The Rise in Health Spending: The Role of Social Security and Medicare

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Abstract

This paper provides an alternative explanation for the rise in health care spending as a share of GDP over the last half century in the United States. Health care spending (% of GDP) has more than tripled since 1950 in the US (i.e., from 4% in 1950 to 13% in 2000). I argue that the expansion of Social Security and Medicare over this time period is an important cause of the rise in health care spending. Social Security affects health care spending via two mechanisms. First, it 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 annuities implicitly provide the elderly with incentives to increase health care spending in order to live longer since people with a longer life get higher payments. Medicare may further amplify the impact of Social Security on health care spending. By subsidizing only the elderly, Medicare may further enlarge the young-elderly gap in marginal propensity to spend on health care, which implies that transferring resources from the young to the elderly (via Social Security) should have a larger impact on aggregate health care spending. I formalize the above-described mechanisms in a modified version of the Grossman (1972) model and calibrate the model to the US economy. The quantitative experiments suggest that the expansion of Social Security and Medicare from 1950 to 2000 is able to explain about half of the rise in health care spending over this period.

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).[1] Why has health care spending as a share of GDP risen so much?

I address the above question in this paper. My main argument is that the expansion of Social Security and Medicare since 1950 in the US is an important cause of the rise in health care spending (as a share of GDP) over the same period. As shown in Figure 2, the size of the US Social Security program has expanded dramatically since 1950. For instance, total expenditures of Social Security were only 0.3 % of GDP in 1950, and jumped to 4.2% in 2000. The size of Medicare has also significantly increased since its implementation in 1965, i.e., from 0.4% of GDP in 1967 to 2.3% of GDP in 2000.

The US Social Security system is a pay-as-you-go system. It collects payroll taxes from the current working people and transfers this money directly to the current elderly (65+) in the form of annuities. Social Security increases health care spending via the following two 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 care spending of the whole economy. 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.[2] Follette and Sheiner (2005) find that elderly households spend a much larger share of their income on health care than non-elderly households. For instance, they find

[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] Marginal propensity to spend on health care is defined as follows: how many cents of health care spending would be induced by one extra dollar of disposable income. For instance, 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 in this example.

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).

Second, since US Social Security pays the elderly in the form of annuities, people who live longer get more benefits from the program. Therefore, Social Security implicitly provides the elderly with incentives to increase health care spending in order to gain extra years of life so that they can get more benefits from the program.[3] Here I assume that health care spending is positively correlated to longevity.

The impact of Medicare on health care spending may seem more intuitive. Since Medicare partially reimburses the elderly's health care spending, it should increase their health care spending due to the negative price elasticity. However, it is worth noting that besides the above-described effect, Medicare may have another effect on health care spending when it coexists with Social Security: it amplifies the impact of Social Security on health care spending. By targeting only the elderly, Medicare may enlarge the gap in marginal propensity to spend on health care between the young and the elderly, which implies that transferring resources from the young to the elderly (via Social Security) should have a larger impact on aggregate health care spending. Follette and Sheiner (2005) provide empirical evidence on the widening health spending gap between the young and the elderly from 1970 to 2002 (see Table 1). In 1970, the gap in health care spending (% of income) between the non-elderly and the elderly was only 11% for the 3rd income quintile. This gap grew to 29% in 2002, which may reflect the differential effects (by age) of Medicare on health care spending.

To formalize the above-described mechanisms, I develop a modified version of the Grossman (1972) model, in which health is treated as a durable capital stock that depreciates over time. Health care spending is an input in the production of new health stock. Agents face a survival

[3] This mechanism was also mentioned in the paper by Becker and Philipson (1998). However, they did not quantify the effect of this mechanism on health care spending. I restate one of the key analytical results in Becker and Philipson (1998) in the appendix to provide some more intuition about this mechanism.

probability in each period over the life cycle and the survival probability is an increasing function of health stock. Agents earn labor income by inelastically supplying one unit of labor in the labor market in each period (before retirement), and they spend their resource either on consumption, which gives them a utility flow in the current period, or on health care, which increases their health stock and survival probability to the next period.[4] The key trade-off facing agents in the model is between the utility flow in the current period and the probability of getting utility flows in the future.

To study how the expansion of Social Security and Medicare since 1950 in the US impacts health care spending, I calibrate the model to the US economy and conduct the following quantitative exercises. First, I construct and compare steady states that mimic the US economy in 1950 and 2000 respectively. The key difference between the two steady states is the Social Security and Medicare policies. This analysis finds that the expansion of Social Security and Medicare from 1950 to 2000 in the US is able to explain 43% of the rise in health care spending as a share of GDP over the same period. It also finds that 31% of this result comes from the interaction between Social Security and Medicare.

I also explore the economy out-of-steady-state (on the transition path). I find that the impact of Social Security and Medicare on health care spending is even larger on the transition path: the expansion of Social Security and Medicare from 1950 to 2000 may account for about half of the rise in health care spending over this period. The reason for this is the following. At steady state, agents are able to undo part of the impact of Social Security by lowering their old-age savings since Social Security payments after retirement are well expected in advance. But agents can not do this on the transition path because they are surprised by the policy changes, which leads to a larger rise in health care spending compared to the steady state analysis.[5]

[4] Agents can also smooth consumption or health care spending over time via saving. But it is assumed that private annuity markets are missing. According to Warshawsky (1988), only approximately 2% - 4% of the elderly population owns private annuities from the 1930s to the 1980s.

[5] It is worth noting that another public health program, Medicaid, may also affect health care spending in the United States. In this paper, I do not model Medicaid since its size is much smaller and doing so would be compu-

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

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

Note: 1st income quintile is the lowest quintile.

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

There are several existing explanations in the literature for the rise in health care spending. One common explanation says that the rise in health care spending over the last half century is due to economic growth. Assuming health care is a luxury good, health care spending as a share of GDP rises as the economy grows. This explanation is formalized by Hall and Jones (2007). One problem with this explanation is that, to account for the entire rise in health care spending over the last half century in the US, the income elasticity of health care spending needs to be well above one, which is supported by little empirical evidence. A simple calculation suggests that an elasticity of 1.63 is needed to account for the entire rise in health care spending as a share of GDP from 1950 to 2000. However, most empirical estimates of the income elasticity of aggregate health spending range from 0.5 to 1.3 (Gerdtham and Jonsson (2000), OECD (2006), etc.). Therefore, it is fair to argue that that economic growth may not be the main cause of the rise in health care spending as a share of GDP.[6]

tationally costly. Kopecky and Koreshkova (2008) provide a detailed analysis of the Medicaid program.

[6] A simple calculation shows that an elasticity of 1.3 can explain 28% of the rise in health care spending (% of GDP) from 1950 to 2000.

Another explanation says that the rise in health care spending is due to the technological advance in the medical sector (for example, Suen (2006), CBO (2008)). By assuming that the (annual) growth rate of health production technology is 3.5%, the Suen (2006) model can explain the entire rise in health care spending in the United States over from 1950 to 2001. However, as Suen himself admits in the paper, there is no good empirical estimate of the growth rate of health technology.[7] Therefore, it is not clear quantitatively how much the health technological advance accounts for the rise in health care spending, even though it is very possible that technological advance plays a role.[8] Furthermore, as Hall and Jones (2007) argue, the technological advance story is not complete for the following two reasons: (1) the new health technologies may not be immediately adopted by the consumers after they are invented; and (2) the technological changes may be endogenous, and new health technologies being invented may reflect the rising demand for health care.

The other conventional explanations include: population aging, health insurance, and rising health care price. All these explanations are found to be not quantitatively important in accounting for the rise in health care spending as a share of GDP in the US (Newhouse (1992), CBO(2006), etc.).

This paper contributes to this literature by providing an alternative explanation, and showing that this explanation is quantitatively important for accounting for the rise in health care spending in the US over the last half century.

The rest of the paper is organized as follows. In the second section, I present some empirical evidence that supports the theory proposed in this paper. I set up the benchmark model in the third section, calibrate the model in the fourth section, and provide the main results in the fifth section. I provide more results and further discussions in the sixth section, and conclude in the

[7] Suen(2006), page 21.

[8] Jones (2004) develops a model of health in which health technological progress is endogenously determined. He shows that the model has potential to match the data when both economic growth and public health insurance are included. Further empirical work needs to be done to test this new model.

seventh section.

2 Empirical Evidence

In this section, I provide some empirical evidence in support of the explanation proposed in this paper.

