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

Kopecky, Karen A. and Koreshkova, Tatyana

University of Western Ontario, Concordia University

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Karen A. Kopecky
University of Western Ontario
kkopecky@uwo.ca

Tatyana Koreshkova
Concordia University and CIREQ
tkoreshk@alcor.concordia.ca

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Abstract

We consider a life-cycle model with idiosyncratic risk in labor earnings, out-of-pocket medical and nursing home expenses, and survival. Partial insurance is available through welfare, Medicaid, and social security. Calibrating the model to the U.S., we find that nursing home expenses play an important role in the savings of the wealthy. In our policy analysis, we find that elimination of out-of-pocket expenses through public health care would reduce the capital stock by 12 percent, Medicaid and old-age welfare programs crowd out 44 percent of savings and greatly increase wealth inequality, and social security effects are influenced by out-of-pocket health expenses.

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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 U.S. social insurance policies 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 0.67, and is highly concentrated, with the top 10 percent of spenders accounting for 51 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 Medicare Current Beneficiary Survey.

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 OOP 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 a bankruptcy caused by nursing home expenses than under a bankruptcy caused by medical expenses.

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 stage of their lives, individuals face earnings uncertainty. Retired individuals face uncertainty with respect to their survival as well as 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, nursing home, or 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. We allow the insured consumption floor to be specific to the type of bankruptcy.

The absence of insurance markets coupled with borrowing constraints creates a strong incentive for precautionary saving. Means-testing of social insurance implies that the rich rely on private savings much more than the poor. The welfare program discourages saving of low-income workers early on in life, and Medicaid further discourages saving to finance health expenses in old-age. As an individual's permanent earnings increases, he becomes less likely to qualify for Medicaid, and health expenses gain importance in his life-cycle savings. In addition, more savings are 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. Since low-income individuals are more likely to find their nursing home costs, for the most part, unaffordable, they are also more likely to rely on Medicaid to cover nursing home care. Thus, the saving behavior of low-income individuals is driven mostly by smaller OOP medical expenses rather than by nursing home expenses. Saving behavior of wealthier individuals, on the other hand, is driven primarily by nursing home

[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.

expenses. Finally, progressive social security provides better insurance against health expense and survival risk for the poor than the rich. To sum up, individuals across the permanent earnings distribution effectively face different kinds of the OOP health expense risk. How these public insurance programs jointly affect 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 process for medical costs, we use data from the Health and Retirement Study. Since in the data we only observe OOP health expenditures and not total (before Medicaid subsidies) expenditures, we cannot directly infer the medical cost process. Instead, and unlike other studies, we calibrate the process so that the distribution of OOP expenditures generated by the model matches the one observed in the data. Furthermore, since the quality of life in a public nursing home is not directly measured, we calibrate the consumption floor for nursing home bankruptcy by matching Medicaid's share of nursing home expenses in the data. The calibration procedure delivers a value for the consumption floor guaranteed under nursing home bankruptcy which lies below that for medical bankruptcy. We interpret this differential as reflecting a lower quality of life provided by public nursing home care relative to receiving public-assistance while living at home. 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 precautionary savings are primarily accumulated to insure against uncertainty about lifetime OOP health expenses. In particular, uncertainty about length of life which impacts the number of years of expense risk and the size of expenses. Precautionary savings due to health expense risk are driven by OOP nursing home expense risk. Moreover, our policy experiments show 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. Our policy analysis consists of three sets of 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.

Introducing public health care greatly reduces incentives to save for old age. Our model predicts that a complete elimination of OOP health expenses reduces the aggregate capital stock by 12 percent. Both types of health expenses – medical and nursing home – contribute equally to the aggregate effect. However, on the individual level, saving responses differ dramatically across the permanent earnings distribution. The decline in asset holdings of the top two permanent earnings quintiles accounts for three quarters of the aggregate effect, and this decline is driven by the elimination of OOP nursing home expenses. On the contrary, the second and third quintiles respond mostly to the elimination of medical expenses, whereas the bottom quintile's saving behavior is nearly unaffected by public health care. The differential response to public health care is explained by the type of OOP expenses faced by each quintile: while medical expenses dominate the saving behavior of the poor, nursing home expenses have a bigger impact on the saving behavior of the wealthy. Since the top quintile is the major saver in the economy, when prices and taxes are held constant, aggregate effects of policy changes are also driven by nursing home expenses. In a general equilibrium, removal of nursing home expenses results in fewer distortions in saving behavior relative to removal of medical expenses, causing a smaller increase in the capital stock relative to its partial equilibrium level. The importance of a general equilibrium analysis is clear: partial equilibrium overstates the aggregate effect of public health care on capital accumulation by almost 60 percent.

We also find that the introduction of public health care for the elderly dramatically increases within-cohort wealth inequality. This is explained by the fact that individuals in the middle of the permanent earnings distribution face the largest OOP health expenses relative to their income. As a result, in percentage terms, their savings fall the most in response to public coverage of health expenses, reducing their share of aggregate wealth.

The importance of nursing home expenses for savings is driven by 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 under public nursing home care to the level provided to non-nursing home Medicaid recipients, the capital stock drops by 4 percent. In addition, introduction of public health care into such an economy results in a smaller decline in savings than it does in the benchmark economy.

Moreover, we find that government-provided safety nets for the elderly (Medicaid in particular) play a dominant role in wealth accumulation and inequality. While removing all welfare programs in the benchmark economy increases aggregate capital by 134 percent and reduces the wealth Gini by 28 points, removing Medicaid alone increases the capital stock by 126 percent and reduces the wealth Gini by 26 percentage points. The dominant role of Medicaid is explained by the timing of shocks: earnings and health expense shocks are experienced at different stages of the life cycle, allowing workers to buffer their consumption with precautionary savings accumulated in anticipation of health expenses at older ages.

Finally, we find that the presence of OOP health expenses amplifies the effect that the progressivity of social security has on savings but dampens social security's crowding-out effect. Replacing progressive social security benefits with proportional ones reduces the capital stock by 8 percent in the economy with OOP health expenses and by 7 percent in the economy without them. The decline in aggregate capital in the two economies is almost entirely due to lower wealth accumulation by the top permanent earnings quintile – the quintile that faces a substantial increase in its social security replacement rate. Removing social security altogether increases aggregate capital by 37 percent in the economy with OOP health expenses and by 55 percent in the economy without them. The need to finance OOP health expenses at old ages increases saving incentives counteracting the reduction in incentives due to social security.

