The Impact of Medical and Nursing Home Expenses and Social Insurance Policies on Savings and Inequality

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November 26, 2008

Abstract

The objectives of this paper are 1) to assess the impact of medical and nursing home expenses on life-cycle savings and wealth inequality in the U.S., and 2) to quantitatively evaluate the effects of alternative old-age social insurance policies in a general equilibrium framework. We consider a life-cycle model where individuals face uninsurable labor earnings risk, out-of-pocket medical and nursing home expense risk and survival risk. Partial insurance is available through three social insurance programs: welfare, Medicaid and a pay-as-you-go social security system. We find that out-of-pocket health expenses amplify precautionary savings against survival risk and that nursing home expenses drive the savings behavior of wealthier individuals. The dominant role played by nursing home expenses is primarily due to differences in the degree of social insurance available for medical versus nursing home expense risk. We find that elimination of private medical and nursing home expenses through public health care would reduce the capital stock by 20 percent. We also find that while the welfare program for workers has little effect on savings behavior in the presence of large out-of-pocket expenses, Medicaid and old-age welfare programs crowd out over 60 percent of life-cycle savings and dramatically increase wealth inequality. Furthermore, we find that social security amplifies the effect of OOP health expenses on wealth accumulation. Overall, we conclude that out-of-pocket health expenses play an important role in wealth accumulation on aggregate and across the permanent income distribution.

1 Introduction

Out-of-pocket medical and nursing home expenses increase quickly with age and are highly volatile and persistent. The two main ways the elderly insure their consumption against this risk are private savings and social safety nets. The objective of this paper is to assess the role played by medical and nursing home expenses in wealth accumulation and inequality, and to quantitatively evaluate the effects of old-age social insurance policies in the U.S. economy such as Medicaid, the social welfare program, and progressive social security. Our analysis is novel for three reasons. First, we document some facts on the size and distribution of medical and nursing home expenses in the U.S. Second, we explicitly model nursing home expenses in addition to medical expenses in order to capture the fact that nursing home costs are one of the largest faced by the elderly and the least insured. Third, unlike previous studies in the literature, our model is cast in a general equilibrium framework, allowing us to analyze the price effects of policy changes on savings and inequality. We argue that Medicaid provides differential insurance against medical versus nursing home expense risk and show that this differential plays a crucial role in aggregate and cross-sectional wealth accumulation.

Despite the fact that out-of-pocket (OOP) medical and nursing home expenses of the elderly (individuals 65 years of age and over) constitute a relatively small fraction of aggregate income in the U.S., in 2000 these expenses were 1.5 percent of GDP, average individual expenses are high relative to per capita income and this ratio increases with age. For example, for 65 to 74 year-olds average individual expenses were 10 percent of per capita income, while they were as high as 22 percent for those 85 years and older.[1] Recent studies by French and Jones (2003, 2004) and De Nardi, French, and Jones (2006) document the risk of large OOP health expenditures faced by the elderly. Using Health and Retirement Study data from the 2000 to 2006 waves, we find that, consistent with these studies, OOP medical expenses of the elderly are large and volatile. In addition, we find that the cross-sectional distribution of OOP expenditures is highly unequal, with a Gini coefficient of 0.73, and is highly concentrated, with the top 10 percent of spenders accounting for 57 percent of total health expenditures. These observations are in part driven by nursing home expenses which are among the highest health costs faced by individuals: average annual nursing home cost per resident is twice the level of per capita income. Moreover, demand for nursing home care is highly persistent. According to Dick, Garber and MaCurdy (1994), 18 percent of 65 year olds will spend more than 6 months in a nursing home before the end of their life, with nearly half of these individuals spending more than 3 years, and nearly a quarter spending more than 5 years.

[1] Authors calculations for 2002 based on the U.S. Department of Health and Human Services 2004 report.

Most medical and nursing home expense insurance for the elderly in the U.S is publicly-provided as private insurance markets are scarce, especially for long-term care. The major public insurance programs are Medicare and Medicaid. While Medicare is an entitlement program for the elderly and disabled, Medicaid is a means-tested program for the poor. In our theoretical analysis we focus on out-of-pocket health expenses and the Medicaid program.[2] We argue that Medicaid provides differential insurance for medical versus nursing home expense risk by guaranteing a lower level of consumption under bankruptcy caused by nursing home expenses than under bankruptcy caused by medical expenses. As a social safety net, Medicaid targets low income individuals, reducing their risk exposure and hence precautionary savings motive more relative to those with higher incomes. In addition, it is effectively a 100 percent tax rate on the savings of the poor further reducing their incentives to save. As a result it widens the difference between the savings of the rich and poor, promoting wealth inequality.

We build a life-cycle model with overlapping generations of individuals and population growth. Individuals work till age 65 and then retire. During the working stages of their lives, individuals face earnings uncertainty. Retired individuals face uncertainty with respect to their survival and medical and nursing home expenses. Different histories of earnings give rise to cross-sectional wealth inequality well before retirement. We assume that individuals cannot borrow and that there are no markets to insure against labor market, medical and nursing home expense, and survival risk. Partial insurance, however, is available through three programs run by the government: a progressive pay-as-you-go social security program, a welfare program that guarantees a minimum level of consumption under consumer bankruptcy, and a Medicaid-like social safety net that guarantees a minimum consumption level under medical and nursing home bankruptcies, with a consumption floor specific to the type of bankruptcy. The lower consumption floor for nursing home bankruptcy reflects the lower quality of life provided by public nursing home care.

The absence of insurance markets coupled with borrowing constraints creates a strong incentive for precautionary savings as individuals desire to smooth consumption over their lifetime. Means-testing of social insurance implies that rich individuals rely on private savings much more than do poor individuals. The welfare program discourages workers with low earnings from saving to finance their consumption early on in the life cycle, and Medicaid further discourages saving to finance medical and nursing home expenses experienced later on in life. As permanent income increases, individuals become less likely to qualify for Medicaid,

[2] We do not model Medicare because we do not model demand for health care, but treat health expenses as exogenous shocks. In such an environment an entitlement program such as Medicare has no effect on individual behavior apart from the tax distortions induced by its public finance.

and medical and nursing home expenses gain importance in their life-cycle savings. However more savings is required for nursing home than for medical expenses because nursing home costs are one of the largest and most persistent health expense realizations in the model economy. Moreover, since nursing home costs over long periods of time are either all together unaffordable or would require an extremely large fraction of the lifetime earnings of poorer individuals, the savings behavior of lower income individuals is driven mostly by smaller OOP medical expenses rather than by nursing home expenses. The savings behavior of wealthier individuals on the other hand, is driven primarily by nursing home expenses. Since the nursing home state has the lowest insured consumption floor, making this type of bankruptcy more painful, individuals across the permanent income distribution effectively face different kinds of OOP expense risk. In addition, the progressive nature of social security further discourages savings of the poor. How these public insurance programs interact and their joint effect on aggregate wealth accumulation and inequality is a quantitative question we seek to answer.

We calibrate the benchmark economy to a set of cross-sectional moments from the U.S. data. To pin down the stochastic processes for health costs, we use data from the Health and Retirement Study. Since we only observe OOP health expenditures and not the total (before Medicaid subsidies) health expenditures in the data, we cannot directly infer the health cost processes. Instead, and unlike other studies, we calibrate these processes so that the distribution of OOP expenditures generated by the model matches the one observed in the data. Since the quality of life in a public nursing home is not directly measured, we calibrate the consumption floor for nursing home bankruptcy to match the share of nursing home expenses paid for by Medicaid. Comparing the wealth distribution generated by the model, and not targeted by the calibration procedure, with that observed in the U.S., we conclude that the model presents a well-disciplined quantitative theory of life-cycle wealth inequality.

We find that the amount of precautionary savings for survival risk is larger when retired individuals face OOP health expenses that increase with age. Moreover, through three types of policy experiments, we find that medical and nursing home expenses and the structure of the social insurance system in the U.S. play an important role in wealth accumulation and go a long way toward explaining wealth inequality. In the first set of experiments, we introduce public health care such that medical and/or nursing home expenses are fully covered by the government. In the second set of experiments, we vary the availability of safety nets for different types of bankruptcies. In the third set of experiments, we vary social security policy from progressive to proportional to none.

Introducing public health care greatly reduces incentives to save for old age. Our model predicts that a complete elimination of medical expenses reduces the aggregate capital stock by 20 percent. This large decline is driven by the elimination of the nursing home expenses – an important saving motive of richer individuals. In fact, when the public health care system covers all but nursing home expenses the capital stock falls by only 7 percent. In contrast, when only nursing home expenses are covered, the capital stock falls by 12 percent. We find that changes in saving behavior in response to the public health care policy differs dramatically across the permanent income distribution. In particular, the top three income quintiles reduce their savings the most, with the effect of the elimination of the nursing home expenses largely dominating the elimination of the medical expenses. On the contrary, the second quintile responds mostly to the elimination of the medical expenses, whereas the bottom quintile's saving behavior is nearly unaffected by public health care. This difference in the responses to policy changes is explained by the type of OOP expenses faced by each quintile. In particular, nursing home expenses dominate saving motives of richer individuals. Since the top quintile is the major saver in the economy, aggregate effects of policy changes are also driven by the nursing home expenses.

The dominant role of the nursing home expenses is to a large extent due to the differential amount of subsidies provided by Medicaid under nursing home versus medical bankruptcies. In fact, once the government increases the level of consumption provided to individuals in a public nursing home care to the level of the consumption floor in medical bankruptcy, capital stock drops by 9 percent. Introduction of public health care in such an economy results in a much smaller decline in savings than due to the same policies in the benchmark economy.

Moreover, we show that the safety nets provided by Medicaid and old-age welfare programs play a dominant role in wealth accumulation and inequality. We find that removing Medicaid subsidies and transfers for the elderly increases savings by 165 percent and reduces the wealth Gini by 21 percentage points, while removing the welfare program for consumer bankruptcies caused by the earnings risk increases savings only by 7 percent and reduces the Gini by 9 points. Interestingly, removing all safety nets has nearly the same effect as removing the those for the elderly alone. This is because the earnings and the health expense shocks are experienced at different stages of a life cycle, allowing workers to buffer their consumption with precautionary savings accumulated in anticipation of the health expense risk at older ages.

Finally, we find that the interactions between OOP health expenses, Medicaid, and social security have important implications for the aggregate and distributional effects of social insurance policies. In particular, the need to finance OOP health expenses at old ages suppresses the crowding-out effect social security on savings. In addition, Medicaid makes savings of the poor less elastic in response to changes in the social security benefit. Replacing progressive social security benefits with proportional ones reduces the capital stock by 13 percent and the wealth Gini by 3 percentage points. Removing social security altogether increases aggregate capital by 33 percent. Furthermore, the presence of the social security program amplifies the effect of the health expenses on wealth accumulation. Elimination of the health expenses through public health care in an economy without social security reduces aggregate capital by 5 percent, which is a quarter of the change in capital stock in the economy with progressive social security system.

Our analysis extends a large literature on life-cycle savings and wealth inequality. To date, general equilibrium models have primarily focused on idiosyncratic earnings risk as a source of high wealth inequality. Castaneda et al. (2003) present an excellent survey and show that a life-cycle model with idiosyncratic uncertainty about labor market efficiency units can be calibrated to accurately match a wide set of moments characterizing the U.S. earnings and wealth distributions.

However, earnings risk as a sole source of heterogeneity in wealth fails to account for slow rates of dissaving observed for retired individuals, including those without inheritance motives. A number of empirical studies have suggested that the slow dissaving rate is largely due to the anticipation of high medical expense shocks (Hubbard et al. (1995), Palumbo (1999), Scholz et al. (2006), De Nardi et al. (2006), among others). These studies have shown that precautionary savings for medical expense and survival risk can explain a substantial part of old-age savings and inequality in the presence of means-tested social insurance. Moreover, they have shown that the extent of publicly provided insurance against medical expense risk has large effects on savings even for wealthier individuals. While these findings were obtained in partial-equilibrium frameworks, general equilibrium analysis is required to provide a full evaluation of government policies. In our public policy analysis, we find that partial equilibrium understates aggregate effects by as much as 5 percent.

Works most closely related to our analysis are by Hubbard et al. (1995) and De Nardi et al. (2006). The main contributions of our paper relative to these studies include: (*i*) general equilibrium analysis; (*ii*) calibration of the stochastic process governing health expenses instead of treating OOP expenses in the data as before-insurance expenses; (*iii*) explicit modeling of nursing home risk that generates a "Medicaid aversion"; (*iv*) evaluation of a more extensive set of social insurance policies.

The paper proceeds as follows: Section 2 documents some facts on medical and nursing home expenses and social insurance policies. Section 3 presents the model and Section 4 discusses the calibration strategy. A discussion of the benchmark economy as a theory of life-cycle inequality is presented in Section 5, and the results of the policy experiments are in Sections 6. Finally, Section 7 concludes.

2 Evidence on Health Expenses and Public Insurance

In this section we first discuss the size, composition and public insurance coverage of health expenditures on aggregate, and then document the distribution of these expenditures across the elderly. Among personal health expenditures, defined as national health expenditures net of expenditures on medical construction and medical research, we distinguish between medical and nursing home expenditures. Medical expenditures include expenditures on hospital, physician and clinical services, prescription drugs, dental care, other professional and personal health care, home health care, nondurables and durables. Nursing home expenditures include expenditures on care within skilled nursing facilities (facilities for individuals who require daily nursing care and living assistance) but not on the costs of services provided by retirement homes or assisted-living facilities. We take a look at two public health insurance programs: Medicare and Medicaid. While Medicare is a federal entitlement program for the elderly and disabled, Medicaid is a means-tested, federal/state program for the poor. We find that medical expenditures are substantially different from nursing home expenditures in both risk and public insurance coverage.

2.1 Personal Health Expenditures

According to the U.S. Department of Health and Human Services, personal health expenditures accounted for 13 percent of GDP in 2002. Thirty-five percent of these, or 4.4 percent of GDP, were expenditures on the elderly (individuals 65 years of age and over). In per capita terms, however, personal health expenditures on the elderly outweigh expenditures for the rest of the adult population. While the average expenditure on someone less than 65 years of age was close to the national average of 13 percent of per capita GDP, the average expenditure on a 65 to 74 year old was twice this amount, while for 75 to 84 year olds and individuals age 85 and up it was three times and five times this amount, respectively. Personal health expenditures by age as a percent of GDP and per capita GDP are provided in Table 1.