2.1 Health Care Spending By Age

An important implication of the explanation proposed in this paper is that the rise in health care spending is largely driven by the elderly. This is consistent with the US data. Meara, White, and Cutler (2004) document the trends in health care spending by age from 1963 to 2000. They find that health care spending growth among the elderly has been much higher than that among the non-elderly. In Figure 3, I break down the rise in health care spending as a share of GDP from 1963 to 2000 into different age groups. As we can clearly see, the elderly are responsible for the majority of the rise in health care spending, while the other age groups together account for the rest. From 1963 to 2000, health care spending (as a % of GDP) rose by 7.5% (of GDP), and 52% of that is from people above age 65. Note that this is due to: (1) health care spending (per capita) has increased by proportionally more among the elderly than the young (see Figure 4); and (2) the population share of the elderly has increased over this period (see Table 2).

Table 2: Elderly as a percentage of the population, 1963-2000

Percent of population	1963	1970	1977	1987	1996	2000
	9.4%	9.9%	10.9%	12.2%	12.7%	12.6%

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

Table 3: Fixed-effect Panel Regression Results

Dependent Variable: health care spending per capita.

	Regression 1	Regression 2	Regression 3	Regression 4
GDP per capita	1.149*** (0.017)	1.147*** (0.016)	1.172*** (0.013)	1.14*** (0.018)
Public pension	2.993*** (0.633)	2.706*** (0.619)	3.664*** (0.472)	
Pop share (65+)	0.01* (0.006)	0.013** (0.006)		0.027*** (0.005)
Public health share	-0.109 (0.113)			0.079 (0.116)
Constant	-4.241*** (0.178)	-4.327*** (0.131)	-4.454*** (0.121)	-4.341*** (0.183)

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

2.2 A Panel Study Among OECD Countries

Now 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.[9] 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 the dependent variable, h, is the log of health care spending per capita (in real terms). The key variable of interest here is PP, the size of public pension, which is measured by the total public pension payments as a share of GDP. The other control variables include y, the log of GDP per capita (in real terms), $P65$, 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

[9]The data source is OECD health data (2009).

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 3.[10] 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 3), 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.[11]

3 The Benchmark Model

3.1 The Individual

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

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

Here β is the subjective discount factor, $P_{k-1}(\cdot)$ is the conditional survival probability from age $k-1$ to k, which is determined by h_k, the health stock 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,

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

[10]Note that it is not a strictly balanced panel. Several countries are missing data for 1-3 years.

[11]See Gerdtham and Jonsson (2000), and OECD (2006), etc.

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

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

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

where c is consumption, m is health care spending, and b is the transfer from accidental bequests. Here τ_{ss} and τ_m are the payroll tax rates for financing Social Security and Medicare respectively. The set of budget constraints facing retired agents are,

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

where $\Theta(m_j)$ is the Medicare reimbursement. It takes the following form: $\Theta(m_j) = 0$ if $m_j \leq d$, and $\Theta(m_j) = \kappa(m_j - d)$ if $m_j > d$. Here d and κ are respectively the deductible and the coinsurance

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

rate of the Medicare program.

Agents' health stocks evolve over time according to the following equation,

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

Here $\gamma\delta_h^j$ is the health stock depreciation rate, which consists of two components: (1) the deterministic component (age-specific), δ_h^j; and (2) the stochastic component, γ. The stochastic component, γ, is assumed to be i.i.d. across agents and age, and can be interpreted as health shocks. At the beginning of each period, agents receive a health shock $\gamma \in \{\gamma_1, \gamma_2, ..., \gamma_q\}$. The probability of receiving γ_l is represented by Λ_l for all $l \in \{1, 2, ..., q\}$. Note that $I(m_j)$ is the production of the new health stock, in which the health care spending, m_j, is an input. The new-born agents start with the initial health stock: $h_1 = \overline{h}$.

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

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

subject to

$$s' + c + m = w\chi_i\epsilon_j(1 - \tau_{ss} - \tau_m) + s(1 + r) + b, \text{ if } j < R,$$
$$s' + c + m = s(1 + r) + Tr(\chi_i) + \Theta(m), \text{ if } j \geq R,$$

and

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

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 saving for agent i at age j with (s,h,γ), and $M_j^i(s,h,\gamma)$ be the policy rule for health spending.

There exist accidental bequests in the economy, since agents face mortality risks in each period. It is assumed that all the 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, saving s, health status h, permanent earnings shock χ, and health shock γ.

3.2 The Firm

On the production side, a standard Cobb-Douglas production technology is assumed. Production is undertaken in a firm in accordance with

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

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

3.3 Stationary Equilibrium

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

$$\Phi'(j+1,\chi_i,s',h',\gamma_k) = \Lambda_k \sum_{j=1}^{T}\sum_{i=1}^{z}\sum_{l=1}^{q}\int_0\int_0 P_j(h')\Phi(j,\chi_i,s,h,\gamma_l)I_s I_h dsdh, \tag{6}$$

with

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

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

A stationary equilibrium for a given set of government parameters $\{\tau_{ss}, \tau_m\}$, is defined as follows,

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

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

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

$$K = \sum_{i=1}^{z}\sum_{j=1}^{T}\sum_{l=1}^{q}\int_0\int_0 s\Phi(j,\chi_i,s,h,\gamma_l)dsdh,$$

$$L = \sum_{i=1}^{z}\sum_{j=1}^{T}\sum_{l=1}^{q}\int_0\int_0 \chi_i\epsilon_j\Phi(j,\chi_i,s,h,\gamma_l)dsdh.$$

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

4. $\{Tr(\cdot), \Theta(\cdot)\}$ are determined so that Social Security and Medicare are self-financing:

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

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

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

6. the transfer from accidental bequests, b, satisfies

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

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

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

4 Calibration

First, we need to calibrate the model. 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.[13]

4.1 Demography

Assume that one period in the model is 5 years, and agents are born at age 25. Let $T = 16$, so that the maximum possible lifetime is 100 years. The mandatory retirement age, R, is set to 65.

4.2 Preference Parameters

In many standard model environments, the level of period utility flow, $u(\cdot)$, does not matter. However, when it comes to a question of life and death, such as the one addressed in this paper, the level of utility has to be positive so that people would not prefer living shorter. In a standard CRRA utility function, the coefficient of relative risk aversion, σ, needs to be less than one to have a positive period utility flow.[14] In the benchmark calibration, the value of σ is set to 0.95. The

[13]Here I assume that there is neither Social Security nor Medicare in the US economy in 1950. Though Social Security started in 1937 in the United States, its size was negligible until the 1950s (see Figure 2).

[14]An alternative way of avoiding the problem of negative utility is introduced in Hall and Jones (2007): adding a positive constant term into the utility function. I study the case with the Hall and Jones utility function in the sensitivity analysis.

subjective discount factor β is set to $0.963^5 = 0.828$, so that the (annual) interest rate is 4.0%.

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

4.3 Production Technology

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

4.4 Survival Probability Function and Health Technology

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

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

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

According to the National Vital Statistics Reports (2007), the conditional survival probability to the next period (age 30) at age 25 is 99.2% in 1950, and it keeps declining over the life-cycle (see Table 4). To capture this feature in the model, it is assumed that agents start with a high initial level of health stock ($\overline{h}$) at age 25 ($j = 1$), and then their health stock keeps depreciating over the life-cycle (via $\gamma\{\delta_h^j\}_{j=1}^{T-1}$), which lowers their survival probability over the life-cycle. Therefore, the values of $\overline{h}$ and $\{\delta_h^j\}_{j=2}^{T-1}$ are calibrated to match the conditional survival probabilities over the life-cycle, and δ_h^1 is normalized to 0. Figure 5 plots both the model results and the data on survival probabilities over the life-cycle. The calibrated values of $\overline{h}$ and $\{\delta_h^j\}_{j=0}^{T-1}$ are presented in Table 4.