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 the 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 wealthy individuals. While these findings were obtained in partial-equilibrium frameworks, our general equilibrium analysis shows that changes in the interest rate and taxes have large consequences for aggregate effects of social insurance policies.

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 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, or 1.5 percent of GDP, were privately financed either out-of-pocket, with private insurance or through other means, while the remaining 66 percent, or 2.9 percent of GDP, were publicly financed by either Medicare, Medicaid, or other public

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 by How Financed for Individuals 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.

programs. Note that Medicaid finances a substantial portion – 14 percent – of the elderly's medical expenses, or 0.6 percent of GDP. Table 3 shows that medical expenditures of the elderly net of Medicare are primarily funded by private sources: either OOP directly or indirectly through insurance payments. Private payments of the elderly accounted for 12.3 percent of per capita GDP while Medicaid accounted for 5.2 percent. In addition, both private and Medicaid payments for medical care as a share of per capita GDP increase with age. Note that Medicaid's share of total expenditures net of Medicare increases with 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 have large medical expenditures and to be impoverished by large OOP medical expenditures at earlier ages, making them eligible for Medicaid transfers.

Table 3: Per Capita Private and Medicaid Health Expenditures as a 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

Nursing home costs are one of the largest OOP health expenses faced by the elderly. According to the Medicare Current Beneficiary Survey, in 2002 nursing home care accounted for 19 percent of personal health expenditures for individuals ages 65 and over and 0.85 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 – 190 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 result in high costs and unreliable coverage, Brown and Finkelstein (2008) find that the lack of private long-term care insurance markets is largely due to the public insurance system (Medicare and Medicaid) crowding out private insurance. This occurs despite the fact that the public insurance system is far from satisfactory since it provides only a limited reduction in risk exposure except for the poorest individuals. As a result, relative to other health expenditures, only a small amount of nursing home care costs for individuals over 65 are covered by Medicare or through private insurance. Table 4 provides a breakdown of nursing home care expenses for individuals ages 65 and over by payment source. As shown in the table, the elderly's nursing home costs are primarily funded either out-of-pocket (37 percent) or by Medicaid

Table 4: Percent of Nursing Home Residents by Primary Payment Source for Individuals of All Ages and Sources of Payment for Nursing Homes/Long-term care Institutions for Individuals Ages 65 and Over, 2002

Source of Payment	% of NH residents ‡	% of total NH exp.‡‡	% of GDP ‡‡
Total NH exp.	100	100	0.85
Private	**26**	**43**	**0.37**
Out-of-pocket		37	0.31
Private Insurance		2	0.02
Other		4	0.04
Public	**74**	**57**	**0.48**
Medicare	15	18	0.15
Medicaid	58	37	0.31
Other	1	2	0.02

‡ Source: Kaiser Commission on Medicaid and Uninsured, prepared by E. O'Brien and R. Elias, 2004
‡‡ Source: Medicare Current Beneficiary Survey, 2002.

(37 percent). The table also shows the breakdown of nursing home residents of all ages by primary payment type. Note that the majority, 58 percent, of nursing home residents at any given time are Medicaid recipients while the smallest percentage are primarily 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 in excess of $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 does 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) who find that wealthy people tend to avoid public long-term care due to its low quality of life. This avoidance is termed "Medicaid aversion."

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 a nursing home, with very little out-of-pocket expense risk thanks to Medicare, there is still a sizable risk of long-term stay in a nursing home resulting in large OOP 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 consists of individuals, both married and single, 65 years of age and older. 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 unequal, with a Gini coefficient of 0.67 and a normalized standard deviation of 2.77. 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 more than a fifth of total OOP expenses. Moreover, OOP expenses increase with permanent earnings. Since data on lifetime earnings is not available to us, we use social security income (SSI) as a 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 a 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.

Table 5: OOP Health Expense Distribution: Selected Moments

OOP Health Expenses		
Gini	0.67	
Shares of Total, %		
First Quintile	0.13	
Second Quintile	2.75	
Third Quintile	9.76	
Fourth Quintile	20.16	
Fifth Quintile	67.21	
Top 10%	50.71	
Top 5%	38.84	
Top 1%	21.77	
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.
[†] percent of average annual lifetime earnings in 2000

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 expenditures and the Medicaid program.

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, works during the first R periods of his life, and retires at age $R+1$. While working, an 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 guarantees a minimum consumption level in case of a bankruptcy. This consumption 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 $\Lambda_{hh'}$. The initial distribution of medical expenditure shocks is given by Γ_h and it is independent of the individual state.

The need for nursing home care in the next period of life, at age $j+1$, arises with probability $\theta(j+1, h)$ at each age $j > R+1$ and with probability $\bar{\theta}_{R+1}$ at age $R+1$. The probability of entering a nursing home next period is increasing in age. For agents beyond age $R+1$ the entry probability is increasing in the previous period's medical expense. 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 either earnings, medical expenditure, nursing home, or 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]

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 $s_j = 1,\ j = 1, 2, ..., R$. Let $\bar{\theta}_j$ denote the unconditional (independent of the previous period's medical expense) probability of entering a nursing home at age j. Then, without conditioning on his current medical expense shock, an age-$(j-1)$, retired individual enters a nursing home in period j with probability $\bar{\theta}_j > 0$. 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 unconditional probability of entering a nursing home, so $\lambda_{R+1} = \bar{\theta}_{R+1}$. Finally, for a retired cohort of age $R+1 < j \leq J$, the fraction λ_j evolves according to

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

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

The state of a working individual consists of his age j, assets a, average lifetime earnings to date $\bar{e}$, and current productivity shock z. The individual's taxable income y consists of his interest income ra and labor earnings e net of the payroll tax $\tau_e(e)$. The individual allocates his assets, taxable income less income taxes $\tau_y(y)$, and transfers from the government

[3] We do this to avoid the unrealistic impact that redistributing bequests as lump-sum transfers would have on agents eligibility for means-tested transfers. In addition, we wish to avoid the unrealistic impact that an arbitrary redistribution of bequests would have on individuals' saving behavior in response to policy changes.

$T(j,y,a)$ between consumption c and savings a' by solving

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

subject to

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

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

3.4 Old-age Health Care

Retired individuals face uncertainty about their medical and nursing home needs. The 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, 1, indicating that he is currently in a nursing home under private care, or 2, indicating that he is currently in a nursing home under public care.

