\lambda_{10}$</td>
<td>$\lambda_{11}-\lambda_{15}$</td>
</tr>
<tr>
<td>Value</td>
<td>1.2</td>
<td>1.0</td>
<td>0.99</td>
<td>0.93</td>
<td>1.35</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Table 4: Labor efficiency by age, $\epsilon$

<table>
<thead>
<tr>
<th>Age</th>
<th>25-29</th>
<th>30-34</th>
<th>35-39</th>
<th>40-44</th>
<th>45-49</th>
<th>50-54</th>
<th>55-59</th>
<th>60-64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor efficiency $\epsilon_j$</td>
<td>1.0</td>
<td>1.18</td>
<td>1.25</td>
<td>1.27</td>
<td>1.27</td>
<td>1.25</td>
<td>1.20</td>
<td>1.09</td>
</tr>
</tbody>
</table>

(Source: calculated from IPUMS 1950, with the labor efficiency of age 25-29 is normalized to one.)

Table 5: The Social Security Benefit Formula

<table>
<thead>
<tr>
<th>$y \in (0, 0.27\bar{y})$</th>
<th>Marginal Replacement rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y \in (0.27\bar{y}, 1.25\bar{y})$</td>
<td>33%</td>
</tr>
<tr>
<td>$y \in (1.25\bar{y}, 2.46\bar{y})$</td>
<td>15%</td>
</tr>
<tr>
<td>$y \in (2.46\bar{y}, \infty)$</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 6: Benchmark Model Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Targets to match</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta = 0.98^5$</td>
<td>..</td>
</tr>
<tr>
<td>$\alpha = 0.3$</td>
<td>Capital share: 0.3</td>
</tr>
<tr>
<td>$\delta = 1 - (1 - 0.07)^5$</td>
<td>Capital depreciation rate: 7% (annual)</td>
</tr>
<tr>
<td>$\sigma = 0.9$</td>
<td>..</td>
</tr>
<tr>
<td>$a = 0.022$</td>
<td>Health Spending as a share of GDP in 1950: 3.9%</td>
</tr>
<tr>
<td>$\theta = 0.15$</td>
<td>income elasticity of health spending: 1.15.</td>
</tr>
<tr>
<td>$A = 3200$</td>
<td>GDP per capita in 1950: $1937$ (current dollars)</td>
</tr>
<tr>
<td>$\sigma^2_{\chi} = 0.2$</td>
<td>Moffitt and Gottschalk (2002)</td>
</tr>
</tbody>
</table>
Table 7: Health Care Spending (% of GDP) in 1950 and 2000: Model vs. Data

<table>
<thead>
<tr>
<th></th>
<th>1950</th>
<th>2000</th>
<th>(\Delta_{1950-2000})</th>
<th>% of the data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>3.9</td>
<td>12.5</td>
<td>8.6</td>
<td>..</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp. 1: Health insurance ↑</td>
<td>3.9</td>
<td>7.0</td>
<td>3.1</td>
<td>36%</td>
</tr>
<tr>
<td>Exp. 2: Income growth</td>
<td>3.9</td>
<td>4.6</td>
<td>0.7</td>
<td>8%</td>
</tr>
<tr>
<td>Exp. 3: Social Security ↑</td>
<td>3.9</td>
<td>4.8</td>
<td>0.9</td>
<td>10%</td>
</tr>
<tr>
<td>Exp. 4: The combination of (HS↑+growth)</td>
<td>3.9</td>
<td>8.1</td>
<td>4.2</td>
<td>48%</td>
</tr>
<tr>
<td>Exp. 5: The combination of (HS↑+growth+SS↑)</td>
<td>3.9</td>
<td>9.8</td>
<td>5.9</td>
<td>69%</td>
</tr>
<tr>
<td>Exp. 6: The combination of (HS↑+growth+SS↑+tech)</td>
<td>3.9</td>
<td>12.5</td>
<td>8.6</td>
<td>100%</td>
</tr>
<tr>
<td>Exp. 7: Tech. progress alone (annual growth rate: 0.5%)</td>
<td>3.9</td>
<td>5.1</td>
<td>1.2</td>
<td>14%</td>
</tr>
</tbody>
</table>

Note: \(\Delta_{1950-2000}\) is the rise in health spending (% of GDP) from 1950 to 2000.