Table 4: Survival probabilities (in 1950) and health depreciation rates

Age	SP-data	SP-model	Parameter	Value
25	0.992	0.992	$\overline{h}$	425
30	0.990	0.990	δ_h^2	6.5%
35	0.986	0.985	δ_h^3	7.5%
40	0.978	0.978	δ_h^4	1%
45	0.966	0.967	δ_h^5	11.5%
50	0.949	0.950	δ_h^6	12%
55	0.924	0.927	δ_h^7	14.5%
60	0.890	0.892	δ_h^8	16%
65	0.844	0.845	δ_h^9	17.5%
70	0.770	0.768	δ_h^{10}	24%
75	0.668	0.664	δ_h^{11}	30%
80	0.538	0.540	δ_h^{12}	38%
85	0.389	0.396	δ_h^{13}	47%
90	0.246	0.256	δ_h^{14}	57%
95	0.132	0.139	δ_h^{15}	68%

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

Note that the scale parameter, a, directly controls the health stock 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 stock. 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 stock takes the following form,

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

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 stock at different ages, they directly determine the relative health care spending over the life-cycle. I calibrate these parameters to match the relative health care spending (per capita) by age.[15] Since the data is only available for six age groups: $\{25-34, 35-44, 45-54, 55-64, 65-74, 75+\}$, the following assumptions need to be made: $\lambda_1 = \lambda_2$, $\lambda_3 = \lambda_4$, $\lambda_5 = \lambda_6$, $\lambda_7 = \lambda_8$, $\lambda_9 = \lambda_{10}$, $\lambda_{11} = \lambda_{12} = ... = \lambda_{15}$. Since it is relative health spending (per capita), one of the six age groups needs to be normalized: $\lambda_3 = \lambda_4 = 1$ because the age group of 35-44 is normalized in the data. The rest of the λ parameters are calibrated to match the relative health spending over the life-cycle. The calibrated values are presented in Table 5. The model results and the data on the relative health care spending (per capita) over the life-cycle are in Figure 6.

The curvature in the health production function, θ, directly controls how fast the marginal product of health spending diminishes as health spending increases, and should be related to the elasticity of health care spending. Therefore, I calibrate the value of θ to match the income elasticity of health spending, 1.149, which is the result from the panel regression in the second section.

Table 5: Health technology parameters: λs

Age	25-35	35-44	45-54	55-64	65-74	75+
Parameter	λ_1,λ_2	λ_3,λ_4	λ_5,λ_6	λ_7,λ_8	λ_9,λ_{10}	λ_{11}-λ_{15}
Value	1.3	1.0	0.93	0.85	1.15	3.25

4.5 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 (see Table 6).

The logarithm of the individual-specific permanent earnings shock, $\ln \chi_i$, is assumed to follow

[15] The 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.

the normal distribution: $N \sim (0, \sigma_\chi^2)$. Discretizing the distribution into 5 states and transforming the values back from the logarithms, I get a finite set of $\{\chi_1, \chi_2, ..., \chi_5\}$, with the corresponding probabilities $\{\Delta_i\}_{i=1}^5$. The variance of the log of the permanent earnings shock, σ_χ^2, is set to 0.2 based on the estimation of Moffitt and Gottschalk (2002).

The shock to health depreciation, γ, is assumed to be i.i.d. across agents and over the life cycle. There is little information in the literature on the magnitudes of the health shock and its distribution. Therefore, the values of γ and their probabilities are chosen arbitrarily here: $\gamma \in \{0.8, 1.2\}$, with its probability, $Prob(\gamma = 0.8) = Prob(\gamma = 1.2) = 0.5$.[16]

Table 6: Labor efficiency by age, ϵs

Age	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Labor efficiency ϵ_j	1.0	1.18	1.25	1.27	1.27	1.25	1.20	1.09

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

Table 7 summarizes the results of the benchmark calibration.

Table 7: Benchmark Model Calibration

Parameter	Targets to match
$\beta = 0.963^5$	Interest rate (annual): 4%
$\alpha = 0.3$	Capital share: 0.3
$\delta = 1 - (1 - 0.07)^5$	Capital depreciation rate: 7%(annual)
$\sigma = 0.95$	..
$a = 0.01137$	Health Spending as a share of GDP in 1950: 3.9%
$\theta = 0.17$	Income elasticity of health spending: 1.15.
$A = 3300$	GDP per capita in 1950: \$1937 (current dollars)
$\sigma_\chi^2 = 0.2$	Moffitt and Gottschalk (2002)

[16] I tried $\gamma \in \{0.8, 1.2\}$ as robustness check and find the results do not significantly change.

5 Quantitative Analysis

The quantitative question asked here is: how much can the expansion of US Social Security and Medicare from 1950 to 2000 account for the rise in health care spending as a share of GDP over the same period?

To answer this question, I first conduct steady state comparison, and then explore the economy out-of-steady-state (on the transition path).

5.1 Steady State Comparison

I construct and compare two steady states: the 1950 steady state and the 2000 steady state, which mimic the US economy in 1950 and 2000 respectively. The key difference between the two steady states is that the 2000 steady state has both Social Security and Medicare that match the actual programs in the US economy in 2000, while the 1950 steady state has neither of them.[17] The Social Security and Medicare programs in the 2000 steady state are described in details below.

The payroll tax rate for US Social Security in 2000 is 12.4%, which is used in the 2000 steady state. To capture the benefit-defined feature of US Social Security, I follow Fuster, Imrohoroglu, Imrohoroglu (2007) and use the benefit formula described in Table 8, where y is the agent's lifetime

Table 8: The Social Security Benefit Formula

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

earnings, and $\overline{y}$ is the average lifetime earnings. Then I rescale every beneficiary's benefits so that the Social Security program is self-financing.

[17] Though Social Security started in 1937 in the United States, its size was negligible until the 1950s (see Figure 2).

The elderly also qualify for the Medicare program in the 2000 steady state. The payroll tax rate for Medicare is 2.9% in 2000, which is used in the model. The Medicare reimbursement formula takes the following form: $\Theta(m_j) = 0$ if $m_j < d$, and $\Theta(m_j) = \kappa(m_j - d)$ if $m_j \geq d$. According to the data provided by Centers for Medicare & Medicaid Services, the Medicare deductible is \$776 (in current dollars) in 2000, which is approximately 2.2% of the GDP per capita in that year. I calibrate d in the 2000 steady state to match this ratio (2.2% of GDP per capita). I choose the value of κ, the coinsurance rate, so that Medicare is self-financing. This results in a value of 0.51 for κ, which is consistent with the estimate provided in Attanasio, Kitao, and Violante (2008).

Table 9: Health Care Spending (% of GDP) in 1950 and 2000: Model vs. Data

	1950	2000	$\Delta_{1950-2000}$	Explaining The Data
Data	3.9%	12.5%	8.6%	..
Benchmark Model	3.9%	7.6%	3.7%	43.2%
Decomposition of the Result				
Only Social Security	3.9%	4.7%	0.8%	9.6%
Only Medicare	3.9%	5.6%	1.7%	20.0%
The Interaction (the residual)	..	..	..	13.6%

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

The main findings of the steady state analysis are reported in Table 9. As can be seen, Social Security and Medicare together are able to explain 43.2% of the rise in health care spending (% of GDP) from 1950 to 2000, while Social Security alone only accounts for 9.6% of the rise and Medicare alone accounts for 20.0% of the rise. Note that the summation of the independent effects of these two programs is much smaller than their combined effect (43.2% > 9.6%+20.0%). The gap between the two is the interaction between the two programs. Simple calculation suggests that the interaction between these two programs is responsible for 13.6% of the rise in health care spending, which is 31% of the combined effect. The intuition behind the interaction is as follows. Since Medicare targets only the elderly, it further enlarges the young-elderly gap in marginal propensity to spend on health care. This larger gap implies that transferring resources (via Social Security) from the young to the elderly has a larger impact on aggregate health spending.

5.2 Health Care Spending By Age

An important prediction of the model is that the elderly should experience a much bigger rise in health care spending than the non-elderly. This is true in the benchmark results (see Figure 7). The health care spending (per capita) rises proportionally much more for the elderly than the rest age groups. Quantitatively, the model can account for most of the rise in health care spending (per capita) for the elderly from 1950 to 2000. However, the model does not do as good of a job in explaining the rise in health care spending among the non-elderly. This result also suggests that there exist other mechanisms that contribute to the rise in health care spending.

5.3 Other Life-cycle Features

Figures 8, 9, and 10 plot the life-cycle profiles of saving, consumption, and survival probability in different steady states.

As for the consumption profile, two things are worth mentioning (see Figure 8). First, the relative consumption level of the elderly in the 2000 steady state is much higher than that in the 1950 steady state. This reflects the elderly-oriented feature of the Social Security and Medicare programs. Second, the consumption profiles in the model are hump-shaped, which is a well observed fact in the data. Note that standard models usually have difficulty generating a hump-shaped consumption profile (Hansen and Imrohoroglu (2008)). The reason why this model generates hump-shaped consumption profiles is because it assumes that private annuity markets are missing. This result is also found in Hansen and Imrohoroglu (2008).