How were the large expenditures on the elderly financed? Table 2 shows that 34 percent of total personal health expenditures, consisting of 1.5 percent of GDP, were privately financed either out-of-pocket, with private insurance or through other means, while the remaining 66 percent, consisting of 2.9 percent of GDP, were publicly financed by either Medicare, Medicaid, or other public programs. Note that Medicaid finances a substantial portion, 14 percent, of the elderly's medical expenses, consisting of 0.6 percent of GDP. Table 3 shows that medical expenditures of the elderly net of Medicare are primarily funded by private

Table 1: Personal Health Expenditures, 2002

	by age %	total % of GDP	per capita % of GDP p.c.
All ages	100	13	13
Under 65	65	8.6	13*
65+	35	4.4	36
65-74	13	1.6	26
75-84	14	1.7	40
85+	8	1	66

Source: U.S. Department of Health and Human Services.

* 19-64 year old

Table 2: Personal Health Expenditures Finance, Ages 65 and over, 2002

Source of Payment	% of total	% of GDP
All	100	4.4
Private	**34**	**1.5**
Out-of-pocket*	16	0.7
Private Insurance	16	0.7
Other	2	0.1
Public	**66**	**2.9**
Medicare	48	2.1
Medicaid	14	0.6
Other	4	0.2

Source: U.S. Department of Health and Human Services.

sources: either OOP directly or indirectly through insurance payments. Private payments accounted for 12.3 percent of per capita GDP for the elderly while Medicaid accounted for 5.2 percent. In addition, both private and Medicaid payments for medical care as a share of per capita GDP are increasing with age. Note that Medicaid's share of total expenditures net of Medicare is increasing in age as well, it is 22 percent for 65 to 74 year-olds, 29 percent for 75 to 84 year-olds, and 41 percent for individuals ages 85 and up. Older individuals are more likely to currently have large medical expenditures and to have been impoverished by large OOP medical expenditures in earlier years, making them now eligible for Medicaid transfers.

Table 3: Per capita private and Medicaid health expenditures as percent of per capita GDP, 2002

Age	Private	Medicaid
65+	12.3	5.2
65-74	9.7	2.7
75-84	12.7	5.2
85+	21.6	15.1

Source: U.S. Department of Health and Human Services.

2.2 Nursing Home Care

According to the U.S. Department of Health and Human Services, in 2002 nursing home care accounted for 23 percent of personal health expenditures for individuals ages 65 and over and 1.01 percent of GDP. However, since only 4 percent of the elderly resided in nursing homes (Federal Agency Forum of Aging-Related Statistics), the cost per nursing home resident was substantially higher – 225 percent of per capita GDP. Consistent with these statistics, the Metlife Market Survey of Nursing Home and Assisted Living Costs reports that the average daily rate for a private room in a nursing home in 2005 was $203 or $74,095 annually while the average daily rate for a semiprivate room was $176 or $64,240 annually.

Nursing home expenses in the U.S. are predominantly financed either OOP or publicly by either the Medicare or Medicaid programs. However, Medicare coverage for nursing home care is limited in that it only covers costs for the first six months of care and partially subsidizes the next six months. Thus while Medicare is the primary payer of nursing home costs for residents with short-term stays (stays of less than one year) its contribution to costs after the first year is extremely small. In addition private insurance markets for long-term care are scarce. While this is in part due to supply-side problems that results in high costs and unreliable coverage, Brown and Finkelstein (2008) find that the lack of private long-term care insurance markets is in part because the public insurance system (Medicare and Medicaid) substantially crowds-out private insurance. This occurs despite the fact that the public insurance system is extremely poor in that it provides only a limited amount of reduction in risk exposure to all except the poorest individuals. Given the non-existent coverage of long-stay nursing home costs by the Medicare program and the lack of/disincentives for private insurance it is not surprising that, relative to other health expenditures, only a small amount of nursing home care costs are covered by Medicare or through private insurance. As a result, nursing home costs are primarily funded either out-of-pocket (28 percent) or by Medicaid (45 percent). Table 4 provides a breakdown of nursing home care expenses for

Table 4: Sources of Payment for Nursing Home/Long-term care Institution for Individuals Ages 65 and Over, 2002

Source of Payment	% of NH residents ‡	% of total NH exp.‡‡	% of GDP ‡‡
Total NH exp.	100	100	1.01
Private	**26**	**40**	**0.41**
Out-of-pocket		28	0.28
Private Insurance		8	0.08
Other		4	0.04
Public	**74**	**60**	**0.61**
Medicare	15	13	0.13
Medicaid	58	45	0.45
Other	1	2	0.02

‡ Source: Kaiser Commission on Medicaid and Uninsured, prepared by E. O'Brien and R. Elias, 2004
‡‡ Source: U.S. Department of Health and Human Services, 2002.

individuals by payment source. The table also shows the breakdown of all nursing home residents by payment type. Note that the majority, 58 percent, of nursing home residents at any given time are Medicaid recipients while the smallest percentage are financed through Medicare.

Moreover, there are important differences in the Medicaid qualifications for medical expenses versus nursing home expenses. In particular, non-nursing home recipients of Medicaid are allowed to keep their homes, cars, income, and other assets guaranteeing them a certain level of consumption. However, nursing home residents on Medicaid must contribute all their non-home, non-car assets until they have less than $2,000 and all of their monthly income, excluding a small (between $30 and $90) "personal needs allowance" to their nursing home and medical expenses. Although they can keep their home and car while confined to a nursing home, these assets do not contribute much if any to their level of consumption. In a nursing home facility, Medicaid covers room and board, nursing care, therapy care, meals, and general medical supplies. However, Medicaid will not pay for a single room, personal television and cable, phone and service, radios, batteries, clothes and shoes, repairs of personal items, personal care services, among other goods and services. The result is that the quality of life delivered to Medicaid-funded nursing home residents falls well below that of privately-financed nursing home residents. This view is supported by survey evidence documented by Ameriks et al. (2007). They find that wealthy people tend to avoid public long-term care due to its low quality of life. This avoidance is termed "Medicaid aversion."[3]

[3]There is plentiful informal evidence on "Medicaid aversion" in the media with statements such as "...I know what a humiliation it was to my hard-working, upper-middle-class mother to wind up a charity case.

Most estimates suggest that at age 65 the probability of ever entering a nursing home before death is somewhere between 0.3 and 0.4 and the average duration of stay is approximately 2 years. However, while the majority of entrants will spend less than 1 year in the home, with very little out-of-pocket expense risk thanks to Medicare, a smaller but still sizable risk of long-term stay in a nursing home remains with an even smaller but non-negligible risk of extended stay and enormous expenses. For example, Brown and Finkelstein (2008) estimate, consistently with the findings of Dick, Garber, and MaCurdy (1994), that approximately 40 percent of entrants will spend more than 1 year in a nursing home, while approximately one fifth will spend more than 5 years.

In our theoretical analysis, we capture the differential public insurance for nursing home versus medical expenses by allowing for a differential in the consumption floor guaranteed under a medical bankruptcy versus nursing home bankruptcy and calibrating the differential to be consistent with the data on Medicaid's share of total nursing home expenses. We show that this differential insurance for medical versus nursing home expenses plays an important role in the saving behavior of the wealthy.

2.3 Distribution of Out-of-Pocket Health Expenditures

To assess the cross-sectional inequality in health expenditures, we use the Health and Retirement Survey, waves 2002, 2004 and 2006, covering medical and nursing home expense information for the years 2000 through 2005. Our sample includes single individuals 65 years old and over, who are not married or cohabiting in any point over the survey.[4] We include insurance premia in the out-of-pocket health expenditures. Table 5 presents a set of moments describing the distribution of OOP medical and nursing home expenses for this sample.

We find that the distribution of OOP health expenses across the elderly is highly inequality, with a Gini coefficient of 0.73 and a normalized standard deviation of 2.14. In addition, the expenses are highly concentrated at the top of the distribution, with the top 10 percent of the elderly accounting for more than half and the top 1 percent for a quarter of total OOP expenses. Moreover, the OOP expenses increase with permanent income. Since the data on the lifetime earnings is not available to us, we use social security income (SSI) as a

" New York Times, September 29, 2008, "Choosing Long-Term Care: Advice From an Expert."

[4]In this version of the paper, we restrict the sample to single individuals because the model presented in the next section does not incorporate marriages. This abstraction substantially simplified our analysis which was important at the first stage of this research. However, we recognize that a more rigorous policy analysis requires taking into account married households not only because they potentially face a different OOP health expense risk, but also a spousal survival risk and a potentially smaller nursing home risk. Therefore, we plan to address this issue in the future draft of the paper.

Table 5: OOP Health Expense Distribution: Selected Moments

OOP Health Expenses		
Gini	0.73	
Shares of Total, %		
First Quintile	0.02	
Second Quintile	1.36	
Third Quintile	7.94	
Fourth Quintile	17.94	
Fifth Quintile	73.03	
Top 10%	57.3	
Top 5%	45.52	
Top 1%	24.25	
Shares and Mean Expenses of SSI groups, %	*shares*	*mean*†
First Quintile	13.4	17
Second Quintile	16.7	21
Third Quintile	18.4	23
Fourth Quintile	23.0	29
Fifth Quintile	28.5	36
Top 10%	7.5	
Top 5%	6.5	
Top 1%	1.4	

Source: 2002, 2004, and 2006 Data from the Health and Retirement Study.
† normalized by p.c. income

proxy. The top SSI quintile spends OOP about twice as much as the bottom quintile. Such a pattern is expected in the presence of a means-tested subsidy which provides more social insurance to the lower-income quintiles. Although some studies find that the rich spend more on health services not only due to lower subsidies, but also due to consumption of higher quantity/quality of health services (see, for example, De Nardi, French and Jones (2006)), in this analysis we take an extreme but simple view that attributes the differences in the OOP health expenses across income groups entirely to the means-testing of social insurance.

3 The Model

In light of the evidence presented in the previous section, we model nursing home care explicitly to allow for differential treatment of medical and nursing home expenses by public policy. Our theoretical analysis focuses on OOP health expenditure risk and Medicaid program. We do not model Medicare because we do not model demand for health care, but treat health expenses as exogenous shocks. In such an environment an entitlement program as Medicare has no effect on individual behavior apart from the tax distortions induced by the public finance of Medicare.

3.1 Economic Environment

Time is discrete. The economy is populated by overlapping generations of individuals. An individual lives to a maximum of J periods. During the first R periods of his life the individual works, and at the age $R+1$ he retires. While working, the individual faces uncertainty about his earnings, and starting from the retirement age, he faces uncertainty about his survival, medical expenses, and nursing home needs. The government runs a social insurance program that guaranties a minimum consumption level in case of a bankruptcy. This level differs by the type of bankruptcy: consumer bankruptcy for workers, medical bankruptcy for retired non-nursing home residents and nursing home bankruptcy for nursing home residents. In addition, the government runs a pay-as-you-go social security program. Markets are competitive.

Individual earnings evolve over the life-cycle according to a function $\Omega(j, z)$ that maps individual age j and current earnings shock z into efficiency units of labor, supplied to the labor market at wage rate w. The earnings shock z follows an age-invariant Markov process with transition probabilities given by $\Lambda_{zz'}$. The efficiency units of the new-born workers is distributed according to a p.d.f. Γ_z.

Similarly, medical expenditures evolve stochastically according to a function $M(j, h)$ that maps individual age j and current expenditure shock h into out-of-pockets costs of health care. The medical expenditure shock h follows an age-invariant Markov process with transition probabilities $\Lambda_{hh'}$. Initial distribution of medical expenditure shocks is given by Γ_h and it is independent of the individual state.

Nursing home needs arise with probability θ_{j+1} at each age $j > R$, and this probability increases with age. For simplicity, we assume that nursing home is an absorbing state. While in a nursing home, agents have constant medical expenditure M^n, which corresponds to the health shock value h^n.

There are no insurance markets to hedge neither earnings, medical expenditure, nursing home, nor mortality risks. Self-insurance is achieved with precautionary savings (labor supply is exogenous). Individuals cannot borrow. Unintended bequests are taxed away by the government and are used to finance government expenditure and social insurance transfers.

3.2 Demographics

Agents face survival probabilities that are conditional on both age and nursing home status. The probability that an age-$(j-1)$ individual survives to age j is s_j if he is not residing in a nursing home, and $s_j^n < s_j$ if he is in a nursing home. Since a working-age agent faces neither mortality nor nursing home risk, his survival probability is $s_j = 1$, $j = 1, 2, ..., R$. An age-$(j-1)$, retired individual, on the other hand, enters a nursing home in period j with probability $\theta_j > 0$. Let λ_j denote the fraction of cohort j residing in a nursing home. This fraction is zero for working-age cohorts. For a newly retired cohort, the fraction is just the probability of entering a nursing home, so $\lambda_{R+1} = \theta_{R+1}$. Finally, for a retired cohort of age $R+1 < j \leq J$, the fraction λ_j evolves according to

$$\lambda_j = \frac{\theta_j s_j (1 - \lambda_{j-1}) + s_j^n \lambda_{j-1}}{\bar{s}_j},$$

where the denominator, $\bar{s}_j = s_j(1 - \lambda_{j-1}) + s_j^n \lambda_{j-1}$, is the average survival rate from age $j-1$ to j and the numerator is a weighted sum of the survival rate of new entrants and the survival rate of current residents.

Population grows at a constant rate n. Then the size of cohort j relative to that of cohort $j-1$ is

$$\eta_j = \frac{\eta_{j-1} \bar{s}_j}{1+n}, \text{ for } j = 2, 3, ..., J.$$

3.3 Workers' Savings

State of a working individual includes his age j, assets a, average lifetime earnings to date $\bar{e}$, and current productivity shock z. An individual allocates his assets, taxable income y (from interest income ra and labor earnings e net of labor earnings taxes $\tau_e(e)$) less income taxes $\tau_y(y)$, and transfers from the government $T(j, y, a)$ between consumption c and savings a' by solving

$$V(j, a, \bar{e}, z) = \max_{c, a' \geq 0} \{U(c) + \beta E_z V(j+1, a', \bar{e}', z')\} \quad (1)$$

subject to

$$
\begin{aligned}
c + a' &= a + y - \tau_y(y) + T(y, a), && (2)\\
y &= e - \tau_e(e) + ra, && (3)\\
e &= w\Omega(j, z), && (4)\\
\bar{e}' &= (e + j\bar{e})/(j + 1), && (5)\\
T(y, a) &= \max\left\{0, \underline{c}^w - [a + y - \tau_y(y)]\right\}. && (6)
\end{aligned}
$$

where $\underline{c}^w$ is a minimum consumption level for consumer bankruptcy.