3.4.1 Medical care

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

$$V(R,a,\bar{e},z) = \max\nolimits_{c,a'\geq 0}\Big\{U(c)+\beta s_{R+1}(1-\bar{\theta}_{R+1})E\big[V(R+1,a',\bar{e},h',0)\big]+ \tag{7}$$

$$\beta s_{R+1}\bar{\theta}_{R+1}\max\big[V(R+1,a',\bar{e},h^n,1),V(R+1,a',\bar{e},h^n,2)\big]\Big\} \tag{8}$$

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 his remaining resources between consumption and savings. Conditional on survival, the agent will entering a nursing home next period with probability $\theta(j+1,h)$. 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

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

subject to

$$c+M(j,h)+a' = a+y-\tau_y\Big(\max\big\{0,ra-\max[0,M(j,h)-\kappa ra]\big\}\Big)+T\left(j,a,h\right), \tag{10}$$

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

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

where $\underline{c}^m$ is the minimum consumption level guaranteed under a medical bankruptcy. Agents receive a medical expense income tax deduction. In other words, individuals pay taxes on their interest income minus the fraction of their medical expenses that exceed κ percentage of their taxable income.

3.4.2 Nursing home care

Once nursing home needs arise, an individual has to choose between private and public nursing home care. We assume that private care differs from public 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 letting $\underline{c}^n$ differ from $\underline{c}^m$, we allow for differential insurance provided under medical and nursing home bankruptcies. Hence the government's per resident cost of nursing home care is $M^n+\underline{c}^n$. To qualify for public nursing home care, an individual must meet the following eligibility criteria: his income net of taxes plus the value of assets have to fall below a threshold level. Note that individuals will only choose public care if their consumption level under private care falls below $\underline{c}^n$. In addition, since the agents' income streams during retirement are deterministic and constant, an agent receiving public care would never choose to switch to private care in the future. Thus, for simplicity, we assume that when an individual enters public care he surrenders all of his assets as well as current and future pension income to the government and has no further decisions to make.

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

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

subject to

$$c+M^n+a'=a+y-\tau_y\Big(\max\big\{0,ra-\max[0,M^n-\kappa ra]\big\}\Big), \quad (14)$$

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

where the value of entering a public nursing home is

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

Note that there are no government transfers to individuals receiving private nursing home care. However, such individuals are still eligible for a medical expense tax deduction.

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 $X \in \{X_W, X_R\}$. 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:

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

   for all $X_0 \in \Xi$, where

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

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

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

total means-tested transfer payments are

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

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 part of 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 population 65 year old and over to that 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 5 possible values for z. Thus, specifying the earnings process requires setting 26 parameters: 2 coefficients on age and age-squared in the deterministic component, 5 productivity shock levels, 25 elements of $\Lambda_{zz'}$ and 5 grid points for 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 and from the two highest ones to the lowest one are 0. These restrictions, 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 to be calibrated from 25 to 16. Finally imposing that the elements of the initial distribution sum to one leaves 22 parameters that need to be determined.

The coefficients on age and age-squared are obtained from 1968 to 1996 PSID data for male workers.[4] Thus β_1 is set to 0.109 and β_2 is set to -0.001. The 20 remaining parameters are chosen by targeting the variance of log earnings of 55 year-olds relative to 35 year-olds, the first-order autocorrelation of the 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, the same 8 points in the Lorenz curve for Social Security income, 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 the Lorenz curve for Social Security income and mean Social Security by quintile are computed using the sample from

[4]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.

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 process, 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. The targets and their values in the data are summarized in the next section. The distributional moments were documented in section 2 using the HRS data. OOP and Medicaid expenses by age groups are 2001-2006 averages based on the aggregate data from the U.S. Department of Health and Human Services. Note that our measure of OOP health expenditures corresponds to the sum of all private health care expenditures, including the costs of health insurance.

4.3.2 Nursing Home Expense Risk

Starting at age R, agents face age-specific probabilities of entering a nursing home in the following period and starting at age $R+1$, entry probabilities depend on both age and health. The unconditional probabilities of entering a nursing home at each age $j+1$ are $\{\bar{\theta}_j\}_{j=R+1}^{J}$ and the probabilities conditional on health are $\{\theta(j+1,h)\}_{j=R+1}^{J}$. We assume that, at each age j, the probability of entering a nursing home next period increases in $M(j,h)$ at a constant rate or

$$\ln \theta(j+1,h) = \beta_{n,1}^{j} + \beta_{n,2}^{j} \ln M(j,h), \quad j = R+1, \ldots, J.$$

For simplicity we assume that the rate at which the entry probability increases with health is constant across ages, i.e., $\beta_{n,2}^{j} = \beta_{n,2}$ for all $j > R$. In addition, we assume that the unconditional 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, given $\beta_{n,2}$, the parameters $\{\beta_{n,1}^{j}\}_{j=R+1}^{J}$ are chosen such that the unconditional nursing home entry probabilities satisfy

$$\bar{\theta}_j = \begin{cases} \bar{\theta}_{65-74}, & \text{for } 1 \leq R+j < 6, \\ \bar{\theta}_{75-84}, & \text{for } 6 \leq R+j < 11, \\ \bar{\theta}_{85+}, & \text{for } 11 \leq R+j \leq J, \end{cases}$$

and the 3 probabilities, $\bar{\theta}_{65-74}$, $\bar{\theta}_{75-84}$, and $\bar{\theta}_{85+}$, 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 growth rate $\beta_{n,2}$ is chosen along with the parameters of the medical expense process by targeting Medicaid's share of medical expenses by age.

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 statistics drawn from the Medicare Current Beneficiary Surveys from the period 2000 to 2003, the average cost of nursing home care net of Medicare payments was 0.68 percent of GDP. Note that in the model, total nursing home expenses are computed as the sum of the medical costs and consumption in a nursing home: $M^n + \underline{c}^n$.

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.[5] 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)).[6] These estimates suggest that the minimum consumption floor for individuals is somewhere in the range of 10 to 20 percent.[7] We set the consumption floor for consumer

[5] 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.

[6] 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: Educational Attainment and Synthetic Estimates of Work-Life Earnings.* U.S. Census Bureau Special Studies. July 2002. The weights are taken from *Educational Attainment: 2000* Census Brief. August 2003.