The savings profiles are hump-shaped in both steady states (see Figure 9). Compared to the 1950 steady state, agents in the 1950 steady state save relatively less for the retirement and drive down the savings more quickly after retirement. This suggests that Social Security and Medicare have crowding-out effects on private savings, which is also found in the previous literature (for example, Fieldstein 1974).

The conditional survival probabilities by age in the model are plotted in Figure 10. As can be seen, the changes in survival probability by age between these two steady states simply reflect the corresponding changes in health care spending: the survival probability increases significantly after age 65 since the elderly experiences a dramatic rise in health care spending, while survival probability does not change much for people under age 65. Comparing to the data (which is also shown in Figure 10), the changes in survival probability in the model are much smaller than those observed in the data between 1950 and 2000. This may be because the increase in survival probability over 1950-2000 in the US is not solely due to the rise in health care spending happened during the same period. For instance, other factors, such as increased education, behavioral changes, technological changes, and declines in pollution, may also have caused the increase in survival probability (Chay and Greenstone 2003, Grossman 2005, Hall and Jones (2007), etc.).[18] There is a large literature on the relationship between health care spending and survival probability/mortality rate (see Cutler, Deaton, and Lleras-Muney (2006) for a survey of the literature). While most studies find that health care spending has a positive effect on survival probability, there is no consensus on the magnitude of the effect so far in the literature.

5.4 The Transition Path

A fundamental assumption imposed in the steady state analysis above is that the rise in health care spending over the last half century in the US is a steady-state behavior. This is a strong assumption, given the fact that the values of some key economic variables and related policy

[18] Another reason why health care spending only accounts for a small part of the rise in survival probability in the model is the calibration strategy adopted in this paper. In the calibration exercise, the value of the scale parameter in survival probability function, a, is calibrated to match the level of the health spending share in 1950 (3.9% of GDP). This generates a very low value of a that implies low effectiveness of health care spending in terms of increasing survival probability. Hall and Jones (2007) do not target the level of the health spending share in 1950 and instead exogenously assume a higher effectiveness of health care spending in terms of increasing survival probability. In their model, health care spending can account for a much larger part of the rise in survival probability. However, the health spending shares (% of GDP) in their model are much higher compared to the data, for instance, the health care spending (% of GDP) is above 10% in 1950 in their baseline scenario.

parameters have been significantly changing over this period. The advantage of the steady state analysis is its simplicity, which makes it possible for us to explore the mechanisms with various quantitative exercises. However, it is also obvious that the steady-state assumption is restrictive. Now I relax this assumption and study the effect of Social Security and Medicare on health care spending out-of-steady-state; that is, exploring the economy on the transition path.

The quantitative strategy adopted in this section is to shock the 1950 steady state with Social Security and Medicare policy changes, and then compute the transition path converging to the 2000 steady state. Table 10 lists the Social Security and Medicare tax rates from 1955 to 2000 in the US, which are used as the policies changes to shock the 1950 steady state.

Table 10: Social Security and Medicare during 1955-2000

Year	Social Security tax rate	Medicare tax rate
1955	4%	..
1960	6%	..
1965	7.25%	..
1970	8.4%	1.2%
1975	9.9%	1.8%
1980	10.6%	2.1%
1985	11.4%	2.7%
1990	12.4%	2.9%
1995	12.4%	2.9%
2000	12.4%	2.9%

In each period, the corresponding Social Security benefits and Medicare coinsurance rates are adjusted so that both programs are self-financing. The Medicare deductible is assumed to be constant (2.2% of GDP per capita) on the transition path.

Note that since the policies are changing gradually on the transition path, agents' knowledge about future policy changes is very important for agents' current decisions. For example, when the government at the beginning of 1960 announces that the Social Security tax rate will be raised to

6% from 4% (the rate in 1955), the agents' reaction to this policy change is largely dependent on their expectation about whether the government will keep raising the Social Security tax rate in the following years. If the agents expect that the Social Security tax rate will stay at 6% after 1960, their reaction to the policy change in 1955 would be relatively small, i.e. a small crowding-out effect from Social Security on private savings. However, they will be surprised again by the future policy changes. If the agents expect that the Social Security tax rate would keep rising in the following years to 12.4% in 2000, then their reaction to the policy change in 1960 would be much larger but they won't ne surprised again by the future policy changes. Therefore, what information agents have about the policy changes in the future and when they get the information are very important for studying agents' behaviors on the transition path.

Unfortunately, we know little about people's expectations about future policy changes during the 1950-2000 period. To avoid this problem, I run two exercises in this section. In the first exercise, I assume that agents are myopic: they always expect the policies to stay unchanged in the future. In the second exercise, I assume that agents have perfect foresight: they know the whole path of Social Security policy changes from 1955 to 2000 once the government starts the expansion of the Social Security program at the beginning of 1955. They also know the whole path of Medicare policy changes from 1970 to 2000 once the government introduces a Medicare program into the economy at the beginning of 1970. The results of the two exercises are shown in Figure11. They should provide a reasonable range for the true results, since people's true expectation about future policy changes should lie in between these two extreme cases.

The key difference between the two exercises is that agents are surprised by policy changes in each period in the myopic case, while agents are only surprised twice (in 1955 and 1970) by policy changes in the perfect foresight case.[19] As shown in Figure 11, the transition paths in the two exercises do not differ dramatically. The reason for this is that the policy changes in 1955 and 1970 are relatively larger than the years following them, which reduces the importance of agents'

[19] I assume that the tax rate stays at 12.4% forever after 2000, and agents all know that.

expectation about future policy changes (see Table 10).

As can be seen, the rise in health care spending is larger on the transition path than that in the steady state analysis. In the myopic case, health care spending increased from 3.9% of GDP in 1950 to 8.1% of GDP in 2000, and in the perfect foresight case, it increased from 3.9% of GDP in 1950 to 8.0% of GDP in 2000. This suggests that the expansion of Social Security and Medicare from 1950 to 2000 can explain 47.8%-49.0% of the rise in health care spending as a share of GDP over this period. I use this result as the main finding of this paper for the effect of Social Security and Medicare on health care spending.

The reason for the difference between steady state results and transition path results is as follows. In the steady state analysis, agents are well informed about the changes of these programs and can adjust their behaviors to (partially) offset the impact of policy changes, e.g., lowering old-age savings to offset the impact of intergenerational redistribution (via Social Security). However, agents on the transition path are surprised by the policy changes, which means that they can not do this kind of intertemporal adjustments. This leads to a larger rise in health care spending on the transition path. In both transition path exercises, the life-cycle features of the results are very similar with those described in the steady state analysis, and therefore are not reported in the paper.[20]

It is worth noting that the transition paths also match the data fairly well in terms of timing. This can be best seen in Figure 12, in which I detrend these time series and plot the deviations.[21] The model matches the data very well in most years except 1955, in which the model has a positive deviation and the data have a negative deviation. This difference between the model and the data may be due to the steady state assumption adopted in the model for the year 1950, which implies that agents do not foresee the Social Security policy change in 1955 at all in the model. If some agents foresee the policy change in 1955, then the model would generate a smaller rise in health

[20]They are available from the author upon request.
[21]I assume a linear trend here.

care spending in 1955.

6 The Value of Life and the Hall-Jones Utility

Note that in models with endogenous longevity, such as the one studied in this paper, the value of life matters. In this section, I check 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.

Table 11: The Marginal Cost of Saving a Life (in 2000$)

Age	1950 Steady Sate (million)	2000 Steady State (million)	The Data (million)
25	7.66	5.94	
30	7.33	5.58	
35	5.98	4.92	
40	4.66	4.07	
45	3.50	3.24	
50	2.58	2.60	
55	1.79	1.92	
60	1.21	1.37	
65	0.79	1.96	
70	0.44	1.23	
75	0.25	0.74	
80	0.12	0.40	
85	0.05	0.21	
90	0.02	0.16	
95	0.004	0.13	
Average	3.51	3.16	2.0-9.0

As shown in Table 11, the marginal cost of saving a life declines with age in the model, which is consistent with the findings in the literature of estimating VSL. Compared to the 1950 steady state, the marginal cost of saving a life at age 65 and above are relatively higher in the 2000 steady state, which may reflect the positive effect of Social Security and Medicare on the marginal cost of saving a life.