Table 8: The Marginal Cost of Saving a Life (in 2000$)

<table>
<thead>
<tr>
<th>Age</th>
<th>Benchmark (in thousand)</th>
<th>Benchmark+SS (in thousand)</th>
<th>Benchmark+growth (in thousand)</th>
<th>Model2000 (in thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>7171</td>
<td>5913</td>
<td>20479</td>
<td>25802</td>
</tr>
<tr>
<td>30</td>
<td>6402</td>
<td>5550</td>
<td>18647</td>
<td>25565</td>
</tr>
<tr>
<td>35</td>
<td>5419</td>
<td>4980</td>
<td>15674</td>
<td>22366</td>
</tr>
<tr>
<td>40</td>
<td>4034</td>
<td>3882</td>
<td>12062</td>
<td>18548</td>
</tr>
<tr>
<td>45</td>
<td>3048</td>
<td>3103</td>
<td>9152</td>
<td>14808</td>
</tr>
<tr>
<td>50</td>
<td>2184</td>
<td>2334</td>
<td>6647</td>
<td>11537</td>
</tr>
<tr>
<td>55</td>
<td>1461</td>
<td>1665</td>
<td>4492</td>
<td>8306</td>
</tr>
<tr>
<td>60</td>
<td>956</td>
<td>1159</td>
<td>2966</td>
<td>5893</td>
</tr>
<tr>
<td>65</td>
<td>578</td>
<td>744</td>
<td>1822</td>
<td>3889</td>
</tr>
<tr>
<td>70</td>
<td>327</td>
<td>451</td>
<td>1041</td>
<td>2427</td>
</tr>
<tr>
<td>75</td>
<td>172</td>
<td>258</td>
<td>565</td>
<td>1502</td>
</tr>
<tr>
<td>80</td>
<td>85</td>
<td>143</td>
<td>288</td>
<td>899</td>
</tr>
<tr>
<td>85</td>
<td>35</td>
<td>79</td>
<td>125</td>
<td>491</td>
</tr>
<tr>
<td>90</td>
<td>13</td>
<td>60</td>
<td>48</td>
<td>296</td>
</tr>
<tr>
<td>95</td>
<td>5</td>
<td>47</td>
<td>16</td>
<td>204</td>
</tr>
</tbody>
</table>

Average (in million) | 3.4 | 3.2 | 10.0 | 14.3
### Table 9: Sensitivity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Hall-Jones utility ($\sigma = 1.1$)</th>
<th>$\theta = 0.1$</th>
<th>$\theta = 0.2$</th>
<th>$r^b = 0.6$</th>
<th>$r^b = 1.0$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp. 1: Health insurance ↑</td>
<td>36%</td>
<td>36%</td>
<td>34%</td>
<td>39%</td>
<td>36%</td>
<td>35%</td>
</tr>
<tr>
<td>Exp. 2: Income growth</td>
<td>8%</td>
<td>22%</td>
<td>4%</td>
<td>12%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Exp. 3: Social Security ↑</td>
<td>10%</td>
<td>11%</td>
<td>9%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Exp. 4: The combination of (HS↑+growth)</td>
<td>48%</td>
<td>71%</td>
<td>40%</td>
<td>59%</td>
<td>49%</td>
<td>47%</td>
</tr>
<tr>
<td>Exp. 5: The combination of (HS↑+growth+SS↑)</td>
<td>69%</td>
<td>97%</td>
<td>58%</td>
<td>81%</td>
<td>69%</td>
<td>68%</td>
</tr>
<tr>
<td>Exp. 6: The combination of (HS↑+growth+SS↑+tech)</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Exp. 7: Tech. progress alone</td>
<td>14%</td>
<td>1%</td>
<td>9%</td>
<td>20%</td>
<td>14%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Note: $\Delta_{1950-2000}$ is the rise in health spending (% of GDP) from 1950 to 2000.

### Table 10: Social Security and the financial burden of the health insurance program

<table>
<thead>
<tr>
<th></th>
<th>Tax to finance the health insurance program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model2000 (RR: 40%)</td>
<td>5.8%</td>
</tr>
<tr>
<td>Model2000 (RR: 4%)</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

Note: SS refers to Social Security, RR is the replacement rate.
Table 11: Fixed-effect Panel Regression Results

**Dependent Variable**: health care spending per capita.

<table>
<thead>
<tr>
<th></th>
<th>Regression 1</th>
<th>Regression 2</th>
<th>Regression 3</th>
<th>Regression 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GDP per capita</strong></td>
<td>1.149***</td>
<td>1.147***</td>
<td>1.172***</td>
<td>1.14***</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.016)</td>
<td>(0.013)</td>
<td>(0.018)</td>
</tr>
<tr>
<td><strong>Public pension</strong></td>
<td>2.993***</td>
<td>2.706***</td>
<td>3.664***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.633)</td>
<td>(0.619)</td>
<td>(0.472)</td>
<td></td>
</tr>
<tr>
<td><strong>Pop share (65+)</strong></td>
<td>0.01*</td>
<td>0.013**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Public health share</strong></td>
<td>-0.109</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.113)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>-4.241***</td>
<td>-4.327***</td>
<td>-4.454***</td>
<td>-4.341***</td>
</tr>
<tr>
<td></td>
<td>(0.178)</td>
<td>(0.131)</td>
<td>(0.121)</td>
<td>(0.183)</td>
</tr>
</tbody>
</table>

Note: ***: 1% significant, **: 5% significant, *: 10% significant

Figure 1: Health Care 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 Care 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: Survival Probabilities By Age (in 1950)

Figure 5: Relative Health Care Spending (per capita) By Age
Figure 6: 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 7: Life-cycle profile of health spending (per capita): decomposition  
(The age group 35-44 in 1950 is normalized to one.)

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