[7] 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

and medical bankruptcy, $\underline{c}^w = \underline{c}^m$, to 15 percent of the average value of the agents' expected average lifetime earnings.

Obtaining an estimate of a consumption floor provided under a nursing home bankruptcy is problematic because it requires estimating the value of the rooms and amenities that nursing homes provide to Medicaid-funded residents. Instead, we calibrate the minimum consumption level for nursing home residents, $\underline{c}^n$, to match Medicaid's share of nursing home expenses for individuals 65 and over. According to the Current Medicare Beneficiary Survey, over the period 2000 to 2003, on average, Medicaid's share of the elderly's total nursing home expenses net of those paid by Medicare was approximately 45 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 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

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

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

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

with two 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 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.

The tax rate $\hat{\tau}_y$ is also determined in equilibrium. As is the case under the U.S. tax system, taxable income is income net of health expenses that exceed 7.5 percent of income. Thus κ is set to 0.075. 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. Information on the algorithm used to compute the equilibrium along with 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. The equilibrium tax rates in the benchmark economy are 0.254 for income tax and 0.079 for payroll tax. Note that our calibration produced a value for the nursing home consumption floor, $\underline{c}^n$, which lies below the non-nursing home consumption floor, $\underline{c}^m$. We view this differential as reflecting a lower quality of life enjoyed in a public nursing home facility relative to receiving public assistance while living at home. As we show later in our quantitative analysis, the low quality of life under public nursing care plays an important role in individual saving decisions.

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 earnings 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 match it with a much greater precision then other sources of heterogeneity 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.

Table 6: Calibrated Parameters

parameter	**description**	**values**
β	subjective discount factor	0.954^{*}
γ	coefficient of risk aversion	2.0
n	population growth rate	0.021
	consumption floors	
$\underline{c}^w$	consumer bankruptcy	$0.15^{\dagger}$
$\underline{c}^m$	medical bankruptcy	$0.15^{\dagger}$
$\underline{c}^n$	nursing home bankruptcy	$0.09^{\dagger}$
M^n	medical cost of nursing home care	$0.86^{\dagger}$
ϕ^n	relative survival probability for nursing home residents	0.919
	probabilities of entering a nursing home in next 2 years	
$\bar{\theta}_{65-74}$	65 to 74 year-olds	0.004
$\bar{\theta}_{75-84}$	75 to 84 year-olds	0.0136
$\bar{\theta}_{85+}$	85 and up	0.0551
$\beta_{n,2}$	growth rate of nursing home prob. with medical expenses	0.938
	coefficients in the deterministic component of medical expenses	
$\beta_{m,1}$	age	0.13
$\beta_{m,2}$	age-squared	-0.0058
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.

†Fraction of expected average annual lifetime earnings.

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 aggregate levels of OOP health expenses and their observed distribution across the population. 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 OOP health expenses in the benchmark economy closely replicates a wide range of data moments. 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 successfully predicts the fraction of nursing home residents receiving Medicaid subsidy and the probability of entering a nursing home for a long-term stay.

5.2 Wealth Inequality

Before proceeding to the model predictions about wealth inequality under the benchmark calibration, it is useful to discuss the driving forces behind wealth inequality in the model. In the model economy, individuals face uncertainty about their earnings, medical and nursing home expenses, and survival. The absence of insurance markets coupled with borrowing constraints creates a strong incentive for precautionary saving as individuals desire to smooth consumption over their lifetime. Means-testing of social insurance implies that richer individuals rely on self-insurance through private savings much more than poorer ones. The welfare program discourages saving of low-income workers early on in life, and Medicaid further discourages their saving to finance health expenses experienced later on. As an agent's permanent earnings increase, he becomes less likely to qualify for Medicaid, and health expenses gain importance in his life-cycle savings. However, the relative importance of medical versus nursing home expenses for saving differs across the permanent earnings distribution. Note that, as the most persistent and one of the largest health expense realizations in the model economy, nursing home expenses require a higher level of savings than medical expenses. As a result, for low-income individuals, saving for nursing home expenses is either infeasible or relatively more costly than for wealthier individuals. Hence low-income individuals are more likely to allow Medicaid to cover their nursing home care costs, saving instead for smaller OOP medical expenses. Saving behavior of wealthier individuals, on the other hand, is driven

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

Targeted Moments	Data	Model	Data	Model
OOP Expenses				
Gini	0.67	0.68		
Shares of Total, %				
First Quintile	0.13	0.10		
Second Quintile	2.75	2.60		
Third Quintile	9.76	9.32		
Fourth Quintile	20.16	20.79		
Fifth Quintile	67.21	67.19		
Top 10%	50.71	50.47		
Top 5%	38.84	40.57		
Top 1%	21.77	14.45		
Shares and Mean Expenses of SSI groups	*shares, %*		*mean, % p.c. income*	
First Quintile	13.4	2.7	17	1
Second Quintile	16.7	18.1	21	17
Third Quintile	18.4	23.3	23	22
Fourth Quintile	23.0	27.5	29	26
Fifth Quintile	28.5	28.3	36	26
Top 10%	7.5	14.2		
Top 5%	6.5	7.2		
Top 1%	1.4	1.4		
Shares of GDP by Age, %				
65-74	0.61	0.63		
75-84	0.55	0.51		
85+	0.34	0.32		
Medicaid				
Shares of GDP by Age, %				
65-74	0.17	0.18		
75-84	0.23	0.22		
85+	0.23	0.24		
Nursing Home				
Costs				
Share of GDP, %	0.68	0.69		
Share of Total Health Expenses, %	33	33		
Medicaid Share of NH Costs, %	45	44		
Resident Share in Age Group, %				
65+	4.5	4.7		
65-74	1.1	1.0		
75-84	4.7	4.7		
85+	18.2	18.2		

Table 8: Medical and Nursing Home Expenses: Aggregate Summary

Health Expense	Data	Model
Medical		
OOP, % of GDP	1.5	1.5
Medicaid, % of GDP	0.6	0.6
Nursing Home		
OOP, % of GDP, %	0.38	0.39
Medicaid, % of GDP	0.31	0.30
Independent Moments		
Fraction of NH residents on Medicaid	0.58*	0.60
Nursing Home Entry Probability	0.14†	0.15

* includes individuals under 65

† probability of entering and staying a year or more

by both medical and nursing home expenses. Moreover, self-insurance against the nursing home shock by wealthier individuals is in part driven by the relatively lower consumption floor guaranteed under a nursing home bankruptcy which makes this type of bankruptcy relatively more painful. In summary, individuals across the permanent earnings distribution effectively face different kinds of OOP health expense risk and this variation has a significant impact on the distribution of wealth in the economy. Another factor important to the distribution of wealth in the model economy is the fact that progressive social security provides better insurance against health expense and survival risk for the poor than the rich. The importance of different types of OOP health expenses and the structure of the social insurance system for aggregate wealth accumulation and inequality is a quantitative question we seek to answer.