On average, the marginal cost of saving a life in the two steady states are 3.51 millions and 3.16 millions (in 2000 $) respectively, which are consistent with the empirical estimates of VSL provided in the literature. The empirical estimates of VSL range from approximately 2 millions to 9 millions.[22] Note that the value of life is positively related to income. The empirical estimate of the income elasticity of VSL ranges from 0.5 to 1.0 (Viscusi and Aldy (2003)). Thus the value of life should be higher in 2000 than in 1950 given the dramatic economic growth between these two years. The reason why this is not seen in the model results is because I assume no growth between 1950 and 2000 in the benchmark model. When economic growth is included, the value of life should be much higher in 2000 in the model.

6.1 The Hall-Jones Utility Function

As argued before, the utility function, $u(\cdot)$, has to be positive so that agents would not prefer living shorter in the model.[23] This restriction implies that in the standard CRRA utility function, $\frac{c^{1-\sigma}}{1-\sigma}$, the value of σ has to be below one. However, most empirical estimates of this parameter in the literature suggest that the value of σ should be one (log utility) or above. In the benchmark calibration, I choose the value of σ to be 0.95, which is very 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

[22]See Hall and Jones (2007), Viscusi and Aldy (2003), Ashenfelter and Greenstone (2004), and Murphy and Topel (2005).

[23]Note that a similar problem also appears in the fertility literature (see Jones and Schoonbroodt (2009) for a detailed discussion).

value of σ above one. The Hall-Jones utility function is specified as follows,

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

where π_c is a positive constant term. By choosing a proper value of π_c, the utility function can be positive for cases with σ above one.

Here I replicate the steady state analysis under the Hall-Jones utility function, in which I keep the parameter values resulted from the benchmark calibration and choose the value of π_c so that the value of life is also consistent with the benchmark calibration. I explore two values for σ: 1.05 and 1.5. The results are reported below.

Table 12: Health Care Spending (% of GDP): The Hall-Jones Utility Function

	1950	2000	$\Delta_{1950-2000}$	Explaining The Data
Data	3.9%	12.5%	8.6%	..
Benchmark Model	3.9%	7.6%	3.7%	43.2%
Hall-Jones Utility (σ=1.05)	3.8%	7.5%	3.8%	43.9%
Hall-Jones Utility (σ=1.5)	3.4%	7.0%	3.7%	42.8%

As shown in Table 12, the main results do not change significantly when the Hall-Jones utility function is used.

7 Conclusion

In this paper, I propose an alternative explanation for the rise in health care spending as a share of GDP in the United States over the last 50 years. I show that the expansion of the Social Security and Medicare programs from 1950 to 2000 is an important cause of the rise in health spending over this period.

Social Security affects health care spending via two mechanisms. First, it 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, the Social Security annuities implicitly provide the elderly with incentives to increase health care spending in order to live longer since people with a longer life get more years of annuities. Medicare may further amplify the impact of Social Security on health care spending. By subsidizing only the elderly, Medicare further enlarges the young-elderly gap in marginal propensity to spend on health care, which implies that transferring resources from the young to the elderly (via Social Security) should have a larger impact on aggregate health care spending.

To analyze the impact of Social Security and Medicare on health care spending, I first conduct a panel study among 14 OECD countries on the relationship between the size of public pension and health care spending. I find that the size of public pension has a significant effect on health care spending, which supports the the explanation proposed in this paper.

Then, I formalize the above-described mechanisms in a modified version of the Grossman (1972) model and calibrate the model to the US economy. The quantitative exercises find that the expansion of Social Security and Medicare from 1950 to 2000 in the United States may be able to account for about half of the rise in health care spending over this period. They also find that the transition path generated by the Social Security and Medicare policy changes in the model matches the timing of the rise in health care spending over this period fairly well. Furthermore, the model can also account for the changing life-cycle profile of health care spending over this period.

References

Acemoglu, D., A. Finkelstein, and M. J. Notowidigdo (2009): "Income and Health Spending: Evidence from Oil Price Shocks," NBER working paper 14744.

Arias, E. (2007): "United States Life Tables, 2004," National Vital Statistics Reports; Vol 56 No 9. Hyattsville, MD: National Center for Health Statistics.

Ashenfelter, O., and M. Greenstone (2004): "Using Mandated Speed Limits to Measure the Value of a Statistical Life," *Journal of Political Economy*.

Attanasio, O., S. Kitao, and G. L. Violante (2008): "Financing Medicare: A General Equilibrium Analysis," in Demography and Economics, edited by J. Shoven, NBER.

Becker, G., and T. Philipson (1998): "Old-Age Longevity and Mortality-Contingent Claims," *Journal of Political Economy*, 106(3).

Blomqvist, A. G., and R. A. L. Carter (1997): "Is health care really a luxury?," *Journal of Health Economics*.

CBO (2008): "Technological Change and the Growth of Health Spending," ¡http://www.cbo.gov/ftpdocs/89xx/doc8947/01-31-TechHealth.pdf¿.

Chay, K. Y., and M. Greenstone (2003): "The Impact of Air Pollution on Infant Mortality: Evidence from Geopraphic Variation in Pollution Shocks Induced by a Recession," *Quarterly Journal of Economics*, pp. 1121–1167.

Cutler, D. M., A. S. Deaton, and A. Lleras-Muney (2006): "The Determinants of Mortality," *Journal of Economic Perspectives*, pp. 97–120.

Feldstein, M. (1974): "Social Security, Induced Retirement, and Aggregate Capital Accumulation," *Journal of Political Economy*, 82, 905–926.

Follette, G., and L. Sheiner (2005): "The Sustainability of Health Spending Growth," *Federal Reserve Board Staff Working Paper*, 2005-60.

Fuster, L., A. Imrohoroglu, and I. Selahattin (2007): "Elimination of Social Security in a Dynastic Framework," *Review of Economic Studies*, 74(1).

Gerdtham, U., and B. Jonsson (2000): "International Comparisons of Health Expenditure: theory, data and econometric analysis," in A.L. Culyer and J. Newhouse (eds). Handbook of Health Economics. Amsterdam: Elsevier.

Grossman, M. (1972): "On the Concept of Health Capital and the Demand for Health," *Journal of Political Economy*, 80(2).

——— (2005): "Education and Nonmarket Outcomes," in *Handbook on the Economics of Education*, Eric Hanushek and Finis Welch, eds. (Amsterdam: North-Holland, 2005).

Hall, R., and C. Jones (2007): "The Value of Life and the Rise in Health Spending," *Quarterly Journal of Economics*.

Hansen, G. D., and S. Imrohoroglu (2008): "Consumption over the Life Cycle: The Role of Annuities," *Review of Economic Dynamics*.

Jones, C. I. (2004): "Why Have Health Expenditures as a Share of GDP Risen So Much?," unpublished manuscript, UC Berkeley.

Jones, L. E., and A. Schoonbroodt (2009): "Complements versus Substitutes and Trends in Fertility Choice in Dynastic Models," *International Economic Review*, forthcoming.

Kopecky, K. A., and T. Koreshkova (2008): "The Impact of Medical and Nursing Home Expenses and Social Insurance Policies on Savings and Inequality," unpublished manucript, University of Western Ontario.

Manning, W. G., J. P. Newhouse, N. Duan, E. B. Keeler, and A. Leibowitz (1987): "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment," *American Economic Review*, 77:3.

Meara, E., C. White, and D. M. Cutler (2004): "Trends In Medical Spending By Age, 1963-2000," *Health Affairs*.

Moffitt, R., and P. Gottschalk (2002): "Trends in the Transitory Variance of Earnings in the United States," *Economic Journal*.

Murphy, K. M., and R. H. Topel (2006): "The Value of Health and Longevity," *Journal of Political Economy*, 114(5).

Newhouse, J. P. (1992): "Medical Care Costs: How Much Welfare Loss?," *Journal of Economic Perspectives*, 6(3), 3–21.

Parkin, D., A. McGuire, and B. Yule (1987): "Aggregate Health Care Expenditures and National Income: Is Health Care a Lux- ury Good?," *Journal of Health Economics*, 6:2.

Schieber, G., and J. P. Poullier (1989): "Overview of International Comparisons of Health Care Expenditures," *Health Care Financing Review*, Annual Supplement, 1-8.

Suen, R. M. H. (2006): "Technological Advance and the Growth in Health Care Spending," unpublished manuscript, UC Riverside.

Viscusi, K., and J. Aldy (2003): "The Value of a Statistical Life: A Critical Review of Market Estimates throughout the World," *Journal of Risk and Uncertainty*, pp. 5–76.