3.4 Old-age Health Care

Retired individuals face uncertainty about their medical and nursing home needs. Nursing home state is entered once and for all, but every period individuals can choose between private and public nursing home care. An individual's nursing home status is denoted by the variable l, which takes a value of either 0, indicating that the individual is currently not in a nursing home, or 1 − currently in a private nursing home care, or 2 − currently in a public nursing home care.

3.4.1 Medical care

A working individual of age R with state $(a, \bar{e}, z)$, conditional on surviving to the next period, upon retirement, will enter a nursing home with probability θ_{R+1}. His future state contains a health shock, h', that determines his medical care costs. The problem of this individual is

$$
V(R, a, \bar{e}, z) = \max_{c,a' \geq 0} \left\{U(c) + \beta s_{R+1}(1 - \theta_{R+1}) EV(R + 1, a', \bar{e}', h', 0) + \right. \quad (7)
$$

$$
\left. \beta s_{R+1}\theta_{R+1} \max\left[V(R + 1, a', \bar{e}', h^n, 1), V(R + 1, a', \bar{e}', h^n, 2)\right]\right\} \quad (8)
$$

subject to the constraints above.

Resources of a retired individual of age $j > R$ come from the return on his savings $(1 + r)a$; his social security benefit $S(\bar{e})$ and government transfers $T(j, a, \bar{e}, h)$. After paying health care costs $M(j, h)$ and income taxes, the individual allocates the remaining resources between consumption and savings. We assume that the health shock does not directly affect agents' utility. An age-j individual with assets a, average life-time earnings $\bar{e}$, health shock h, and who is not in a nursing home solves

$$V(j,a,\bar{e},h,0)=\max_{c,a'\geq 0}\{U(c)+\beta s_{j+1}(1-\theta_{j+1})E_hV(j+1,a',\bar{e},h',0)+ \\ \beta s_{j+1}\theta_{j+1}\max\left[V(j+1,a',\bar{e},h^n,1),V(j+1,a',\bar{e},h^n,2)\right]\} \tag{9}$$

subject to

$$c+M(j,h)+a'=a+y-\tau_y(ra)+T(j,a,h), \tag{10}$$

$$y=S(\bar{e})+ra, \tag{11}$$

$$T(j,a,h)=\max\{0,\underline{c}^m+M(j,h)-[a+y-\tau_y(ra)]\} \tag{12}$$

where $\underline{c}^m$ is a minimum consumption level for medical bankruptcy.

3.4.2 Nursing home care

Once nursing home needs arise, individual has to choose between private and public nursing home care. We assume that private care differs from the public one only in the consumption value it provides (nicer rooms but the same medical care). Public nursing home care provides a uniform level of consumption, denoted by $\underline{c}^n$. By setting $\underline{c}^n<\underline{c}^m$ we intent to capture lower insurance provided under nursing home banruptcy. Hence per resident cost of nursing home care to the government is $M^n+\underline{c}^n$. To qualify for public long-term care, an individual must meet eligibility criteria: his income net of taxes plus the value of assets have to fall below a threshold level. For simplicity, we assume that an individual surrenders all of his assets as well as current and future pension income to the government and has no further decision to make.

An individual in private nursing home care decides how much to save and whether to enter a public nursing care by solving

$$V(j,a,\bar{e},h^n,1)=\max_{c,a'\geq 0}\left\{u(c)+\beta s^n_{j+1}\max\left[V(j+1,a',\bar{e},h^n,1),V(j+1,a',\bar{e},h^n,2)\right]\right\} \tag{13}$$

subject to

$$c+M^n+a'=a+y-\tau_y(ra), \tag{14}$$

$$y=S(\bar{e})+ra, \tag{15}$$

where

$$V(j+1,a',\bar{e},h^n,2)=\sum_{i=j}^{J}\left[\beta^{i-j}\prod_{k=j}^{i-1}s^n_{k+1}u(\underline{c}^n)\right]\equiv\bar{V}^n_{j+1}.$$

Note that there are no government transfers to the individuals in a private nursing home care.

3.5 Goods Production

Firms produce goods by combining capital K and labor L according to a constant-returns-to-scale production technology: $F(K, L)$. Capital depreciates at rate δ and can be accumulated through investments of goods: $I = K' - (1-\delta)K$. Firms maximize profits by renting capital and labor from households. Perfectly competitive markets ensure that factors of production are paid their marginal products. Goods can be consumed by individuals, used in health care and invested in physical capital.

3.6 General Equilibrium

We consider a steady-state competitive equilibrium in this economy. For the purposes of defining an equilibrium in a compact way, we suppress the individual state into a vector (j, x), where

$$x = \begin{cases} x_W \equiv (a, \bar{e}, z), & \text{if } 1 \leq j \leq R, \\ x_R \equiv (a, \bar{e}, h, l), & \text{if } R < j \leq J, \end{cases}$$

Accordingly, we redefine value functions, decision rules, taxable income and transfers to be functions of the individual state (j, x): $V(j, x)$, $c(j, x)$, $a'(j, x)$, $l(j, x_R)$, $y(j, x_W)$ and $T(j, x)$. Define the individual state spaces $X_W \subset [0, \infty) \times [0, \infty) \times (-\infty, \infty)$, $X_R \subset [0, \infty) \times [0, \infty) \times (-\infty, \infty) \times \{0, 1, 2\}$, and denote by $\Xi(X)$ the Borel σ-algebra on X. Let $\Psi_j(X)$ be a probability measure of individuals with state $x \in X$ in cohort j. Note that these agents constitute an $\eta_j \Psi_j(X)$ fraction of the total population.

DEFINITION. A steady-state equilibrium is $\{c(j, x), a'(j, x), l(j, x_R), V(j, x)\}_{x \in \{x_W, x_R\}}$, $\{\Psi_j\}_{j=1}^J$, $\{w, r, K, L\}$ and $\{\tau_s(e), d, \tau_y(y), S(\bar{e})\}$ such that

1. Given prices, the decision rules $c(j, x)$, $a'(j, x)$, $l(j, x_R)$ solve the dynamic programming problems of the households (1),(7),(9),and (13).

2. Prices are competitive:

   (a) $w = F_L(K, L)$

   (b) $r = F_K(K, L) - \delta$

3. Markets clear

(a) Goods: $\sum_j \eta_j \int_X c(j,x)d\Psi_j + (1+n)K + \tilde{M} + G = F(K,L) + (1-\delta)K$

(b) Capital: $\sum_j \eta_j \int_X a'(j,x)d\Psi_j = (1+n)K$

(c) Labor: $\sum_j \eta_j \int_X \Omega(j,z)d\Psi_j = L$

(d) Medical care:
$\sum_{j=R}^{J} \eta_j \int_{X_R} \{M(j,h)\mathbf{I}[l(j,x)=0]d\Psi_j + M^n\mathbf{I}[l(j,x)>0]\}\, d\Psi_j = \tilde{M}.$

4. The laws of motion for the invariant distributions of agents are consistent with the individual behavior:

$$\Psi_{j+1}(X_0) = \int_{X_0} \left\{ \int_X Q_j(x,x')\mathbf{I}\,[j'=j+1]\, d\Psi_j \right\} dx'$$

for all $X_0 \in \Xi$, where

$$\begin{aligned}
Q_j(x,x') \equiv\ & \mathbf{I}\,[j=1, a'=a'(1,a,0,z), \bar{e}'=w\Omega(1,z)]\,\Gamma_z \\
& + \mathbf{I}\,[1 \le j < R, a'=a'(j,a,\bar{e},z), \bar{e}'=(w\Omega(j,z)+j\bar{e})/(j+1)]\,\Lambda_{z,z'} \\
& + \mathbf{I}\,[j=R, a'=a'(R,a,\bar{e},z), \bar{e}'=\bar{e}] \\
& \times \{\Gamma_{h'}\mathbf{I}\,[l'=0]\,(1-\theta_{R+1}) + \mathbf{I}\,[h'=h^n, l'>0]\,\theta_{R+1}\} \\
& + \mathbf{I}\,[R < j \le J, a'=a'(j,a,\bar{e},h,0), \bar{e}'=\bar{e}] \\
& \times \{\Gamma_{h,h'}\mathbf{I}\,[l'=0]\,(1-\theta_{j+1}) + \mathbf{I}\,[h'=h^n, l'=1]\,\theta_{j+1}\}\, \frac{s_{j+1}}{\bar{s}_{j+1}} \\
& + \mathbf{I}\,[R < j \le J, a'=a'(j,a,\bar{e},h^n,1), \bar{e}'=\bar{e}, l'=1]\, \frac{s^n_{j+1}}{\bar{s}_{j+1}} \\
& + \mathbf{I}\,[R < j \le J, a'=0, \bar{e}'=\bar{e}, l'=2]\, \frac{s^n_{j+1}}{\bar{s}_{j+1}}
\end{aligned}$$

and $\mathbf{I}$ is an indicator function.

5. Social security payments are financed by labor earnings taxes:

$$SStransfers = EarnsTaxes$$

where total earnings tax revenue is

$$EarnsTaxes = \sum_{j=1}^{R} \eta_j \int_{X_W} \tau_e(e)d\Psi_j,$$

and total social security payments is

$$SStransfers = \sum_{j=R+1}^{J} \eta_j \int_{X_R} S(\bar{e}) d\Psi_j.$$

6. Government budget is balanced:

$$IncTaxes + Bequests = MTTransfers + GovtSpend$$

where income taxes are given by

$$IncTaxes = \sum_{j=1}^{J} \eta_j \int_X \tau_y(y(j,x)) d\Psi_j,$$

bequests are given by

$$\begin{aligned} Bequests = \frac{1+r}{1+n} \sum_{j=R+1}^{J} \eta_{j-1} \int_X \{\mathbf{I}[l(j-1,x)=0](1-s_j) \\ +\mathbf{I}[l(j-1,x)>0](1-s_j^n)\} \, a'(j-1,x) d\Psi_{j-1} \end{aligned}$$

total means-tested transfer payments are

$$\begin{aligned} MTTransfers = \sum_{j=1}^{J} \eta_j \int_X T(j,x) d\Psi_j + \sum_{j=R+1}^{J} \eta_j \left(M^n + \underline{c}^n - S(\bar{e})\right) \int_{X_R} \mathbf{I}[l(j,x)=2] d\Psi_j \\ - \frac{1+r}{1+n} \sum_{j=R+2}^{J} \eta_{j-1} \int_{X_R \times X_R} \mathbf{I}[l(j-1,x)<2, l(j,x')=2] a'(j-1,x) Q(x,x') d\Psi_{j-1} d\Psi_j, \end{aligned}$$

and the government spends

$$GovtSpend = G.$$

4 Calibration

The model is calibrated to match a set of aggregate and distributional moments for the U.S. economy, including demographics, earnings, medical and nursing home expenses, as well as features of the U.S. social welfare, Medicaid, social security and income tax systems. Some of the parameter values can be determined ex-ante, others are calibrated by making the moments generated by a stationary equilibrium of the model target corresponding moments in the data. The calibration procedure minimizes the difference between the targets from the data and model-predicted values. Our calibration strategy for stochastic processes for earnings and medical expenses is similar to Castaneda et al. (2003): we do not restrict the processes to, for example, AR(1), but instead target a wide set of moments characterizing the earnings and OOP health expense distributions. Unlike Castaneda et al., we do not target the distribution of wealth because our objective is to learn how much wealth inequality can be generated by idiosyncratic risk in earnings, health expenses and survival in a pure life-cycle model.

We start by presenting functional forms and setting parameters whose direct estimates are available in the data. Although the calibration procedure identifies the rest of the parameters by solving a simultaneous set of equations, for expositional purposes, we divide the parameters to be calibrated into groups and discuss associated targets and their measurement in the data. Most of the data statistics used in the calibration procedure are averages over or around 2000-2006, which is the time period covered by the HRS. More fundamental model parameters rely on long-run data averages.

4.1 Age structure

In the model, agents are born at age 21 and can live to a maximum age of 100. We set the model period to two years because the data on OOP health expenses is available bi-annually. Thus the maximum life span is $J = 40$ periods. For the first 44 years of life, i.e. the first 22 periods, the agents work, and at the beginning of period $R + 1 = 23$, they retire.

Population growth rate n targets the ratio of 65 years old and over to those 21 years old and over. According to U.S. Census Bureau, this ratio was 0.18 in 2000. We target this ratio rather than directly set the population growth rate because the weight of the retired in the population determines the tax burden on workers, which is of a primary importance to our policy analysis.

4.2 Preferences

The momentary utility function is assumed to be of the constant-relative-risk-aversion form

$$U(c) = \frac{c^{1-\gamma}}{1-\gamma},$$

so that $1/\gamma$ is the intertemporal elasticity of substitution. Based on estimates in the literature, we set γ equal to 2.0. The subjective discount factor, β is determined in the calibration procedure such that the rate of return on capital in the model is consistent with an annual rate of return of 4 percent.

4.2.1 Technology

Consumption goods are produced according to a production function,

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

where capital depreciates at rate δ. The parameters α and δ are set using their direct counterparts in the U.S data: a capital income share of 0.3 and an annual depreciation rate of 7 percent (Gomme and Rupert (2007)). The parameter A is set such that the wage per an efficiency unit of labor is normalized to one under the baseline calibration .

4.3 Earnings Process

In the model, worker's productivity depends on his age and an idiosyncratic productivity shock according to a function $\Omega(j, z)$. We assume that this function consists of a deterministic age-dependent component and a stochastic component as follows:

$$\log \Omega(j, z) = \beta_1 j + \beta_2 j^2 + z,$$

where z follows a finite-valued Markov process with probability transition matrix $\Lambda_{zz'}$. Initial productivity levels are drawn from the distribution Γ_z.

We assume that there are 4 possible values for z. Thus specifying the earnings process requires setting 26 parameters: the 2 coefficients on age and age-squared in the deterministic component, the 4 productivity shock levels, the 16 elements of $\Lambda_{zz'}$ and the 4 points of the initial distribution of z. In order to reduce the number of unknowns, we fix the grid points. Moreover, we assume that the probabilities of going from the two lowest productivity levels to the highest one are 0. This restriction combined with imposing the condition that the rows of $\Lambda_{zz'}$ must sum to one reduces the number of parameters in the probability transition matrix that must be calibrated from 16 to 10. Finally imposing that the elements of the initial distribution sum to one leaves 15 parameters that need to be determined.