To assess the model's fitness to address this question, we compare the wealth inequality generated by the model to the data. Recall that our calibration procedure did not target any wealth distribution moments. Table 9 reveals that cross-sectional wealth inequality in the benchmark economy has a remarkable fit of the U.S. wealth distribution, as documented in Rodriguez et al. (2002). The share of wealth help by the top 1 percent of the population in the model economy, 28 percent, is remarkably high for a pure overlapping-generations model. 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 uncertain lifetimes.

In an empirical analysis, Dynan, Skinner and Zeldes (2004) document that the saving rates of working age households increase with current and permanent income. We compute

Table 9: Wealth: Selected Moments

Moments	Data	Model
Wealth[†]		
Gini	0.80	0.83
shares of total, %		
First Quintile	-0.3	0
Second Quintile	1.3	0
Third Quintile	5.0	1.0
Fourth Quintile	12.2	12.9
Fifth Quintile	81.7	86.0
Top 10%	69.1	66.8
Top 5%	57.8	51.7
Top 1%	34.7	28.0

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

the saving rates for each earnings quintile by age as the ratio of the change in asset holdings of a quintile to the current disposable income of that quintile. Figure 1b shows that in the benchmark economy, for the first four quintiles, individuals in the higher permanent earnings quintiles save a higher fraction of their current disposable income. Individuals in the highest permanent earnings quintile have the highest average saving rate up until age 40.

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 aggregate savings? To address this question we conduct a few partial equilibrium experiments. To evaluate the role of health expense risk, we shut down uncertainty about all health expenses by making each retired individual face a deterministic health expense profile regardless of their nursing home status. The expense profile is set to the average profile 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, on aggregate, health expense risk plays a relatively minor role: precautionary savings account for 4 percent of the total capital stock (Table 10). Not surprisingly, given the high concentration of wealth in the model economy, health expense risk is more important on the individual level. Precautionary savings of the fourth and fifth permanent earnings quintiles account for 8 and 5 percent of their wealth respectively. The aggregate effect is smaller because individuals in the lower quintiles accumulate more wealth with deterministic health expenses as they are less likely to qualify for Medicaid subsidies in the absence of large shocks.

Notice, however, that although all quintiles face higher OOP health expenses due to a lower Medicaid subsidy (for which they qualify with certainty after some age), their OOP nursing home expenses drop. To disentangle the contribution of the nursing home expense risk to savings from that of the medical expenses, we consider an economy where every retired individual faces certain medical expenses but their nursing home expense risk is the same as in the benchmark economy. We find that uncertainty about medical expenses alone accounts for only 1 percent of aggregate capital accumulation, driven by the savings of the top two quintiles (second column in Table 10). We conclude that uncertainty about nursing home expenses is a more important motive for precautionary savings than uncertainty about medical expenses. The intuition behind this novel result in the literature is simple: 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.

To assess the contribution of precautionary savings due to survival risk, we consider certain lifetimes 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 lifetime 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 an 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 plays a much more prominent role in savings than health expense risk. Precautionary savings due to survival risk accounts for 15 percent of the capital stock in the benchmark economy. Why is survival risk so important for savings given that social security already partially insures individuals against this type of risk? This happens for two reasons. First, social security income is insufficient for consumption smoothing of richer individuals, and second, the presence of health expenses and their growth with age make surviving increase lifetime health expense risk. Means-testing of Medicaid makes this risk more important for wealthier individuals. As Table 10 shows, deterministic survival leads to a decrease in the wealth of the top three permanent earnings 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 no one lives 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

Table 10: Effects of Old-Age Uncertainty

Health Expenses *Survival*	Deterministic Random	Det. except NH Random	Random Deterministic	None Deterministic
		relative to baseline		*relative to random survival and no health expenses*
Agg. Capital	0.961	0.989	0.847	0.948
wealth of PI quintiles				
First Quintile	1.09	1.06	1.04	1.06
Second Quintile	1.16	1.07	1.00	1.07
Third Quintile	1.04	1.00	0.89	1.02
Fourth Quintile	0.92	0.97	0.81	0.99
Fifth Quintile	0.95	0.99	0.88	0.95
OOP expenses of PI quintiles				
First Quintile	1.24	1.20	0.99	
Second Quintile	1.33	1.19	1.03	
Third Quintile	1.21	1.06	0.98	
Fourth Quintile	1.04	1.01	0.89	
Fifth Quintile	1.01	1.00	0.88	
Nursing home OOP expenses of PI quintiles				
First Quintile	0.95	1.03	0.42	
Second Quintile	0.77	1.09	0.49	
Third Quintile	0.53	1.06	0.46	
Fourth Quintile	0.34	1.02	0.38	
Fifth Quintile	0.31	1.00	0.36	

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 only account for 5 percent of the aggregate capital stock. Moreover, precautionary savings are only accumulated by the top permanent earnings quintile; 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 individual wealth accumulation. This is another novel result in the literature.

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 as savings get depleted toward the end of the life cycle. The major beneficiaries of the Medicaid program are in the bottom 20 percent of the permanent earnings distribution. Similarly, Figure 2b shows that the main nursing home beneficiaries of Medicaid are those in the bottom 40 percent of the permanent earnings distribution and older individuals from higher quintiles. Note that the take up rate of Medicaid is much higher among nursing home residents. This occurs for two reasons. First, the nursing home expense shock is one of the largest in the benchmark economy and is an absorbing state. As a result, nursing home residents quickly deplete their assets and qualify for Medicaid sooner than the general population. Second, the probability of entering a nursing home next period is increasing in agents' current period medical expense shock. Hence nursing home residents are more likely than the rest of the population to have incurred high medical expenses in the past that have depleted their savings increasing their likelihood of Medicaid eligibility.