Warshawsky, M. (1988): "Private Annuity Markets in the United Stats: 1919-1984," *Journal of Risk and Insurance*, 55(3), 518–528.

Worthington, N. (1975): "National Health Expenditures, 1929-74," Social Security Bulletin, 38:2.

8 Appendix I

8.1 Becker and Philipson (1998)

Here I restate one of the analytical results in Becker and Philipson (1998) to provide the intuition of second mechanism via which Social Security affects health care spending. Assume that the agent's value function is denoted by V(C,T(h)), which is an increasing and concave function in C and $T(\cdot)$, consumption and life span. Life span, $T(\cdot)$, is an increasing and concave function in h, health care spending, and the agent's total disposable resource is $W = (C + h)$. Then the agent's optimal choice of health care spending (interior solution) should satisfy the following condition:

$$V_C = V_T T_h, \tag{8}$$

where the left-hand side is the marginal cost of health care spending, the utility loss from the forgone consumption. The right-hand side is the marginal benefit of health care spending, the utility gain from the increase in life span. Now consider that part of the disposable resource, τW, is annuitized by the Social Security program, $\tau W = aT(h)$, where a is the annuity. Then the optimality condition (1) becomes,

$$V_C = V_T T_h + V_C a T_h. \tag{9}$$

Comparing to condition (1), condition (2) has an extra term on the right-hand side, $V_C a T_h$, which represents the utility gain from the extra resource brought by the increase in life span. Given the same W, it is obvious that the optimal health care spending is higher under condition (2) than that under condition (1).

Table 13: Per Capita Health Spending by Quintile (in 2004 $).

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

Note: 1st income quintile is the lowest quintile.

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

8.2 Health care spending by income

The theory proposed in this paper also has interesting implications about the cross-section of health care spending by income. An implicit assumption of this theory is that people were financially constrained in their old age when there was no Social Security and Medicare. Social Security and Medicare affect health care spending by loosening people's old-age budget constraint: on one hand, Social Security increases the elderly's income, on the other hand, Medicare makes health care cheaper for the elderly. Therefore, a direct implication of this theory is that the impact of Social Security and Medicare on health care spending should be larger for the poor than the rich. This is also consistent with the US data. Follette and Sheiner (2005) find that health care spending (in real terms) increased for households in all income quintiles between 1970 and 2002, and it increased the most for households in the first income quintile (see Table 13). Health care spending per household (in real terms) increased by a factor of 6.3 for elderly households in the first income quintile from 1970 to 2002, and this number declines along the income distribution.

It is worth noting that the negative relationship between household income and health care spending growth is reversed at the top of the income distribution: households in the fifth income quintile experienced a bigger rise in health care spending than those in the fourth quintile (see Table 13). This may be due to the technological advance in the health sector. The fundamental assumption in the technological advance theory (see Suen (2006)) is that people were constrained by technology, but not by money. When there are new health technologies available, people will choose to use them. An implication of the technological advance theory is that the rise in health care spending should be larger for the rich, since newly-invented technologies are usually very expensive and the rich are more likely to be able to afford them.

The non-monotone relationship between household income and health care spending growth provides us information about the validity of the Social Security and Medicare theory compared to the technological advance theory. As shown above, health care spending growth is negatively related with household income within most households(1st-4th quintiles), which implies that Social Security and Medicare may be an important reason for the rise in health care spending of these households (in 1st-4th income quintiles). For the very rich households, the health technological advance may be the driving force of the health care spending growth.

8.3 Economic Growth

Note that I assume no economic growth in all the analysis conducted above. Now I consider how including economic growth may change the results obtained above. Here I assume that the 1950 steady state and the 2000 steady state have different income levels to capture the economic growth from 1950 to 2000, and there is no growth at steady state.[24]

The data show that the real GDP per capita increased by a factor of 2.97 from 1950 to 2000 in the US. To match this, I increase the value of the labor-augmented technology, A, to 10230 in the

[24] The existence of steady-state growth may not be guaranteed in a model with endogenous longevity. See Chakraborty (2004) for a detailed discussion.

2000 steady state.[25] I replicate the steady state analysis and report the results below,

Table 14: Economic Growth and Health Care Spending (% of GDP)

	1950	2000	$\Delta_{1950-2000}$	Explaining The Data
Data	3.9%	12.5%	8.6%	..
Benchmark Model (with growth)	3.9%	8.6%	4.7%	54.3%
Counterfactual Steady State (with only growth)	3.9%	4.7%	0.81%	9.5%

As shown in Table 14, the benchmark model is able to explain 54.3% of the rise in health care spending (% of GDP) from 1950 to 2000. Note that this result is not only attributed to the expansion of Social Security and Medicare from 1950 to 2000, but also to the income growth over this period. To decompose the two effects, I compute a counterfactual steady state in which the only difference between the 1950 steady state and the 2000 steady state is the income difference. The result suggests that the income growth from 1950 to 2000 alone only accounts for 9.5% of the rise in health care spending, which suggests that the expansion of Social Security and Medicare from 1950 and 2000 may be able to explain for 44.3% of the rise in health care spending over the period.[26] As can be seen, including income growth does not significantly change the main findings of the quantitative analysis.

9 Appendix II(incomplete)

9.1 Solvency of Social Security and Medicare

An interesting implication of the model is that, the financial burden on Medicare is largely dependent on the size of Social Security in the economy. As shown in Table 15, in the steady state with

[25]Note that I need to increase A by a factor 3.1 to increase the real GDP per capita by a factor of 2.97, because Social Security and Medicare discourage saving and lower the aggregate capital level.

[26]Note that the reason why economic growth has a positive effect on health spending as a share of GDP is because the income elasticity of health spending implied in the calibrated model is 1.14 (¿1).

both Social Security and Medicare, the Medicare program can be financed by a payroll tax of ..%. However, the same Medicare program only needs a payroll tax of ..% when there is no Social Security co-existing in the economy. This big impact that Social Security has on the financial burden of Medicare is because of that the expenses of Medicare are largely dependent on the elderly's health care spending. When Social Security raises the elderly's health care spending, it also raises the financial burden on the Medicare program.

Table 15: Impact of Social Security on the financial burden of Medicare

	Tax to finance Medicare
Benchmark	..%
no SS	..%

Note: SS refers to Social Security, RT is replacement rate.

The policy implication of the interaction between Social Security and Medicare is very important. The solvency problem is often at the center of the debates about health care policy and Social Security policy reforms in the United States. Ignoring the interaction between Social Security and Medicare could lead us to wrong policy decisions.

9.2 Policy Experiments

9.3 Add A Bequest Motive(to be added)

The value of death is always normalized to zero so far. Now I consider a case in which the value of death is different from zero.