The coefficients on age and age-squared are obtained from 1968 to 1996 PSID data for male workers.[5] Thus β_1 is set to 0.109 and β_2 is set to -0.001. The 13 remaining parameters

[5] The sample is restricted to the heads of household, between the age of 18 and 65, not self-employed, not working for the government, working at least 520 hours during the year; excluding observations with the average hourly wage (computed as annual earnings over annual hours worked) less than half the minimum wage in that year; weighted using the PSID sample weights. We thank Gueorgui Kambourov for providing us with the regression results.

are chosen by targeting the variance of log earnings of 55 year-olds relative to 35 year-olds, the first-order autocorrelation of the process's stochastic component, the Gini coefficient for earnings, 8 points on the Lorenz curve for earnings, corresponding to the five quintiles and top 1,5, and 10 percent of the distribution, and mean Social Security income levels by Social Security income quintile. Using PSID data, Storesletten et al. (2004) estimate the variance of log annual earnings to be 0.46 for 35 year-olds and 0.87 for 55 year-olds. Thus we target a relative variance for 55 year-olds of 1.89. The target for the first-order autocorrelation of annual z is 0.98, taken from Guvenen (2008) and also based on PSID data. The data points for the earnings Lorenz curve are taken from Rodriguez at el. (2002). The targets on mean Social Security by quintile are computed using the sample from the HRS data described in Section 2. We target mean Social Security income by quintiles since we also target mean OOP medical expenditures by Social Security income quintiles, as discussed below. We use social security income quintiles as a proxy for lifetime earnings quintiles because lifetime earnings is not available to us.

4.3.1 Medical Expense Process

Retired agents not residing in a nursing home face medical expenses that are a function of their current age and medical expense shock. Similarly to the earnings process, we assume that medical expenses can be decomposed into a deterministic age component and a stochastic component:

$$\ln M(j,h) = \beta_{m,1}j + \beta_{m,2}j^2 + h,$$

where h follows a finite state Markov chain with probability transition matrix $\Lambda_{hh'}$ and newly retired agents draw their medical expense shock h from an initial distribution denoted by Γ_h.

We assume that for each age there are 4 possible medical expense levels, which we fix exogenously. Thus specifying the process for h requires choosing 20 parameters: 16 parameters specifying the probability transition matrix for h, $\Omega_{hh'}$, and 4 parameters characterizing the initial distribution of medical expenditure shocks, Γ_h. Since the rows of the transition matrix and the initial distribution must sum to one, the degrees of freedom to be determined reduces to 15. Thus, including the coefficients in the deterministic component, 17 parameters still remain to be chosen to specify the medical expense process.

To calibrate the 17 parameters governing the OOP health expense risk, we use 20 aggregate and distributional moments for OOP health expenses: the Gini coefficient and 8 points in the Lorenz curve of the OOP medical expense distribution, shares of OOP health expenses and Medicaid expenses in GDP for each age group: 65 to 74 year-olds, 75 to 84 year-olds, and those 85 and above, and the shares of the OOP health expenses that are paid by each social security income quintile, documented in Section 2. The targets and their values in the data are summarized in the next section. All targets are taken from the HRS sample described in Section 2 except for OOP and Medicaid expenses by age groups, which are 2001-2006 averages based on aggregate data from the U.S. Department of Health and Human Services. Since we include the costs of health insurance in our measure of OOP health costs, we compute OOP health expenditures in the data as the sum of all private health care expenditures.

4.3.2 Nursing Home Expense Risk

Starting at age R until the end of their lives, agents face age-specific probabilities of entering a nursing home, $\{\theta_j\}_{j=R+1}^{J}$. We assume that the probability of entering a nursing home is the same across agents within the following age groups: 65 to 74, 75 to 84, and 85 years old and above. Thus we restrict the nursing home entry probability such that

$$\theta_j = \begin{cases} \theta_{65-74}, & \text{for } 1 \leq R+j < 6, \\ \theta_{75-84}, & \text{for } 6 \leq R+j < 11, \\ \theta_{85+}, & \text{for } 11 \leq R+j \leq J. \end{cases}$$

The 3 probabilities, θ_{65-74}, θ_{75-84}, and θ_{85+}, target the percentage of nursing homes residents in each age group. According to the U.S. Census special tabulation for 2000, these percentages were 1.1, 4.7, and 18.2, respectively.

The medical cost of 2 years of nursing home care in the model economy, M^n targets the share of total nursing home expenses in GDP. According to the U.S. Department of Health and Human Services, over the 2000 to 2005 period, the average cost of nursing home care net of Medicare payments was 0.85 percent of GDP. Note that in the model, total nursing home expenses are computed as $M^n + \underline{c}^n$.

4.3.3 Survival Probabilities

Recall that while agents of age $j = R+1, \ldots, J$ not residing in a nursing home have probability s_{j+1} of surviving to age $j+1$ conditional on having survived to age j, retired agents residing in nursing homes face different survival probabilities, given by $\{s_j^n\}_{j=R+2}^{J}$. These two sets of survival probabilities are not set to match their counterparts in the data for two reasons: first, there are no estimates of survival probabilities by nursing home status available for the U.S., and second, since we are targeting statistics on aggregate nursing home costs, it is important for the model to be consistent with the data on nursing home usage. Therefore, the survival probabilities are set as follows. First, we assume that for each cohort, the probability of surviving to the next age while in a nursing home is a constant fraction of the probability of surviving to the next age outside of a nursing home:

$$s_j^n = \phi^n s_j, \quad \text{for } j = R+2, \ldots, J.$$

Then we pin-down the value of ϕ^n by targeting the fraction of individuals aged 65 and over residing in nursing homes in the U.S. in 2000 subject to the restriction that the unconditional age-specific survival probabilities are consistent with those observed in the data.[6] According to U.S. Census special tabulation for 2000, the fraction of the 65 plus population in a nursing home in 2000 was 4.5 percent.

4.3.4 Government

The government-run welfare program in the model economy guarantees agents a minimum consumption level. The welfare program, which is available to all agents regardless of age, represents public assistance programs in the U.S. such as food stamps, Aid to Families with Dependent Children, Supplemental Social Security Income, and Medicaid. Since estimates of the government-guaranteed consumption levels for working versus retired individuals are found to be very similar, we assume that they are the same. However, the consumption level provided by the government differs for nursing home versus medical bankruptcy. In the literature, estimates of the consumption level for a family consisting of one adult and two children is approximately 35 percent of expected average annual lifetime earnings, while the minimum level for retired households has been estimated to be in the range of 15 to 20 percent (Hubbard, Skinner, and Zeldes (1994) and Scholz, Seshadri, and Khitatrakun (2006)).[7] These estimates suggest that the minimum consumption floor for individuals is somewhere in the range of 10 to 20 percent. However, this statement should be taken with caution. The consumption floor is difficult to measure due to the large variation and complexity in welfare programs and their coverage. In addition, families with 2 adults and adults under 65 without children would receive substantially less in benefits then found above. Consistent with this, by estimating their model, DeNardi, French, and Jones (2006), find a much lower minimum consumption level: approximately 8 percent of expected average

[6]The data on survival probabilities is taken from Table 7 of *Life Tables for the United States Social Security Area 1900-2100* Actuarial Study No. 116 and are weighted averages of the probabilities for both men and women born in 1950.

[7]The average of expected average annual lifetime earnings in 1999 is computed as a weighted average of estimates of average lifetime earnings for different education groups taken from *The Big Payoff: Education Attainment and Synthetic Estimates of Work-Life Earnings.* U.S. Census Bureau Special Studies. July 2002. The weights are taken from *Education Attainment: 2000* Census Brief. August 2003.

annual lifetime earnings. This is similar to a value of about 6 percent used by Palumbo (1999). However, health expenses in the model of DeNardi et al. include nursing home costs, and hence their estimate is not directly comparable to the non-nursing home minimum consumption level in our model. Thus we do not use their estimate, instead, inline with the range of values found in the literature, we set the consumption floor for consumer and medical bankruptcy, $\underline{c}^w = \underline{c}^m$, to 10 percent of the average value of the agents' expected average lifetime earnings.

The consumption floor for nursing home bankruptcy can not be inferred from data since it consists of the values placed on the rooms and amenities that nursing homes provide to Medicaid-funded residents. Thus, the minimum consumption level for nursing home residents, $\underline{c}^n$, is calibrated to target Medicaid's share of nursing home expenses. Over the period 2000 to 2005, according the U.S. Department of Health and Human Services, on average, Medicaid's share of total nursing home expenses net of those paid by Medicare was 52 percent.

The social security benefit function in the model captures the progressivity of the U.S. social security system by making the marginal replacement rate decrease with average lifetime earnings. Following Fuster, Imrohoroglu, and Imrohoroglu (2006), the payment function is set to be consistent with the one used by the U.S social security system. The marginal tax replacement rate is 90 percent for earnings below 20 percent of the economy's average lifetime earnings $\bar{E}$, 33 percent for earnings above that threshold but below 125 percent of $\bar{E}$, and 15 percent for earnings beyond that up to 246 percent of $\bar{E}$. There is no replacement for earnings beyond 246 percent of $\bar{E}$. Hence the payment function is

$$S(\bar{e}) = \begin{cases} s_1\bar{e}, & \text{for } \bar{e} \leq \tau_1, \\ s_1\tau_1 + s_2(\bar{e} - \tau_1), & \text{for } \tau_1 \leq \bar{e} \leq \tau_2, \\ s_1\tau_1 + s_2(\tau_2 - \tau_1) + s_3(\bar{e} - \tau_2), & \text{for } \tau_1 \leq \bar{e} \leq \tau_2, \\ s_1\tau_1 + s_2(\tau_2 - \tau_1) + s_3(\tau_3 - \tau_2), & \text{for } \bar{e} \geq \tau_3. \end{cases}$$

where the marginal replacement rates, s_1, s_2, and s_3 are set to 0.90, 0.33, and 0.15, respectively. While the threshold levels, τ_1, τ_2, and τ_3, are set respectively to 20 percent, 125 percent and 246 percent of the economy's average lifetime earnings.

The payroll tax which is used to fund the social security system is assumed to be proportional, thus

$$\tau_e(e) = \hat{\tau}_e e,$$

where the tax rate $\hat{\tau}_e$ is determined in equilibrium. Likewise, income taxes in the model economy are assumed to be proportional so that

$$\tau_y(y) = \hat{\tau}_y y.$$

The tax rate $\hat{\tau}_y$ is also determined in equilibrium. Finally, government spending, G is set such that, in equilibrium, government spending as a fraction of output is 19 percent.

4.4 Baseline calibration

The model parametrization is summarized in Table 6. The transition probability matrices and other parameters governing the earnings and OOP health expense processes are included in the Appendix. The benchmark model performance relative to calibration targets is discussed in the next section.

5 Life-cycle Theory of Inequality

Building a life-cycle theory of economic inequality is crucial for a social insurance policy analysis for many reasons. To name a few, first, social safety nets target the low income population. Second, different sources of uncertainty potentially induce differential saving responses across the permanent income distribution. Finally, when wealth is highly concentrated in the hands of a few, their saving behavior has large consequences for the whole economy.

In this section we first discuss the performance of the benchmark economy with respect to the data targets outlined in the calibration section. We then assess the ability of the calibrated model to generate cross-sectional and life-cycle wealth inequality as observed in the U.S. economy and examine the contribution of precautionary savings to wealth accumulation and inequality.

The exogeneity of the earnings distribution allows us to calibrate it with a much greater precision then other sources of risk in the model economy. Since the contribution of our analysis comes from modeling medical and nursing home expense risk, we confine our discussion to the latter, while reporting the fit of the earnings distribution in the Appendix.

5.1 Medical and Nursing Home Expenses

In the data, individual medical expenses are observed only net of public subsidies. Hence we calibrate the stochastic process for total medical and nursing home expenses to match the observed distribution of OOP health expenses across the population and their aggregate

Table 6: Calibrated Parameters

parameter	description	values
β	subjective discount factor	0.92*
γ	coefficient of risk aversion	2.0
n	population growth rate	0.021
	consumption floors	
$\underline{c}^w$	consumer bankruptcy	0.1
$\underline{c}^m$	medical bankruptcy	0.1
$\underline{c}^n$	nursing home bankruptcy	0.035
ϕ^n	relative survival probability for nursing home residents	0.92
	probabilities of entering a nursing home	
θ_{65-74}	65 to 74 year-olds	0.004
θ_{75-84}	75 to 84 year-olds	0.0136
θ_{85+}	85 and up	0.0551
	coefficients in the deterministic component of medical expenses	
$\beta_{m,1}$	age	0.15
$\beta_{m,2}$	age-squared	−0.004
A	TFP in production	1.17
α	capital's share of output	0.3
δ	capital's deprecation rate	0.07

*All numbers are annual unless otherwise noted.

levels. In particular, we target the cross-sectional distribution of OOP expenses, shares of OOP and Medicaid expenses in GDP by age group, and the distribution of OOP expenses by social security income. Moreover, the nursing home expense process targets the distribution of nursing home residents and aggregate nursing home costs by source of payment. The results of the calibration procedure are presented in Table 7. Overall, the distribution of the OOP health expenses in the benchmark economy successfully replicates the set of all but one data moment. The model OOP health expense distribution is slightly less concentrated at the top 1% than in the data, implying that our economy features slightly less risk than in the data. The implication of this shortfall is that our policy analysis will deliver slightly smaller effects of the OOP health expense risk. Table 8 summarizes the cross-sectional targets from Table 7 into aggregate statistics for the benchmark economy, showing a good model fit with the data on aggregate. Among the independent moments characterizing health expenses, the model slightly over predicts the fraction of nursing home residents receiving Medicaid subsidy but does well on the normalized standard deviation of OOP health expenses.

5.2 Wealth Inequality

Before going to model predictions about wealth inequality under the benchmark calibration, it is useful to discuss the driving forces behind wealth inequality. In the model economy, individuals face uncertainty about their earnings, medical and nursing home expenses, and survival. Agents are borrowing constrained and private insurance markets are nonexistent. Thus agents have strong incentives to use precautionary savings to smooth lifetime consumption. However, rich individuals will self-insure through savings much more than poor due to the presence of means-tested social insurance. This welfare program discourages savings of workers with low earnings to finance their consumption early on in the life cycle, and Medicaid further discourages savings to finance medical and nursing home expenses experienced later on in life. In addition, due to its high and highly persistent cost, self-financing of nursing home care is, for the most part, infeasible. Thus the precautionary savings of the poor are driven mostly by smaller OOP medical expense shocks rather than by nursing home expense shocks.