Finally, Figure 3a shows the distribution of OOP health expenses by permanent earnings quintile and age. The first quintile faces on average 5 times smaller OOP health expenses than the second quintile. This gap indicates that the lifetime earnings of individuals in the bottom quintile are so 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 individuals in the second permanent earnings quintile cannot afford nursing home costs but pay for smaller medical expenses OOP. Higher quintiles, on the other hand, pay nursing home expenses OOP in addition to medical expenses. Furthermore, as a result of the means-testing of Medicaid, expected OOP health expenses relative to income are the highest for individuals in the middle of the permanent earnings distribution. Figure 3b shows that permanent earnings quintiles two, three, and four expect the largest health expenses relative to their current incomes. These differences in OOP expenses across the permanent earnings 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 benchmark economy. When we refer to the public coverage of nursing home expenses, or equivalently, elimination of nursing home expenses, we mean only the medical expense portion, M^n, of the nursing home cost. Unlike under Medicaid, this subsidy is provided to all nursing home residents, and it does not restrict their consumption to $\underline{c}^n$. Consumption transfers to nursing home residents are subject to means-testing in all policies that we consider below, including those with public coverage of nursing home care.

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, under the third policy both medical and nursing home expenses are paid for by the government. Under all 3 policies consumption transfers are 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) would reduce the aggregate capital stock by 12 percent. To show the importance of the general equilibrium analysis, we repeat the same experiment in a partial equilibrium. We find that changes in after-tax prices – specifically an increase in the after-tax interest rate – offset the decline in the capital stock by 7 percentage points.

To understand which health expenses − medical or nursing home − drive the impact of public health care on capital accumulation, we compare the effects of policies 1 and 2, which eliminate one type of expense at a time. Note that policy 2 does not completely eliminate the nursing home risk per se as it is still present in the survival probabilities, which are lower for the nursing home residents. We find that in a general equilibrium, on aggregate, both types of expenses contribute equally: elimination of either non-nursing home expenses only or nursing home expenses only reduces the capital stock by 7.5 percent relative to the benchmark. In a partial equilibrium, nursing home expenses have a larger effect than medical expenses, accounting for 10 percent of the capital stock compared to 7.6 percent. The relative importance of the nursing home expenses for capital accumulation may seem surprising given that their share of total health expenses is only 20 percent (see Table 8). However, we have shown in Section 5.3 that, in part, nursing home expenses play a larger role because of their higher risk relative to medical expenses.

The larger difference between the partial and general equilibrium capital stocks under policy 2 compared to policy 1 is due to a difference in the saving response to the higher interest rate in general equilibrium under the two different policies. Removing the risk of OOP expenses lowers the risk of additional savings being implicitly taxed-away through means-tested transfers. However removing OOP nursing home expenses reduces the implicit tax risk more than removing OOP medical expenses. Under policy 1, savings are less elastic in response to the higher interest rate than under policy 2. In addition, medical expenses are four times larger than nursing home expenses. Thus the government must raise the income tax rate to finance policy 1 further discouraging savings. Under policy 3, the removal of all OOP health expenses greatly reduces implicit tax risk, making the savings response to rising interest rates even more elastic. The consequent increase in aggregate savings and tax revenue is sufficient to finance the increase in government spending on health expenses with only a tiny increase in the income tax rate.

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 changes? Recall that the major savers in the benchmark economy are located in the top two permanent earnings 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, accounting for a third to a half of the drop in the aggregate capital stock. This is a result of the differential provision of social insurance across the permanent earnings distribution: the rich – the least insured in the benchmark economy – face the largest change in insurance coverage and hence respond the most to public health care.

However, in percentage terms, relative to the quintile's wealth in the benchmark economy, asset holdings of agents in the middle of the permanent earnings distribution – quintiles two to four – respond the most. Under policy 3, these quintiles reduce their wealth by 20 percent whereas the wealth of the first quintile is unaffected and the top quintile reduces its wealth by only 8 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 and 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.

Moreover, as Table 11 indicates, nursing home expenses have a bigger impact than medical expenses on the saving behavior of the top two permanent earnings quintiles, and the reverse is true for the second and third quintiles. These differences in the quintiles' saving responses to policy changes are consistent with the findings and intuition in the previous section: that is, different earnings quintiles are primarily exposed to different kinds of OOP expenses, and hence respond the most to the elimination of their particular expenses. Furthermore, between the two quintiles exposed the most to the nursing home expense risk, the fourth quintile reduces its wealth by a higher fraction than does the fifth quintile. This occurs because, relative to their lifetime earnings, the fourth quintile's OOP nursing home expenses are larger.

One of the motivations for incorporating OOP medical and nursing home expenses into a life-cycle model was 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 the dissaving rates of the elderly. Figure 4b shows these rates for the fourth quintile, as the responses to policy changes are the most dramatic for this population group. Under public coverage of medical expenses, individuals ages 65 to 75 dissave at a nearly half the rate in the benchmark economy, while public coverage of nursing home expenses increases the rate of dissaving relative to the benchmark. We conclude that 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 – public coverage of nursing home expenses in particular – dramatically increases within-cohort wealth inequality among retired individuals (Figure 5a), in spite of having only a small effect on overall cross-sectional inequality (Table 11). At the end of the life cycle, the wealth Gini coefficient increases by as much as 20 points. 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. Notice that prior to the age of 86 years, OOP medical expenses dominate nursing home expenses in reducing wealth inequality, while at later ages their roles are reversed. This is explained by the fact that nursing home risk grows substantially with age: under the benchmark calibration, the probability of entering a nursing home after age 85 is more than triple the probability for ages 75 to 84. Moreover, while we find that public health care reduces consumption inequality, the effect is substantial only among those 85 years and older (Figure 5b). Since these are the people most likely to enter a nursing home, it is not surprising that coverage of the nursing home expenses drives the fall in consumption inequality.

To understand why nursing home expenses play such an important role in capital accumulation, 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 the rest of the population receives in the benchmark economy: $\underline{c}^n = \underline{c}^m$. We term this 'quality' nursing home care. We repeat policy experiments (1) through (3) in the economy with quality nursing home care. The results are presented in Table 12.