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

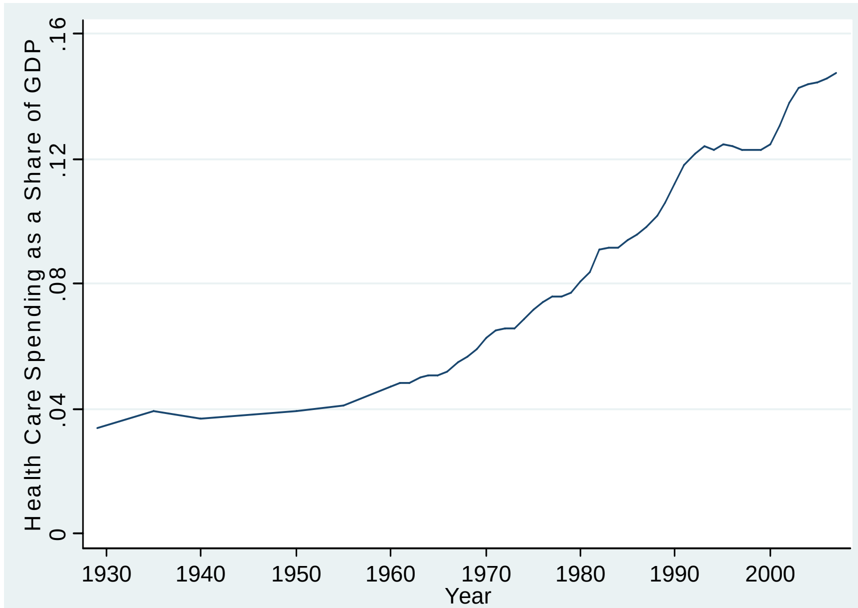
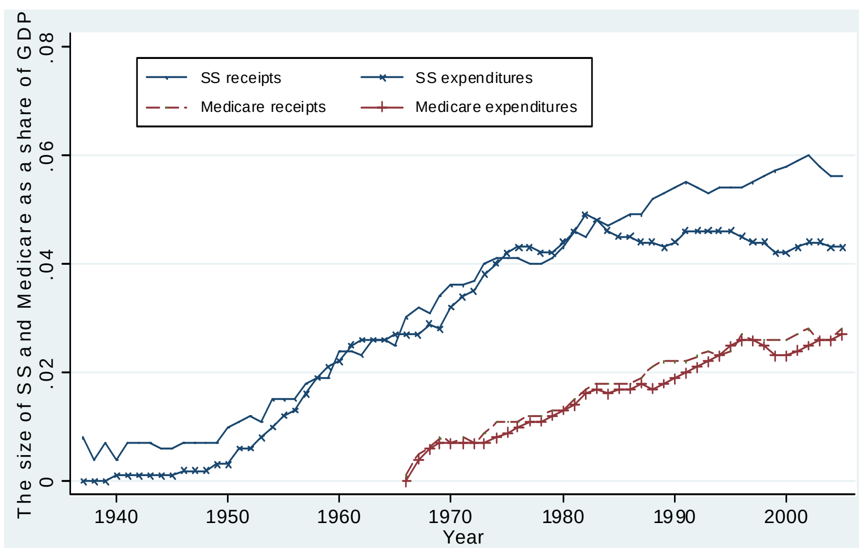
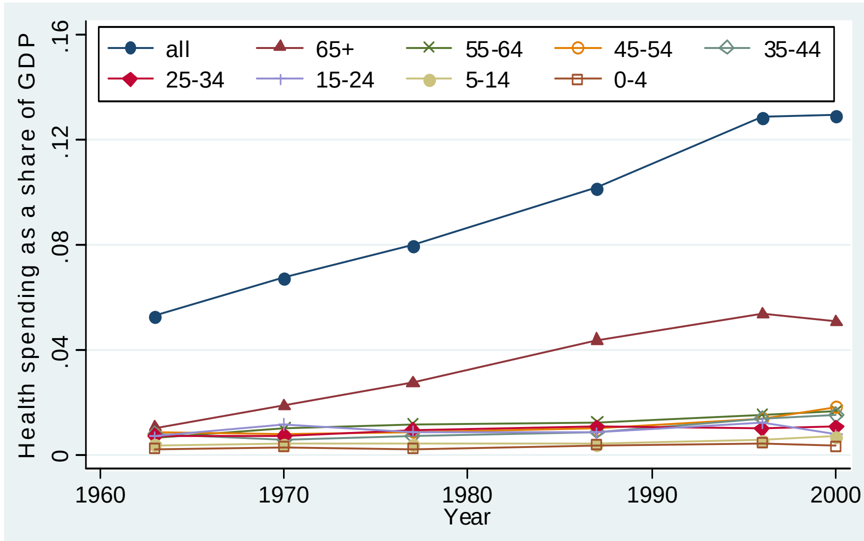


Figure 2: The US Social Security and Medicare: expenditures and receipts as a share of GDP



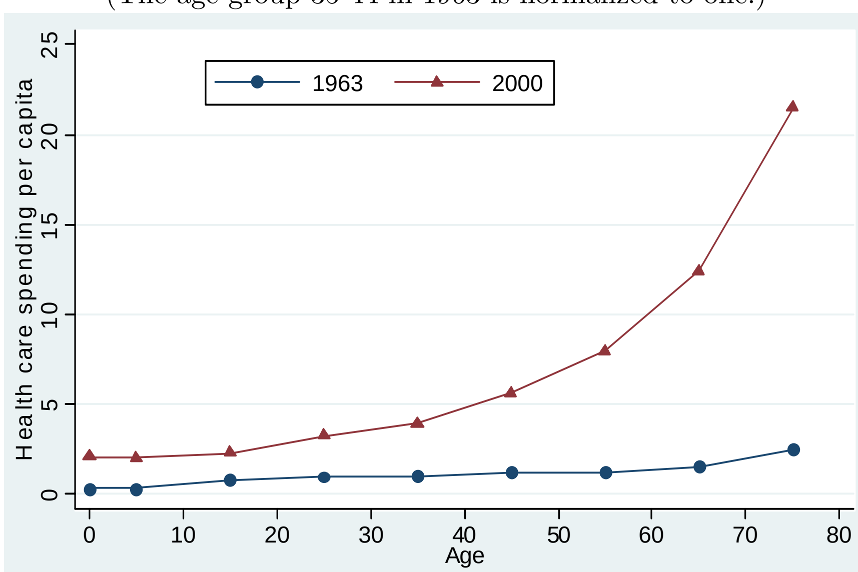
(Data source: Budget of the United States Government, FY 2005, Historical Tables, table 10.1 and 13.1.)

Figure 3: Health Care Spending (as a share of GDP) by Age



(Data source: Author's calculations based on the data provided in Meara, White, and Cutler (2004).)

Figure 4: 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 5: Survival Probabilities By Age (in 1950)

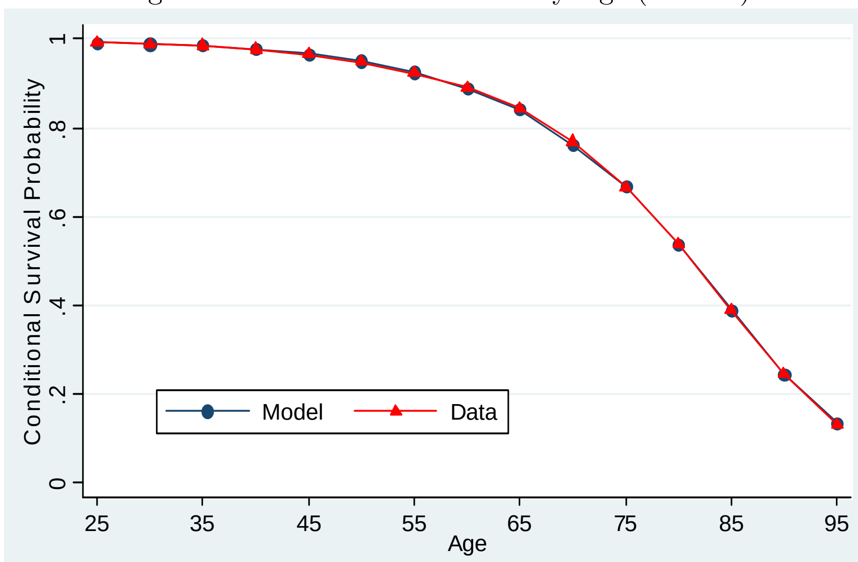


Figure 6: Relative Health Care Spending (per capita) By Age

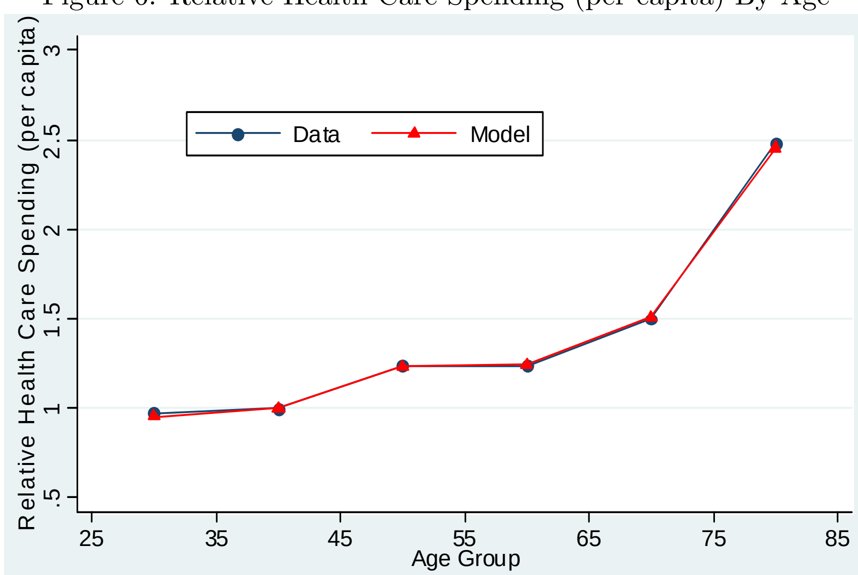


Figure 7: Health Care Spending per capita By Age: Model vs Data
(The age group 35-44 in 1950 is normalized to one.)