As permanent income increases, individuals become less likely to qualify for Medicaid, and medical and nursing home expenses became important for savings behavior. The relatively large and persistent nursing home expenses require more savings than medical expenses. Furthermore, nursing home residents have the lowest insured consumption level, making this type of bankruptcy more painful than non-nursing home medical bankruptcy. Thus the differential insurance for medical versus nursing home bankruptcies implies that individuals

Table 7: Distribution of Medical and Nursing Home Expenses by Source of Payment

Targeted Moments	Data	Model	Data	Model
OOP Expenses				
Gini	0.73	0.73		
Shares of Total, %				
First Quintile	0.02	0.05		
Second Quintile	1.36	1.23		
Third Quintile	7.94	6.52		
Fourth Quintile	17.94	19.37		
Fifth Quintile	73.03	72.82		
Top 10%	57.3	55.75		
Top 5%	45.52	42.55		
Top 1%	24.25	15.19		
Shares and Mean Expenses of SSI groups, %	*shares*		*mean*†	
First Quintile	13.4	6.1	17	1
Second Quintile	16.7	17.3	21	16
Third Quintile	18.4	23.0	23	21
Fourth Quintile	23.0	25.3	29	23
Fifth Quintile	28.5	28.3	36	26
Top 10%	7.5	15.2		
Top 5%	6.5	8.1		
Top 1%	1.4	1.6		
Shares of GDP by Age, %				
65-74	0.61	0.62		
75-84	0.55	0.47		
85+	0.34	0.34		
Medicaid				
Shares of GDP by Age, %				
65-74	0.17	0.16		
75-84	0.23	0.33		
85+	0.23	0.38		
Nursing Home				
Costs				
Share of GDP, %	0.85	0.87		
Share of Total Health Expenses, %	39	37.6		
Medicaid Share of NH Costs, %	53	52		
Resident Share in Age Group, %				
65+	4.5	4.7		
65-74	1.1	1		
75-84	4.7	4.7		
85+	18.2	18.2		

† normalized by p.c. income

Table 8: Medical and Nursing Home Expenses: Aggregate Summary

Health Expense	Data	Model
Medical		
OOP, % of GDP	1.5	1.43
Medicaid, % of GDP	0.6	0.86
Nursing Home		
OOP, % of GDP, %	0.4	0.42
Medicaid, % of GDP	0.45	0.45
Independent Moments		
Fraction of NH residents on Medicaid	0.60	0.68
OOP expenses: std/mean	2.14	2.18

across the permanent income distribution effectively face different kinds of OOP expense risk. Finally, progressive social security provides better insurance against health expense and survival risk for the poor than the rich. How different types of OOP health expenses and the structure of the social insurance system affects savings incentives of the rich and poor is a quantitative question that our analysis seeks to answer.

To assess the model's fitness to address these questions, we compare the model's predictions about wealth inequality in the benchmark economy to that observed in the data. Recall that our calibration procedure did not target any wealth distribution moments. Table 9 reveals that the cross-sectional wealth inequality in the benchmark economy has a remarkable fit of all but one moment in the data: the share of aggregate wealth held by the top 1 percent falls 9 percentage points short of the data. Moreover, the wealth Gini in the benchmark economy is U-shaped over the life-cycle (Figure 1a), which is consistent with the pattern observed in the data (Huggett (1996)). The rise in wealth inequality at the end of the life-cycle is driven by a rising fraction of individuals with zero assets.

In an empirical analysis, Dynan, Skinner and Zeldes (2004) document that saving rates increase with current and permanent income. We compute the saving rates for each income quintile by age as the ratio of the change in asset holdings of the quintile to the current disposable income of the quintile. Figure 1b shows that in the benchmark economy individuals over the age of 40 and in the higher permanent income quintiles save a higher fraction of their current disposable income. Moreover, the two bottom quintiles start dipping into their savings well before retirement.

Table 9: Wealth: Selected Moments

Moments	Data	Model
Wealth†		
Gini	0.80	0.81
shares of total, %		
First Quintile	-0.3	0
Second Quintile	1.3	0
Third Quintile	5.0	2.2
Fourth Quintile	12.2	14.1
Fifth Quintile	81.7	83.7
Top 10%	69.1	68.6
Top 5%	57.8	57.7
Top 1%	34.7	25.7

† Data source: Rodriguez et al. (2002).

5.3 Precautionary Savings Due to Old-Age Uncertainty

How large is the contribution of precautionary savings due to uncertainty about health expenses and survival? To evaluate the role of the health expense risk, we shut down uncertainty about all health expenses, conditional on surviving, by making each retired individual face a deterministic health expense profile set to mean health expenses before Medicaid subsidies in the benchmark economy. Note that uncertainty about health expenses due to random survival still remains. Consistently with De Nardi et al. (2006) and Hubbard et al. (1994), we find that health expense risk conditional of survival plays only a little role on aggregate: precautionary savings account for 2.5 percent of the total capital stock (Table 10). However, on an individual level, conditional health expense risk is more important. Precautionary savings of the fourth and fifth permanent income quintiles account for 4.8 and 4.1 percent of their wealth respectively. The aggregate effect is smaller because the bottom two quintiles accumulate 8.6 percent more wealth as they are less likely to qualify for Medicaid subsidies due to the absence of large shocks. Not surprisingly, given that the effects of health expense risk on savings are fairly small, precautionary savings due to health expense risk contributes little to wealth inequality in the benchmark economy: elimination of health expense risk reduces the wealth Gini by 1 percentage point.

To assess the contribution of precautionary savings due to survival risk, we consider certain life times conditional on nursing home status. That is, since nursing home entry is random and it lowers the entrant's life expectancy, survival risk due to nursing home entry still remains. We set the life-time horizon of an individual who never enters a nursing home equal to the life-expectancy of the same individual in the benchmark economy. Individuals who enter nursing homes live to the age given by the life expectancy conditional on entering a nursing home at age 65 in the benchmark economy. Entering a nursing home after that age is equivalent to an immediate death. We find that survival risk is more important for savings than health expense risk. Precautionary savings due to survival risk accounts for 10 percent of the capital stock in the benchmark economy. Why does survival risk play such a large role given that social security already partially insures individuals against it? This happens for two reasons. First, social security income is insufficient for consumption finance of richer individuals, and second, the presence of health expenses and their growth with age make survival risk contribute to the lifetime health expense risk. The means-testing of Medicaid makes this risk more important for wealthier individuals. As Table 10 shows, precautionary savings due to survival risk account for a larger fraction of the wealth of the upper permanent income quintiles. Notice, however, that part of the fall in their wealth is due to a decline in their OOP health expenses. This decline occurs because none of the individuals live to ages beyond life expectancy when health expenses are, on average, the highest.

How much do health expenses matter for the importance of survival risk? To this end, we repeat the above experiment in an economy identical to the benchmark except with all health expenses removed. The change in the aggregate wealth is reported in the last column in Table 10. Without health expenses, precautionary savings due to survival risk contributes only 3 percent to the aggregate capital stock. Moreover, precautionary savings are accumulated only by the top permanent income quintile, since the rest of the population gets enough insurance from the social security system. We thus conclude that although health expense risk conditional on survival generates little precautionary savings, the presence of health expenses substantially amplifies the role of survival risk in wealth accumulation.

5.4 Medicaid

Our model allows us to examine the differential amount of insurance provided by Medicaid. Figure 2a shows that the number of Medicaid recipients increases with age since savings get depleted toward the end of the life cycle and more individuals qualify for Medicaid subsidies. The major beneficiaries of the Medicaid program are in the bottom 40 percent of the permanent earnings distribution. At the end of the life-cycle, the bottom quintile has twice as many Medicaid recipients as the second quintile and four times as many as the top quintile.

Similarly, Figure 2b shows that the main nursing home beneficiaries of Medicaid are in the bottom 40 percent of the population and older individuals from higher quintiles. Note

Table 10: Effects of Old-Age Uncertainty

Health Expenses	Deterministic	Random	None
Survival	Random	Deterministic	Deterministic
	relative to baseline		*relative to random survival and no health expenses*
Agg. Capital	0.98	0.90	0.97
wealth of PI quintiles			
First Quintile	1.09	1.01	1.01
Second Quintile	1.08	0.98	1.01
Third Quintile	1.01	0.93	1.02
Fourth Quintile	0.95	0.90	1.03
Fifth Quintile	0.96	0.90	0.96
OOP expenses of PI quintiles			
First Quintile	1.81	1.00	
Second Quintile	1.63	0.99	
Third Quintile	1.37	0.91	
Fourth Quintile	1.27	0.87	
Fifth Quintile	1.14	0.84	

that the take up rate of Medicaid is much higher among the nursing home residents. This is due to the fact that the nursing home expense shock is one of the largest in the benchmark economy, and because it is an absorbing state, nursing home residents quickly deplete their assets and qualify for Medicaid sooner than the general population.

Finally, Figure 3a shows the distribution of OOP health expenses by permanent income quintile and age. The first quintile faces on average 3 times smaller OOP health expenses than the second quintile. This gap indicates that the lifetime earnings of individuals in the bottom quintile are sufficiently low that a majority of them cannot afford most of their medical costs even outside of a nursing home, having to rely on Medicaid subsidies. Similarly, a substantial fraction of the second permanent income quintile cannot afford nursing home costs, but pay for smaller medical expenses OOP. Higher quintiles, on the other hand, face OOP nursing home expenses in addition to medical expenses. Furthermore, as a result of the differential insurance provided by Medicaid and the size of health expenses relative to permanent incomes, expected OOP health expenses relative to income are the highest for *middle-income* individuals. Figure 3b shows that, after age 80, permanent income quintiles three and four expect the largest health expenses relative to their current incomes. These differences in OOP expenses across the permanent income distribution will help us to understand the differential responses of individuals to the policy changes discussed below.

6 Public Policy Analysis

The policy analysis presented in this section has two goals: 1) to assess the contribution of medical and nursing home expenses to aggregate capital accumulation and wealth inequality, and 2) to evaluate aggregate and distributional consequences of alternative social insurance policies. To this end, we consider three types of policy experiments. In the first set of experiments, we introduce public health care such that medical and/or nursing home expenses are fully covered by the government. In the second set of experiments, we vary the availability of safety nets for different types of bankruptcies. In the third set of experiments, we vary social security policy from progressive to proportional to none. All the experiments considered below are revenue-neutral in a sense that government consumption remains fixed at the benchmark level.

6.1 Public Health Care

Before proceeding to the discussion of public health care policies, we would like to clarify our terminology. It is important to remember that Medicaid transfers to nursing home residents combine consumption and medical expense subsidies, up to $\underline{c}^n + M^n$ in the model. When we refer to public coverage of nursing home expenses, we mean only the medical expense portion, M^n, of the nursing home cost. Consumption transfers to nursing home residents are subject to means-testing in all policies we consider below.

To examine the role of medical and nursing home expenses jointly and in isolation, we consider three public health care policies: (1) government covers all medical expenses but does not cover nursing home expenses, (2) government covers nursing home expenses only, (3) government covers all health expenses. Under the first policy, social insurance for nursing home residents is unchanged, while the medical expenses of the rest of the population are paid by the government. Under the second policy, the government pays for the medical expenses of all nursing home residents regardless of their income, while the social insurance coverage of all other health expenses is as in the benchmark economy. Finally, the third policy combines the extra insurance provided by the first two policies: the government pays all medical expenses while providing consumption transfers subject to the same means tests as in the benchmark economy. Aggregate and distributional effects of each policy are reported in Table 11.

Introducing public health care greatly reduces saving incentives. Our model predicts that a complete elimination of health expenses (policy 3) will reduce the aggregate capital stock by 20 percent. Which health expenses drive this decline? Comparing effects of policies 1 and 2, we find that nursing home expenses play the dominant role. While eliminating medical expenses for all but nursing home residents reduces the capital stock by 7 percent, eliminating nursing homes expenses alone reduces the capital stock by 12 percent relative to the benchmark. Note that policy 2 does not completely eliminate the nursing home risk per se as it is still present in the survival probabilities. We also find that changes in the equilibrium prices slightly amplify the effects of policy changes: relative to partial equilibrium, the capital stock declines by an extra 1 percent, or 5 percent of the total affect, under policies 2 and 3.

The dominant role of the nursing home expenses may appear surprising because aggregate OOP nursing home expenses are a quarter of aggregate OOP medical expenses (see Table 8). However, what matters for an individual is the relative risk of the OOP nursing home expenses. The nursing home shock is the most persistent shock, one of the largest health cost realizations in the model economy, and the least insured by the government. These three features make nursing home expenses more risky than medical expenses.

Given the large aggregate effect of medical and nursing home expenses on capital accumulation, the following question arises: What part of the population reduces their savings the most in response to the policy change? Recall that the major savers in the benchmark economy are located in the top two permanent income quintiles. Table 11 provides a breakdown of the change in the aggregate capital stock by changes in the asset holdings of each quintile. We find that in absolute terms, the asset holdings of the top quintile decline the most across all three policy experiments: the change in the top quintile's wealth accounts for almost a half of the drop in the aggregate capital stock. This differential effect of public health care on savings behavior by permanent income is a result of the differential provision of social insurance: the rich are the least insured under the social insurance system in the benchmark economy and thus respond the most to public health care as they face the largest change in insurance coverage.

However, in percentage terms, i.e. relative to the quintile's wealth in the benchmark economy, asset holdings of the fourth, followed by the third, quintile respond the most. Under policy 3, the fourth quintile reduces its wealth by 37 percent and the third quintile – by 31 percent. Figure 4a plots the wealth profiles of the fourth quintile under alternative policies. Notice that public health care discourages individual savings well before retirement. Although before retirement savings respond similarly to public coverage of medical or nursing home expenses, after retirement the response to the two policies is dramatically different. Whereas medical expense coverage merely flattens the savings profile between ages 50 and 80, public coverage of nursing home expenses creates strong dissaving incentives at all ages after retirement. In fact, the wealth profile under public coverage of only nursing home expenses lies very close to the wealth profile under public coverage of all health expenses.

Nursing home expenses and not medical expenses are the dominant determinant of savings for all except the bottom 2 permanent earnings quintiles. As Table 11 indicates, the savings behavior of the first quintile (which is least affected by the policy changes) and second quintile respond more to the increase in medical expense coverage rather than the increase in nursing home expense coverage. These differences by quintile in the savings response to policy changes are consistent with the findings and intuition in the previous section: that is, different income quintiles are primarily exposed to different kinds of OOP expenses, and hence respond the most to the elimination of their particular expense. Furthermore, although in the benchmark economy all three top quintiles face nursing home expense risk, the third and fourth quintiles reduce their wealth by a higher fraction than does the fifth quintile because, relative to their lifetime earnings, the third and fourth quintiles OOP nursing home expense risk is larger.