Quality 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 4 percent relative to the benchmark economy. Next, we introduce public health care into the economy with quality nursing home care. Elimination of OOP health expenses in this economy reduces the capital stock by 9 percent, which is 3 percentage points less than the effect of the same policy in the benchmark economy. Moreover, in contrast to the impact of public health care programs without quality nursing homes, quality public nursing home care reduces the relative importance of nursing home expenses for savings. While elimination of OOP medical expenses reduces the capital stock by 8 percent, elimination of OOP nursing home expenses reduces it by only 4 percent. That is, a higher level of public insurance for nursing home expenses makes nursing home bankruptcy less painful, reducing the desire to avoid it with self-insurance. The relative impacts of health expenses on savings are also illustrated in Figure 6 which shows the wealth profiles of the fourth permanent earnings quintile under the different policies. Unlike in Figure 4a, with quality nursing homes, the wealth profile under the publicly-funded nursing home care lies very

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	0.977	0.977	0.962
Agg. Capital	1.00	0.925	0.925	0.878
Capital, Partial Equil.		0.924	0.902	0.810
change in wealth of PE quintiles, % of agg. capital change				
All		100	100	100
First Quintile		0.7	-0.1	0.0
Second Quintile		13.2	-0.3	6.0
Third Quintile		21.7	7.6	15.3
Fourth Quintile		26.8	37.9	35.0
Fifth Quintile		36.0	49.6	39.6
wealth of PE quintiles relative to baseline				
First Quintile	1.00	0.87	1.02	1.00
Second Quintile	1.00	0.72	1.01	0.80
Third Quintile	1.00	0.82	0.94	0.80
Fourth Quintile	1.00	0.91	0.87	0.80
Fifth Quintile	1.00	0.96	0.94	0.92
Income Tax Rate	0.254	0.271	0.259	0.257
OOP, % output	1.46	0.40	1.15	0.06†
Std(OOP) (rel.)	1.00	0.74	0.73	0.10
Wealth Inequality				
Wealth Gini	0.83	0.84	0.83	0.84
shares of total wealth, %				
Fourth Quintile	12.9	11.5	13.1	11.9
Fifth Quintile	86.1	87.7	85.8	87.2
Top 10%	66.8	68.9	67.9	69.8
Top 5%	51.7	54.0	53.8	56.0
Top 1%	28.0	30.0	30.0	31.7

† OOP expenses are positive because, to make our measure of nursing home expenses more consistent with the measure used in the data, we include a consumption component that is not covered under policies 1-3.

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

Policy	**Baseline**	Quality NH	**1(Q)**	**2(Q)**	**3(Q)**
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	0.988	0.965	0.977	0.962
Agg. Capital	1.00	0.962	0.887	0.925	0.877
relative to Quality NH					
Agg. Capital		1.00	0.922	0.961	0.912
Income Tax Rate	0.254	0.259	0.277	0.260	0.257
OOP, % output	1.47	1.47	0.39	1.19	0.10
Std(OOP) (rel.)	1.00	0.99	0.73	0.74	0.16

close to the profile without the coverage. We conclude that higher wealth accumulation for nursing home expenses relative to that for medical expenses is for the most part accounted for by the differential insurance of nursing home versus medical bankruptcies.

6.2 Social Safety Nets

In this section, we examine the role of social safety nets in wealth accumulation and inequality. In our model economy, the welfare program for workers and Medicaid for retirees partially insure against earnings, survival, and health expense risks by providing means-tested transfers that guarantee a minimum consumption level. As means-tested Medicaid transfers effectively tax away savings, they discourage savings disproportionally more for poor individuals, reducing aggregate capital accumulation and increasing wealth inequality. To examine the role of each safety net quantitatively, we consider five more policies, labeled 4 through 8, which (almost completely) remove welfare and/or Medicaid programs. This is achieved by setting 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, labeled 7 and 8, which not only remove safety nets, but also eliminate all OOP health expenses through public health care. The aggregate and distributional effects of policies 4 through 8 are presented in Table 13. Note that the safety net labeled 'Medicaid' also includes the old-age welfare program.

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

Policies	**Baseline**	**4**	**5**	**6**	**7**	**8**
Safety Nets In Place	All	Medicaid	Welfare	None	Medicaid	None
Public Health Care	No	No	No	No	Yes	Yes
Aggregates						
relative to baseline						
Agg. Output	1.00	1.097	1.278	1.290	1.056	1.064
Agg. Capital	1.00	1.360	2.264	2.339	1.199	1.231
Income Tax Rate	0.254	0.224	0.187	0.176	0.253	0.223
Transfers, % output	2.8	0.8	0.9	0.2	0.2	0
OOP, % output	1.5	1.4	1.4	1.4	0	0
Std(OOP) (rel.)	1.0	1.0	1.2	1.2	0	0
Consumption Gini	0.42	0.48	0.49	0.53	0.43	0.49
Wealth Inequality						
Wealth Gini	0.83	0.66	0.57	0.55	0.84	0.64
shares of total wealth, %						
Fourth Quintile	12.9	18.9	26.1	25.9	12.1	18.9
Fifth Quintile	86.1	66.7	55.5	54.4	86.7	65.1
Top 1%	28.0	20.7	12.8	12.4	31.4	22.5

In all the economies we consider here, agents are still partially insured through the progressive social security program against all three types of risk. Apart from this insurance, policy 4 maximizes individual exposure to earnings risk by removing the welfare program for workers, policy 5 maximizes individual exposure to health expense and survival risk by removing Medicaid and the old-age welfare program, and policy 6 maximizes individual exposure to all three types of risks by removing all the welfare and Medicaid programs. 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 134 percent. Which safety nets – those for workers or the elderly – are responsible for the large decrease in precautionary savings, going from policy 6 back to the baseline? Policies 4 and 5 provide the answer: while removing the welfare program for workers (policy 5) in the benchmark economy increases the capital stock by 36 percent, removing the welfare program for the elderly (policy 4) increases the capital stock by 126 percent.

Why is the health expense risk a more important driver of precautionary savings than the 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 working stage of life 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 earnings distribution. However, as discussed in the previous section, the presence of OOP health expenses creates a differential savings response across the permanent earnings 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. This wealth redistribution effect further reduces wealth inequality. In the economy with the least insurance (policy 6), the wealth Gini falls by 28 percentage points relative to the benchmark. Once again, comparing inequality measures under policies 4 and 5 shows that among the three types of risk, health expense together with survival risk account for most of the reduction in wealth inequality. Finally, comparing this change with the reduction in the wealth Gini caused by going from policy 7 to 8 (removing safety net for retirees under full public health care) shows that the differential response to the pure increase in survival risk alone accounts for some but not all of the reduction in the wealth Gini coefficient. We conclude that the Medicaid program is an important generater of overall cross-sectional wealth inequality. Finally, both welfare and Medicaid reduce overall consumption inequality: the Gini coefficient decreases by 6-7 points for each program, and by 11 points in a joint effect.