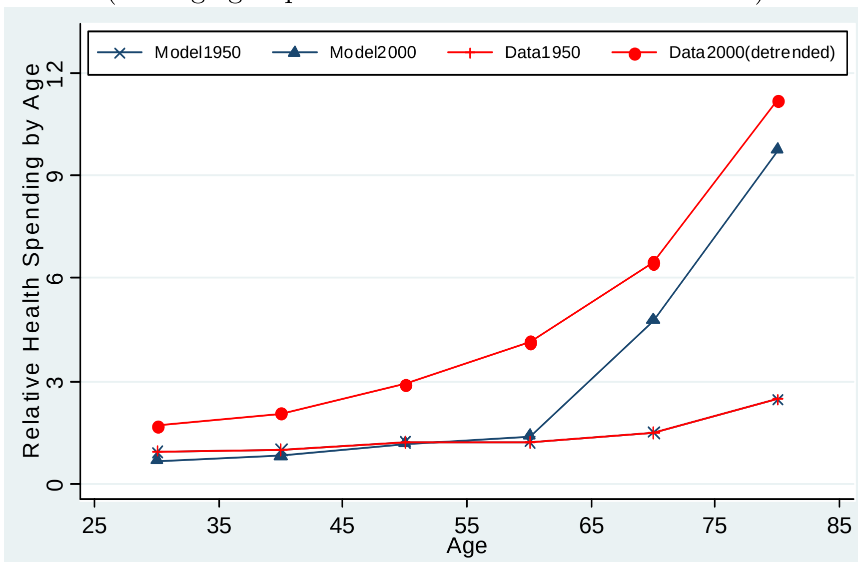


Figure 8: Consumption per capita By Age (in 1950$)- Model Results

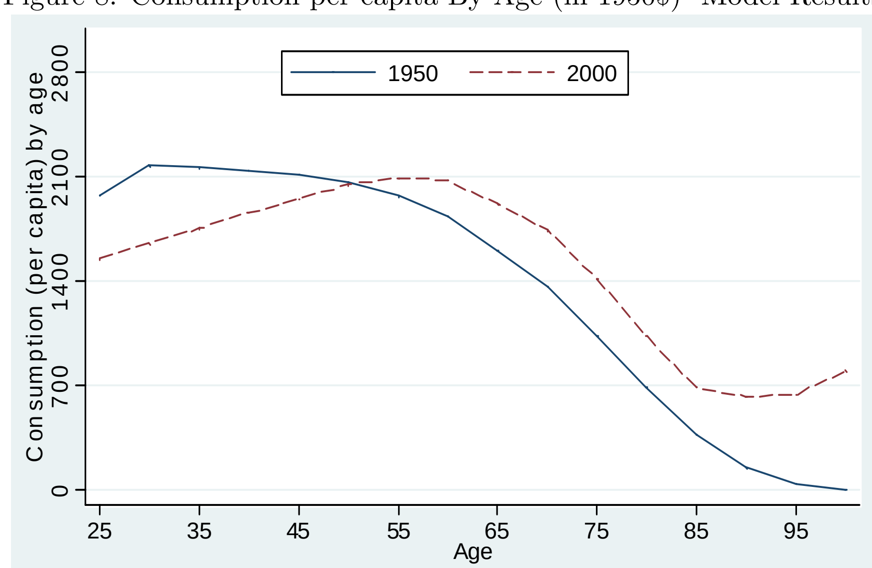


Figure 9: Saving per capita By Age (in 1950$)- Model Results

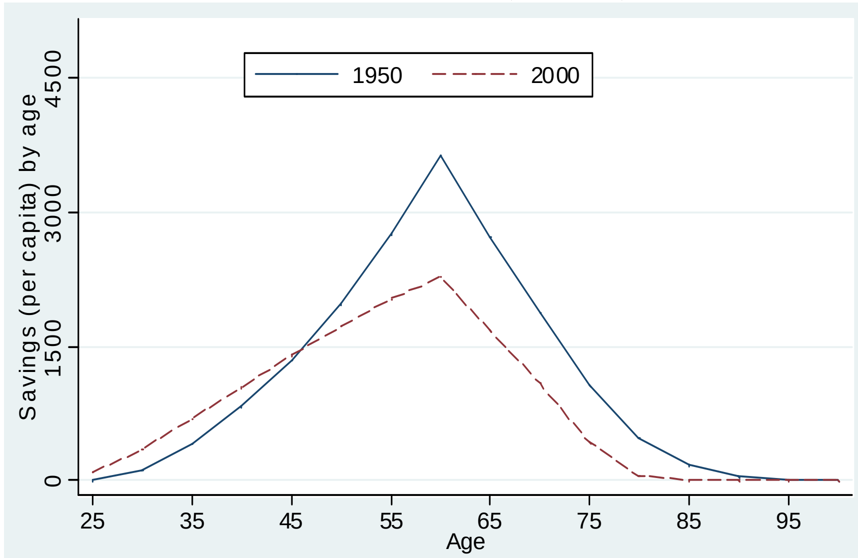


Figure 10: Survival Probability By Age- Model Results

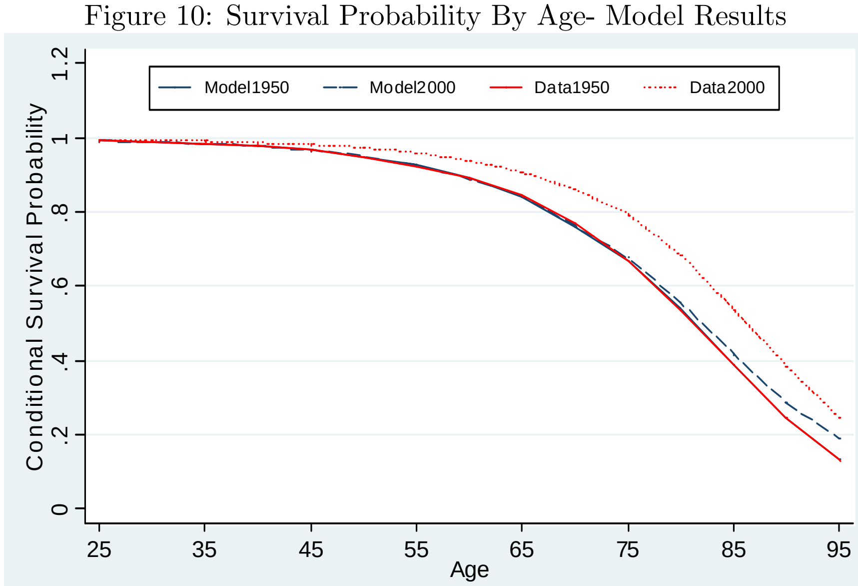


Figure 11: The Transition Paths: Myopic and Perfect Foresight

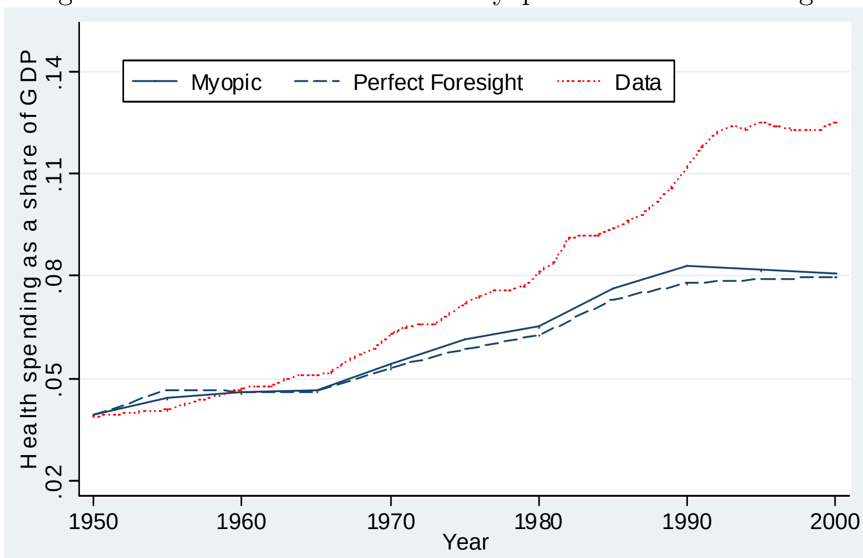


Figure 12: Deviation from the trend: Health Care Spending (% of GDP)