One of the motivations for incorporating OOP medical and nursing home expenses into a life-cycle model was due to the inability of standard life-cycle models to generate low dissaving rates at old ages without resorting to a bequest motive. Our public health care experiments allow us to examine the contribution of medical and nursing home expenses to rates of dissaving for the elderly. Figure 4b shows these rates for the fourth quintile as the differences are most dramatic for this population group. In the benchmark economy, individuals ages 64 to 80 dissave at a rate 20 to 25 percent of their disposable income per model period (about 10 percent in annual terms), while this rate is 30 to 40 percent in the economy without OOP health expenses. Interestingly, it is the nursing home and not medical expenses that slow down wealth depletion after retirement.

Finally, we find that the introduction of public health care slightly increases cross-sectional wealth inequality, as measured by the Gini coefficient as well as by the concentration of wealth at the top of the distribution (Table 11). Higher inequality without health expense risk would appear rather surprising had we not already discussed the differential response of savings to the policy changes across the permanent earnings quintiles. As the top quintile experiences a smaller drop in its wealth relative to the second, third and fourth quintiles, its share of aggregate wealth is bound to rise. Moreover, the largest changes in asset holdings occur after retirement. Thus the increase in wealth inequality is driven by a higher fraction of people with zero assets at the end of the life-cycle due to both lower savings and higher rates of dissaving. Figure 5a illustrates this effect: wealth inequality increases dramatically at the end of the life-cycle. Once again, it is the nursing home risk that drives the changes in within-cohort wealth inequality in response to the public health care policy.

To understand why nursing home risk plays a dominant role in capital accumulation in the benchmark economy, we also consider a social insurance policy that does not discriminate between bankruptcies, i.e. it guarantees the same consumption floor to nursing home residents as provided to the rest of the population in the benchmark economy: $\underline{c}^n = \underline{c}^m$. We term this 'quality' nursing home care. We repeat the policy experiments (1) through (3) in the economy with quality nursing home care. The results are presented in Table 12.

Increasing the quality of public nursing home care reduces 'Medicaid aversion', i.e. incentives of the middle class to avoid public care. Precautionary savings fall and the capital stock declines by 9 percent relative to the benchmark economy. Introducing public health care in the economy with quality nursing home care has a smaller effect on capital accumulation relative to the effect of the same policy in the benchmark economy: under the complete elimination of OOP health expenses, the capital stock declines by 13 percent. Moreover, the dominant role is now played by the medical rather than nursing home expenses: in isolation, they account for 9 percent and 3 percent of the fall in capital. That is, the higher level of insurance for nursing home expenses reduces their risk relative to medical expense risk. Not surprisingly, higher insurance for nursing home expenses plays almost no role in the economy with no OOP health expenses. Thus, comparing the latter economy to the

Table 11: Effects of Public Health Care Policies

Policy	**Baseline**	**1**	**2**	**3**
Medical Expenses	OOP	Public	OOP	Public
Nursing Home Expenses	OOP	OOP	Public	Public
Aggregates				
relative to baseline				
Agg. Output	1.00	0.98	0.96	0.93
Agg. Capital	1.00	0.93	0.88	0.80
Capital, Partial Equil.	1.00	0.94	0.88	0.81
change in wealth of PI quintiles, % of agg. capital change				
All		100	100	100
First Quintile		3.6	0.9	1.6
Second Quintile		14.0	6.5	8.7
Third Quintile		20.0	19.0	19.0
Fourth Quintile		20.4	25.7	23.7
Fifth Quintile		42.5	47.9	47.0
wealth of PI quintiles relative to baseline				
First Quintile	1.00	0.90	0.96	0.88
Second Quintile	1.00	0.87	0.91	0.79
Third Quintile	1.00	0.88	0.82	0.69
Fourth Quintile	1.00	0.88	0.77	0.63
Fifth Quintile	1.00	0.95	0.92	0.86
Income Tax Rate	0.23	0.25	0.25	0.27
OOP, % output	1.43	0.42	1.03	0.03
Std(OOP) (rel.)	1.00	0.75	0.60	0.03
Wealth Inequality				
Wealth Gini	0.82	0.83	0.83	0.84
shares of total wealth, %				
Fourth Quintile	14.4	13.9	13.4	12.3
Fifth Quintile	82.9	83.8	83.8	85.2
Top 10%	67.9	69.5	70.5	73.1
Top 5%	57.1	59.0	60.3	63.1
Top 1%	25.3	26.5	27.4	29.2

Table 12: Effects of Higher Nursing Home Insurance and Public Health Care Policies

Policy	**Baseline**	Quality NH	**1**	**2**	**3**
Medical Expenses	OOP	OOP	Public	OOP	Public
Nursing Home Expenses	OOP	(Q)OOP	(Q)OOP	(Q)Public	(Q)Public
Aggregates					
relative to baseline					
Agg. Output	1.00	0.98	0.94	0.97	0.93
Agg. Capital	1.00	0.91	0.83	0.89	0.80
relative to Quality NH					
Agg. Capital		1.00	0.91	0.97	0.87
Income Tax Rate	0.23	0.25	0.25	0.25	0.27
OOP, % output	1.43	1.36	0.33	1.07	0.07
Std(OOP) (rel.)	1.00	0.87	0.60	0.61	0.1

benchmark, nearly all of the wealth accumulation for nursing home expenses is accounted for by the differential insurance of nursing home versus medical bankruptcies. The wealth profiles of the fourth permanent earnings quintile under the different policies are shown in **??** to illustrate this point.

6.2 Social Safety Nets

In this section, we examine the roles of the social safety nets available to the workers and the old-age population in wealth accumulation and inequality. Social safety nets provide means-tested insurance against earnings, survival, and health expense risks. On the one hand, social safety nets alleviate the need for precautionary savings, more so for poor than for rich, reducing aggregate capital accumulation and increasing wealth inequality. On the other hand, the presence of health expenses stimulate savings, disproportionately more so for the middle income population than for the rich, thus increasing aggregate capital accumulation and reducing wealth inequality. To examine these effects quantitatively, we consider five more policies, labeled 4 through 8, which (almost completely) remove social safety nets for consumer and/or medical and nursing home bankruptcies. This is achieved by setting the consumption floors for workers and/or retirees to a very small value, while leaving all other features of the benchmark economy unchanged. To learn the contribution of health expenses to the effects of safety nets, we consider policies 7 and 8, which, besides removing safety nets, eliminate all OOP health expenses through public health care. We compare the latter

Table 13: Effects of Safety Nets With and Without OOP Health Expenses

Policies	**Baseline**	**3**	**4**	**5**	**6**	**7**	**8**
Safety Nets In Place	All	All	Medicaid	Welfare	None	Medicaid	None
Public Health Care	No	Yes	No	No	No	Yes	Yes
Aggregates							
relative to baseline							
Agg. Output	1.00	0.93	1.02	1.34	1.34	0.94	0.99
Agg. Capital	1.00	0.80	1.07	2.64	2.65	0.82	0.96
Income Tax Rate	0.23	0.27	0.23	0.15	0.15	0.27	0.26
Transfers, % output	1.6	0.8	1.1	0.4	0.3	0.5	0
OOP, % output	1.4	0	1.3	1.5	1.5	0	0
Std(OOP) (rel.)	1.0	0	0.9	1.4	1.4	0	0
Wealth Inequality							
Wealth Gini	0.82	0.84	0.73	0.61	0.61	0.83	0.72
shares of total wealth, %							
Fourth Quintile	14.4	12.3	15.2	22.4	22.4	13.0	14.7
Fifth Quintile	82.9	85.2	74.3	61.8	61.6	83.9	73.6
Top 1%	25.3	29.2	23.3	13.0	13.0	28.6	24.12

with policy 3, which eliminates OOP health expense risk but keeps all the safety nets as in the benchmark economy. The aggregate and distributional effects of policies 3 through 8 are presented in Table 13. Note that the safety net labeled 'Medicaid' also includes the old-age welfare program.

In all the economies we consider here, agents are still partially insured through the progressive social security program against all three types of risk. Taking the insurance provided by the social security program as fixed, policy 4, which removes the welfare program for workers maximizes their exposure to earnings risk, policy 5, which removes Medicaid and the old-age welfare program, maximizes retired individuals' exposure to health expense and survival risk, and policy 6, which removes all the welfare and Medicaid programs, maximizes individual exposure to all three types of risks. Extra risk and higher expected OOP health expenses create strong incentives for precautionary savings across all income levels. In the economy with the most risk (policy 6), the capital stock increases by 165 percent. Which safety nets – those for workers or the elderly – are responsible for the large decrease in precautionary savings when going from policy 6 back to the baseline? Policies 4 and 5 provide the answer: while removing the workers' welfare program and exposing the agents to higher earnings risk (policy 4) increases the capital stock by only 7 percent, removing old-age safety nets exposing agents to higher OOP health expense and survival risk (policy 5) accounts for nearly the entire change in the capital stock under maximum risk exposure. Another way to see the minuscule role of safety nets for workers in precautionary savings is by studying similar policies in an economy with public health care, i.e. comparing policies 3, 7 and 8. The extra earnings risk in economy 7 relative to economy 3 increases the capital stock by a mere 2 percent. Conversely, the elimination of OOP health expenses alone from economy 6 with policy 8 wipes out the entire precautionary savings generated by removal of the social safety nets.

The large effect of old-age safety nets on precautionary savings comes not only from insuring OOP health expenses but also from insuring survival risk. Recall that OOP health expenses amplify the role of the survival risk in the benchmark economy (section 5.3). Policies 7 and 8 allow us to isolate the the role of old-age safety net in precautionary savings due to uncertain life-time. Removing the social safety nets for retirees in the economy without OOP health expenses increases the capital stock by 17 percent. Hence old-age safety nets also play an important role in insuring survival risk.

Why is health expense risk a more important driver of precautionary savings then earnings risk? The answer lies in the timing of the two types of shocks. Individuals accumulate savings during the working stage of life in order to self-insure against health expense shocks experienced after retirement. These precautionary savings present a sufficient buffer against earnings shocks before retirement. That is, consumption smoothing over the earnings risk requires nearly no extra savings. This would not have been the case were the two types of shocks experienced simultaneously.

Now we examine the impact of the public safety nets in the presence of OOP health expense risk on wealth inequality. Removing social safety nets for all or some types of risk reduces inequality by stimulating savings across the entire permanent income distribution. However, as discussed in the previous section, the presence of OOP health expenses creates a differential savings response across the permanent income distribution. Since in the absence of safety nets the poor face higher health expenses relative to their lifetime earnings, they increase their savings by a higher fraction than do the rich, which further reduces wealth inequality. In the economy with the least insurance (policy 6), the wealth Gini falls by 21 percentage points relative to the benchmark. Once again, comparing inequality measures under policies 5 and 6 shows that among the three types of risk, health expense together with survival risk fully account for the reduction in inequality. Finally, comparing with the reduction in the wealth Gini when going from policy 7 to 8 (removing retirees safety nets under full public health care) shows that the differential response to the pure increase in survival risk alone can account for some but not all of the reduction in equality. We conclude that the Medicaid program is an important generator of aggregate wealth inequality.

6.3 Social Security

In this section we examine the effects of social security policy on savings in the presence of OOP health expense risk and Medicaid. The social security system crowds out savings for old age by redistributing resources from working years to retired years. In addition, it crowds out precautionary savings by insuring against survival risk in the form of an annuity payment. The progressivity of the social security benefit redistributes resources across the permanent income distribution, from rich to poor. The question we ask here is does the presence of OOP health expenses at old age matter for the crowding out effect and how much? Moreover, the progressivity of social security benefits may amplify the crowding-out effect on savings of low-income individuals while it may reduce the effect for high-income individuals. These distributional effects are of interest to us because saving behavior differs a lot across individuals in our benchmark economy. Hence another question we ask is how does the progressivity of social security benefits interact with savings due to OOP health expenses?

To provide a quantitative answer to these questions, we consider four additional policies: relative to the baseline, policies 9 and 11 replace the progressive benefit formula with a proportional benefit, equal to that of an individual with average lifetime earnings in the benchmark economy, and policies 10 and 12 completely remove the social security system. Policies 11 and 12, in addition, remove OOP health expenses through public health care. The results of the policy experiments are presented in Table 14. Overall, the results indicate that the presence of OOP health expenses has non-trivial aggregate and distributional implications for the impact of social security on capital accumulation.

Replacing the progressive social security benefit formula with a proportional one has a large negative effect on aggregate capital, and the presence of OOP health expenses amplifies this effect. Removing progressivity reduces the aggregate capital stock by 23 percent in the economy with OOP health expenses (policy 9 relative to baseline) and by 15 percent in the economy without them (policy 11 relative to policy 3). Similarly to other policies we have considered, changes in aggregate capital are driven by wealth accumulation of the top permanent income quintile. Here the role of the top quintile is the most pronounced because moving to the proportional benefit formula increases the social security income of the top quintile relative to its lifetime earnings, while it decreases that income for the rest of the population. Eighty-eight percent of the fall in aggregate capital under policy 9 is due to

Table 14: Effects of Social Security Policies With and Without OOP Health Expense Risk

Policies	**Baseline**	**9**	**10**	**3**	**11**	**12**
Social Security	Prog.	Prop.	None	Prog.	Prop.	None
Public Health Care	No	No	No	Yes	Yes	Yes
Aggregates						
relative to baseline						
Agg. Output	1.00	0.93	1.09	0.93	0.89	1.07
Agg. Capital	1.00	0.77	1.33	0.80	0.68	1.26
relative to Progressive SS, Public Health Care						
Agg. Capital				1.00	0.85	1.58
relative to No Public Health Care, fixed SS system						
Agg. Capital				0.80	0.88	0.95
change in wealth of PI quintiles, % of agg. capital change						
All		100	100	100	100	100
First Quintile		0.0	1.8	1.6	0.0	2.3
Second Quintile		0.0	8.0	8.7	2.8	9.9
Third Quintile		4.4	13.6	19.0	9.1	15.7
Fourth Quintile		7.3	15.4	23.7	12.5	17.3
Fifth Quintile		88.3	61.2	47.0	75.5	54.8
wealth of PI quintiles relative to baseline						
First Quintile	1.00	1.00	0.34	0.88	0.99	1.23
Second Quintile	1.00	1.00	1.23	0.79	0.89	1.32
Third Quintile	1.00	0.92	1.33	0.69	0.75	1.36
Fourth Quintile	1.00	0.87	1.39	0.63	0.68	1.36
Fifth Quintile	1.00	0.70	1.41	0.86	0.63	1.26
SS replacement rates by PI quintiles						
First Quintile	0.87	0.44	0	0.87	0.44	0
Second Quintile	0.56	0.44	0	0.56	0.44	0
Third Quintile	0.48	0.44	0	0.48	0.44	0
Fourth Quintile	0.47	0.44	0	0.47	0.44	0
Fifth Quintile	0.30	0.44	0	0.30	0.44	0
Social Security Tax Rate	0.074	0.098	0	0.074	0.0.98	0
Income Tax Rate	0.23	0.27	0.22	0.27	0.29	0.23
OOP, % output	1.4	1.4	0.83	0	0	0
OOP, % total health exp.	62	53	38	0	0	0
Wealth Gini	0.82	0.79	0.82	0.84	0.80	0.80

lower wealth accumulation by the top quintile.

Distributional effects shed some light on the role of OOP health expenses and Medicaid in the progressivity experiments. First, notice that in the economy with OOP health expenses, the top three permanent income quintiles reduce their savings, while the two bottom quintiles wealth is unaffected. In contrast, in the economy without OOP health expenses, only the top quintile reduces its savings while the rest increase them, offsetting some of the drop in capital accumulation of the top quintile. What explains these asymmetric patterns given that the social security benefit structure changes in the same way across the permanent income quintiles in the two economies? In the economy with OOP health expenses, the Medicaid safety nets tax savings of individuals who are likely to qualify for a Medicaid transfer. This implicit tax makes savings of poorer individuals less elastic with respect to a reduction in the social security benefit. The reduction itself makes retired individuals in quintiles one to four poorer, so they are more likely to qualify for Medicaid. As a result, no one in this economy increases their savings. In the economy without OOP health expenses, the safety nets do not play as big a role at old age. Individuals in the four bottom quintiles replace lost social security income with private savings, and the top quintile's private savings are crowded out by the higher social security benefit.

Contrary to the above results, the presence of the social security system affects savings more in the economy without OOP health expenses. Complete removal of the social security system increases the capital stock by 33 percent in the economy with OOP health expenses (policy 10 relative to baseline) and by 58 percent in the economy without these expenses (policy 12 relative to policy 3). Why does the presence of OOP health expenses reduce the crowding out effect of social security on capital accumulation? Without public health care, individuals maintain large savings well into the retirement to pay OOP health expenses that grow with age. These savings also serve as a self-insurance against survival risk when the social security annuity is removed. As a result, individuals do not need to increase their savings as much as in the economy without OOP health expenses.

Another way to see the above results is by varying the presence of OOP health expenses for a fixed social security system. Both the presence of the social security system and its progressivity amplify the effect of OOP health expenses on wealth accumulation. Elimination of OOP health expenses through public health care in the economy without social security reduces aggregate capital only by 5 percent, which constitutes a quarter of the change in capital in the economy with the progressive social security system and 40 percent of the change in the economy with the proportional social security system.

6.4 Relation to the Literature

Our analysis extends a large body of literature on life-cycle savings and the effects of social insurance policies. Hubbard et al. (1994) find that augmenting a life-cycle model ny including borrowing constraints and uninsurable idiosyncratic earnings risk, OOP medical expense risk, and survival risk greatly improves the model's ability to account for differences in savings patterns across education groups. Hubbard et al. (1995) show that in the presence of means-tested social insurance, the model's prediction that the poor are more likely to hold little or no wealth is consistent with the data. However, they argue that an increase in the consumption floor provided by a welfare program discourages savings of only low-income households leaving high-income household wealth unaffected. We evaluate such policy changes formally and show that on the contrary it is the high income households that respond the most to changes in the social safety nets for medical and nursing home expenses.

The ability of medical expense uncertainty to account for cross-sectional and life-cycle savings patterns depends crucially on the stochastic process for medical expenses. Due to a lack of data, earlier studies indirectly assessed the risk using health status and consumption data. For example, Gertler and Gruber (2002) study the effects of public disability insurance using a panel data set for Indonesia. In order to more accurately assess the risk of OOP health expenses, some studies take a structural model estimation approach. Using PSID data on elderly retirees, Palumbo (1999) finds that, in a model with survival uncertainty, health uncertainty in a important predictor of consumption behavior of retirees. However, the model still fails to account for the low rates of dissaving of the elderly. De Nardi et al. (2006) use a more extensive health expenditure database (AHEAD) to estimate a rich structural model of saving behavior of the elderly with heterogeneity in OOP health expense risk and mortality. Similarly to our cross-sectional results, they find that OOP health expenses and social safety nets have strong effects on individual savings with the largest effects experienced by the top permanent income quintile. Their analysis, however, does not model the wealth distribution at the retirement age, holding it fixed across policy experiments. As we have shown in our model, individuals respond to old-age public policy changes well before their retirement. Although De Nardi et al. estimate a larger risk of OOP health expenses, improving the model predictions about saving behavior of the elderly, they acknowledge that their study still potentially understates the risk of health expenses because these expenses do not include unobserved Medicaid transfers. In contrast, we calibrate the stochastic process for total health expenses, including OOP and Medicaid, so that the distribution of OOP expenses in the model matches a set of moments that we estimate in the data.

A number of the cross-sectional results obtained in our policy analysis are qualitatively consistent with the above literature. The contribution of our analysis is to provide a quantitative evaluation of aggregate and distributional effects of social insurance policies using a theory of life-cycle inequality that is consistent with a large set of cross-sectional and life-cycle patterns on earnings, medical, nursing home, and Medicaid expenses, as well as wealth distribution in the U.S. economy. Furthermore, we explicitly model nursing home risk and study the differential roles played by medical and nursing home expenses and their social insurance − an issue that has not been explored in the previous literature.

Relative to the literature on social security with idiosyncratic risk, such as Huggett and Ventura (1999), Fuster et al. (2004, 2006), our analysis is rather rudimentary as we do not take into account labor supply responses to taxes and wages, nor do we model bequest motives for savings. However, it is the first study to assess the effects of social security policy in an environment with uncertainty about medical and nursing home expenses and their social insurance. Our findings indicate that these features are important for the aggregate and distributional effects of social security.

7 Conclusion

We have built a theory of life-cycle inequality with uninsurable idiosyncratic risk in earnings, medical and nursing home expense and survival, in order to quantitatively assess effects of alternative social insurance policies on wealth accumulation and inequality. We find that medical and nursing home expenses greatly stimulate aggregate capital accumulation but have a small effect on wealth inequality in the presence of social insurance. Removing old-age safety nets including Medicaid has a large positive effect on aggregate capital accumulation and generates a large reduction in wealth inequality. Overall, we find that distributional effects in our model have important aggregate implications. We also find that differential social insurance of medical versus nursing home expenses makes nursing home risk a driving force of the savings behavior of richer individuals. Furthermore, we show that the presence of social security amplifies the effect of the health expenses on wealth accumulation. We conclude that modeling medical and home expenses is crucial for social policy analysis.

Our calibration strategy exploits the assumption that the positive relationship observed between individual permanent income and OOP health expenses (De Nardi et al. (2006)) is completely accounted for by the presence of safety nets. That is, richer individuals face higher OOP expenses due to the means-testing of Medicaid transfers. It would be interesting to relax this assumption by incorporating a choice of health care quality and study how this margin responds to policy changes.

In order to make our results transparent, we simplified our analysis by abstracting from differential mortality, marriages, and endogeneity of labor supply. Since in the data life expectancy is higher for high-income individuals, a lifetime health expense risk faced by these individuals is also higher, which may enhance the differential effects of social insurance policies we found in our study. Marriages may be important because nursing home risk is potentially different for married couples and risk-sharing is available within a household. Abstraction from labor supply decisions means we have not taken into account labor income tax distortions and the insurance role of labor due to intertemporal substitution in response to labor productivity shocks. Moreover, we have focused on life-cycle inequality and omitted bequest motives and any other kind of intergenerational interactions. Fuster (1999) has shown how dynastic linkages have important consequences for the effects of social security policies on wealth inequality. Introducing an the option for informal care through the family – an important substitute for nursing home care – would allow one to analyze care-takers' labor supply responses to social insurance policies. We leave these issues for future research.

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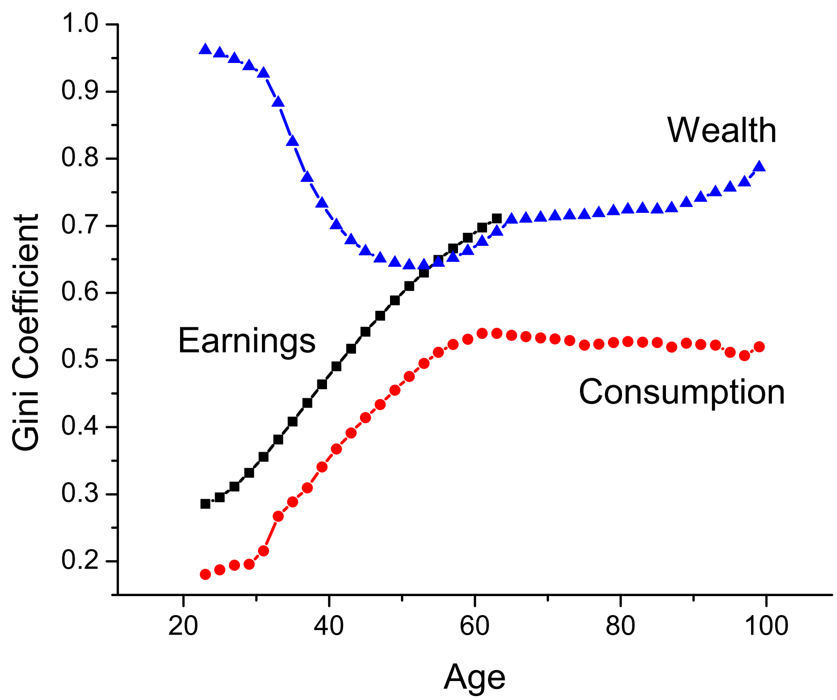
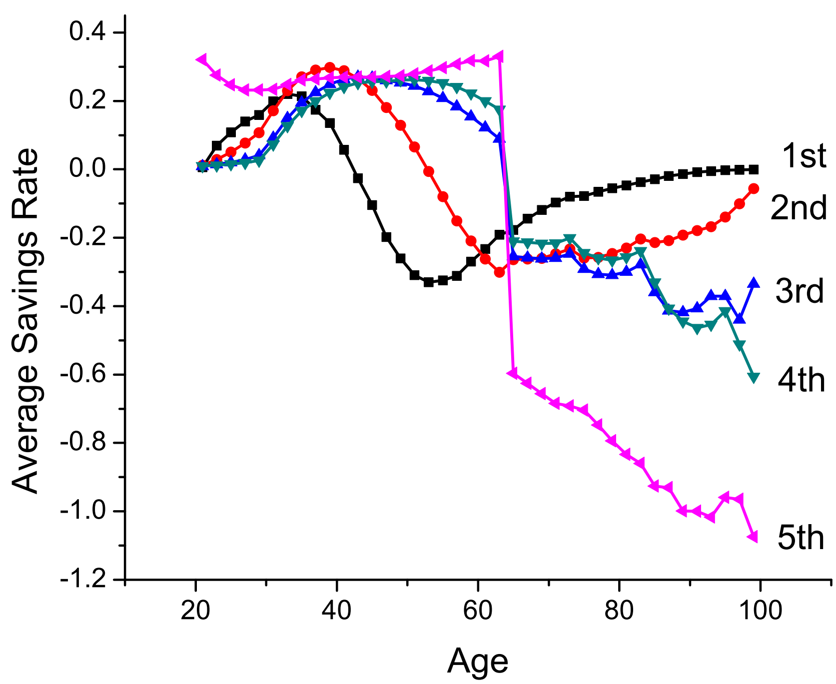
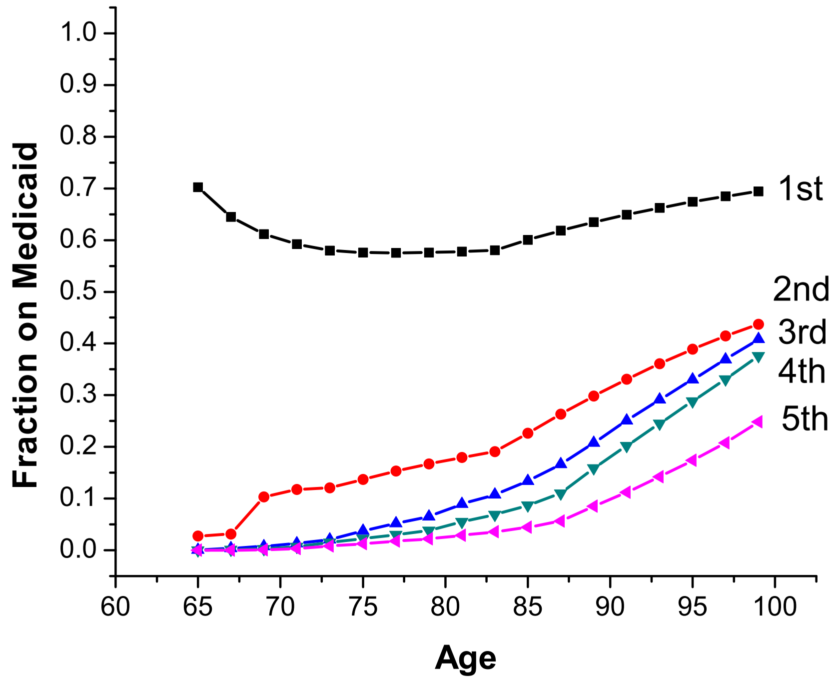


(a) Gini coefficients

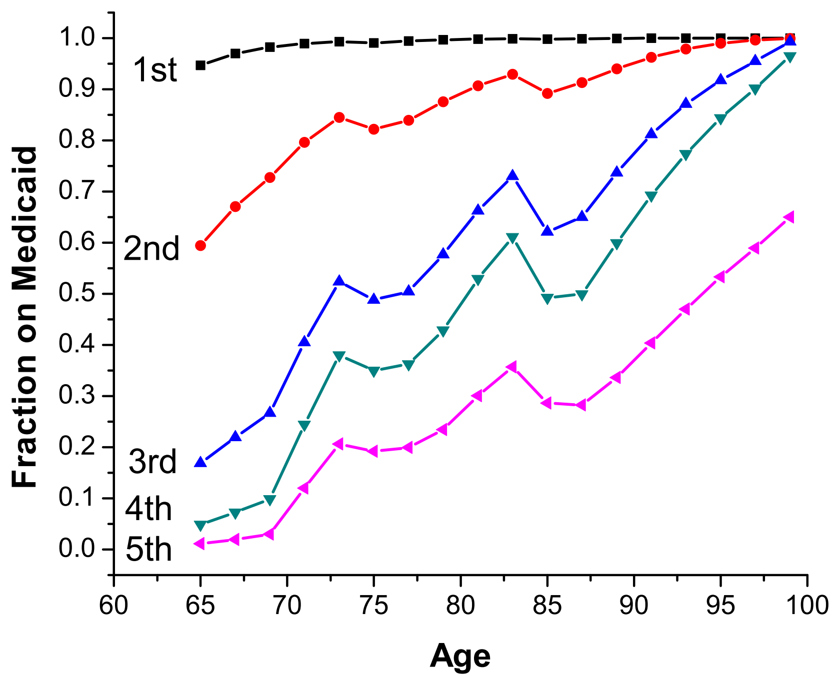


(b) Saving rate

Figure 1: Life Cycle Profiles In the Benchmark Economy: Inequality

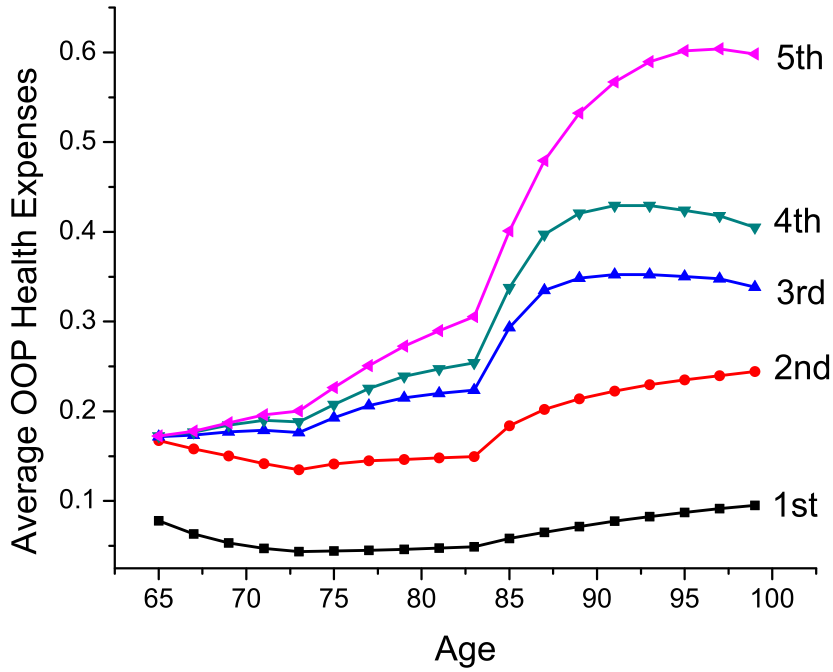


(a) Fraction receiving Medicaid

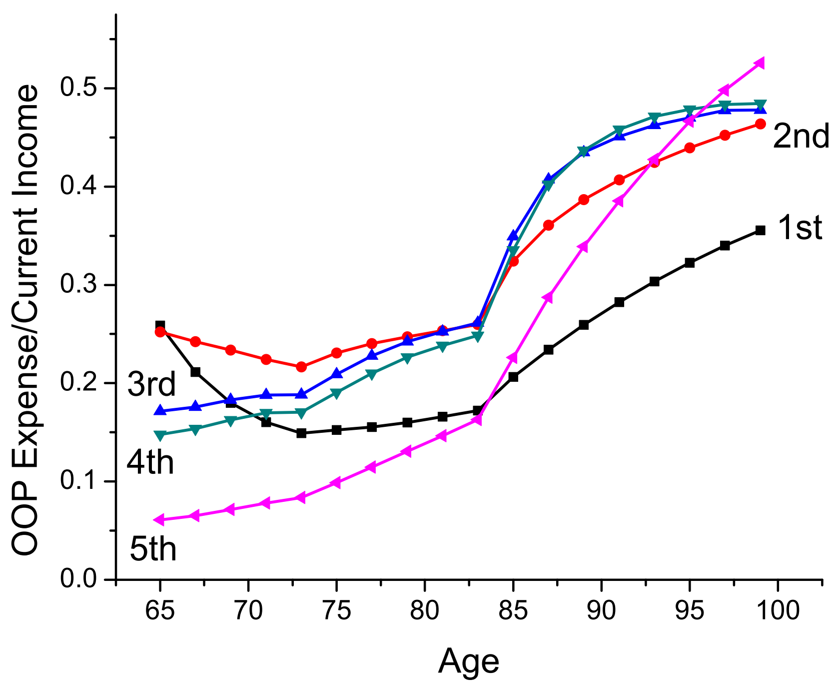


(b) Fraction of nursing home residents on Medicaid

Figure 2: Life-cycle profiles In the Benchmark Economy: Medicaid

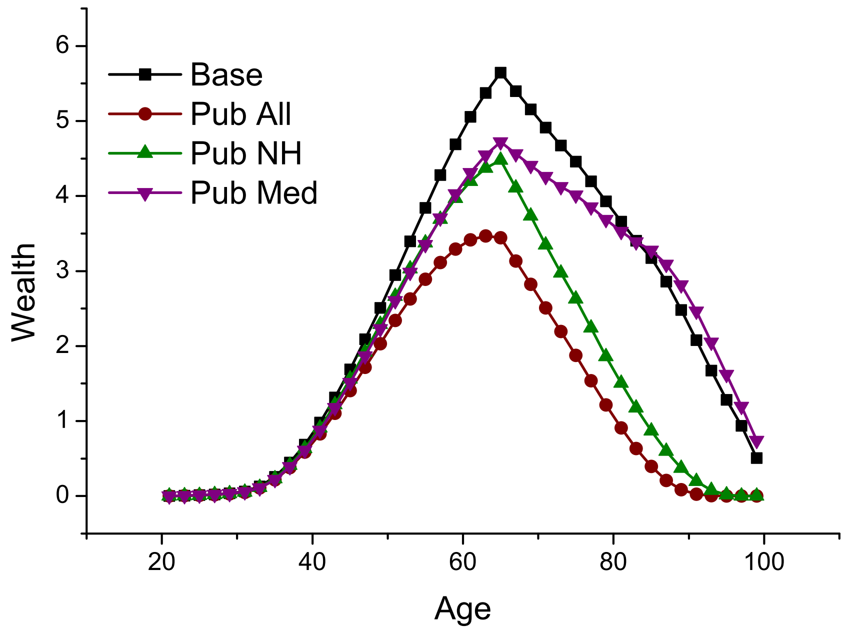


(a) Average OOP health expenses

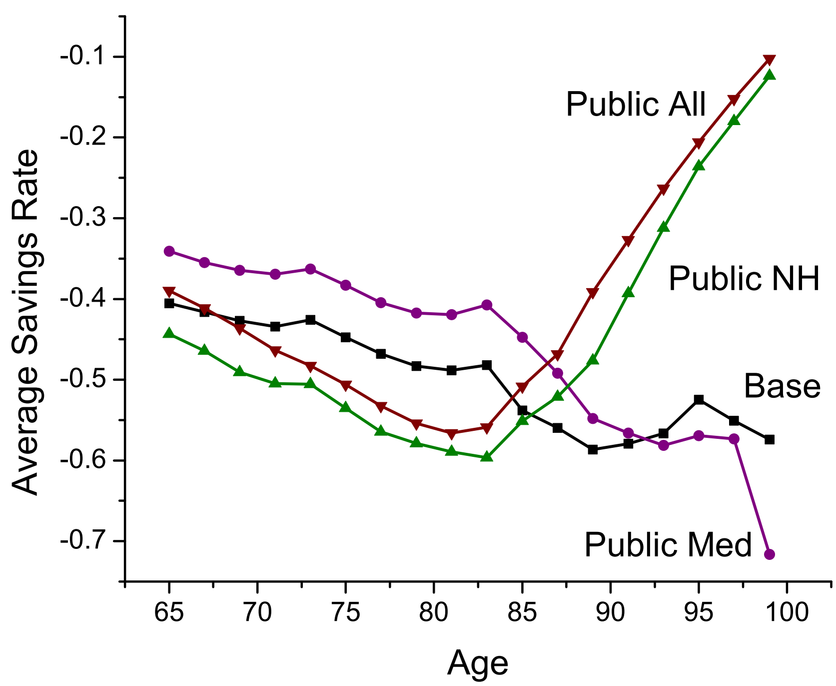


(b) Relative to average current income

Figure 3: OOP Health Expenses by PI quintiles in the Benchmark Economy

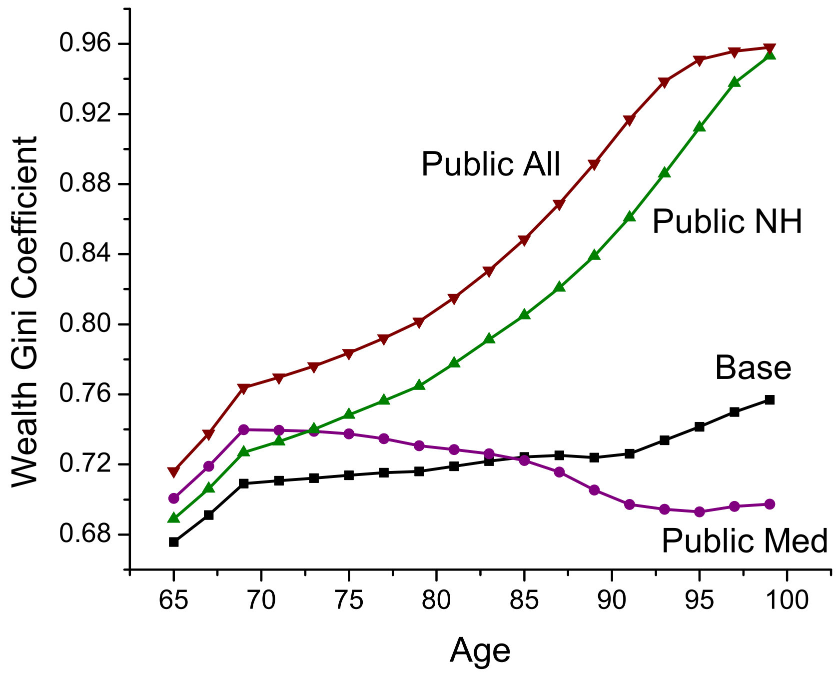


(a) Wealth Profiles of Fourth Quintile

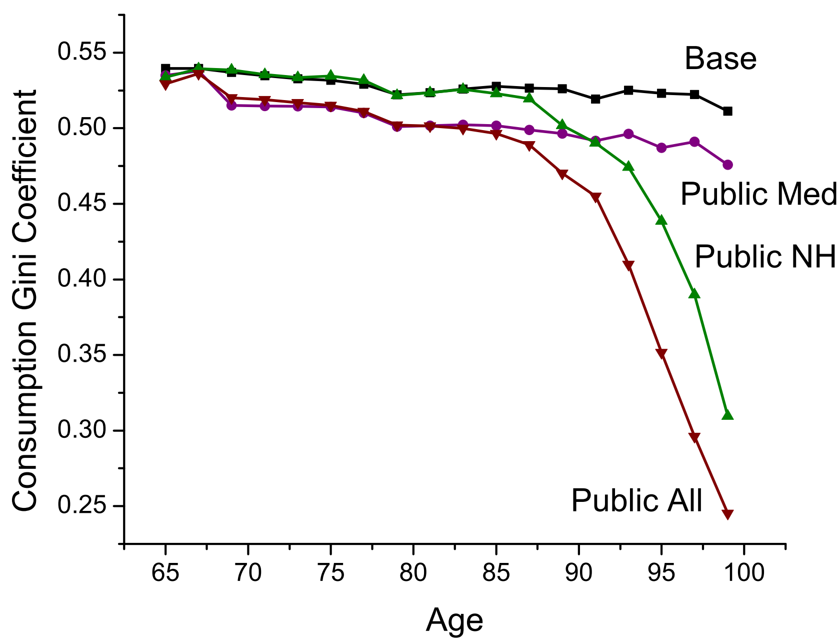


(b) Saving Rates of Fourth Quintile

Figure 4: Public Health Care Policies: Effects on Saving Behavior



(a) Wealth Gini



(b) Consumption Gini

Figure 5: Public Health Care Policies: Inequality Effects

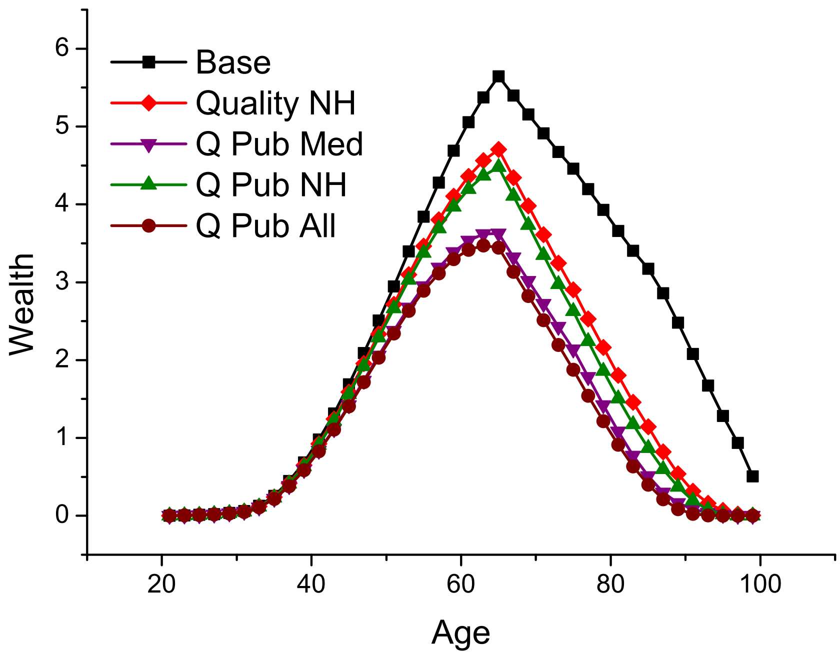


Figure 6: Quality Nursing Home Care and Public Health Care Policies