6.3 Social Security

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

To provide a quantitative answer to these questions, we consider four additional policies: relative to the baseline, policies 9 and 11 replace progressive benefits with a proportional one – the proportion is 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. In addition, under policies 11 and 12 all OOP health expenses are removed through a public health care program. 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 slightly amplifies this effect. Removing progressivity reduces the aggregate capital stock by 8 percent in the economy with OOP health expenses (policy 9 relative to baseline) and by 7 percent in the economy without them (policy 11 relative to policy 3). Similarly to other policies we have considered, changes in the aggregate capital are driven by wealth accumulation of the top permanent earnings quintile. Here the role of the top quintile is pronounced the most because this is the only quintile that sees a substantial increase in its social security replacement rate when moving to the proportional benefit formula. 98 percent of the fall in the aggregate capital under policy 9 is due to lower wealth accumulation by the top quintile.

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

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	0.975	1.099	0.962	0.941	1.096
Agg. Capital	1.00	0.919	1.368	0.878	0.818	1.357
relative to Progressive SS, Public Health Care						
Agg. Capital				1.00	0.932	1.547
relative to No Public Health Care, fixed SS system						
Agg. Capital				0.878	0.889	0.992
change in wealth of PI quintiles, % of agg. capital change						
All		100	100	100	100	100
First Quintile		0.3	0.3	0.0	-0.2	0.6
Second Quintile		-2.9	3.6	6.0	0.3	6.1
Third Quintile		-3.1	12.6	15.3	7.3	15.2
Fourth Quintile		5.8	31.4	35.0	25.8	30.2
Fifth Quintile		98.0	51.2	39.6	63.2	47.0
wealth of PI quintiles relative to baseline						
First Quintile	1.00	0.95	1.31	1.00	1.07	1.60
Second Quintile	1.00	1.07	1.37	0.80	0.98	1.61
Third Quintile	1.00	1.03	1.50	0.80	0.86	1.59
Fourth Quintile	1.00	0.98	1.54	0.80	0.78	1.50
Fifth Quintile	1.00	0.88	1.30	0.92	0.82	1.26
SS replacement rates by PI quintiles						
First Quintile	0.88	0.44	0	0.88	0.44	0
Second Quintile	0.61	0.44	0	0.61	0.44	0
Third Quintile	0.49	0.44	0	0.49	0.44	0
Fourth Quintile	0.43	0.44	0	0.43	0.44	0
Fifth Quintile	0.34	0.44	0	0.34	0.44	0
Social Security Tax Rate	0.079	0.098	0	0.079	0.98	0
Income Tax Rate	0.254	0.266	0.235	0.257	0.268	0.219
OOP, % output	1.4	1.4	0.96	0	0	0
OOP, % total health exp.	70	66	50	0	0	0
Wealth Gini	0.83	0.82	0.81	0.84	0.83	0.81

system increases the capital stock by 37 percent in the economy with OOP health expenses (policy 10 relative to baseline) and by 55 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. The presence of a social security system amplifies the effect of the OOP health expenses on wealth accumulation. Elimination of OOP health expenses through public health care in the economy without social security reduces aggregate capital by only 1 percent, while in the economy with the progressive and proportional social security systems the capital stock falls by 12 and 11 percent respectively.

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 by 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.

Any quantitative study of the impact of medical expenses on 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 process 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 earnings 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 than previous studies, 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 expenses, 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 relatively more important driving force of the saving behavior of richer individuals. Furthermore, we show that OOP health expenses have important implications for the effects of social security on savings. We conclude that modeling medical and nursing 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. However, 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, the 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 through intertemporal substitution in response to 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 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.

Appendix

A.1 Computation

The steps in computing the model equilibrium are as follows. First guesses on aggregate capital and the income tax rate are made. Note that the social security tax rate can be computed ex ante. Second, individual maximization problems are solved. Agents' problems in the last period of their lives are solved first, followed by the previous period, up to the first period. Individual decision rules are computed using piecewise linear interpolation. The grids for assets and average lifetime earnings consist of 200 and 100 nonlinearly-spaced points, respectively. Third, the distribution of the population over the discrete state is computed using forward iteration. Finally, updated aggregates are computed. This procedure is iterated on until the capital stock converges and the government budget constraint holds.

A.2 Earnings Process

The stochastic component of the earnings process consists of a five-state discrete Markov chain. The chain is characterized by a five element grid of possible realizations, an initial distribution over that grid, Γ_z, and a 25 element probability transition matrix, $\Lambda_{zz'}$. The grid, which is set such that expected average annual earnings in the model is normalized to one, is $[-6.4823, 0.0155, 0.8747, 1.2000, 3.2102]$. The initial distribution and probability transition matrix, which contain 20 degrees of freedom after the restrictions on probabilities are imposed, are chosen by minimizing the difference between the model's prediction and the data on the 24 statistics mentioned in Section 4.3. The minimization results are provided in Table 15. The initial distribution generated by the minimization is $[0.0552, 0.5270, 0.2578, 0.1300, 0.0300]$ and the probability transition matrix is

$$\begin{bmatrix} 0.9684 & 0.0267 & 0.0049 & 0.0000 & 0 \\ 0.0424 & 0.9305 & 0.0271 & 0.0000 & 0 \\ 0.0079 & 0.0229 & 0.9682 & 0.0010 & 0.0000 \\ 0 & 0.0052 & 0.0635 & 0.9300 & 0.0013 \\ 0 & 0.0104 & 0.0198 & 0.0200 & 0.9497 \end{bmatrix}.$$

As a check on the calibration of the earnings process, Table 16 shows average annual earnings by permanent earnings quintile from the model. Earnings are converted to 2000 dollars using our estimate of expected average lifetime earnings of $32,828 (see footnote **??**).

Table 15: Targets for Earnings Process: Data and Model

Targeted Moments	Data	Model		
Earnings				
First-order autocorrelation	0.98	0.97		
Variance log earnings, ratio age 55 to age 35	1.89	1.33		
Gini	0.61	0.56		
Shares of Total, %				
First Quintile	-0.2	0.3		
Second Quintile	4.0	7.4		
Third Quintile	13.0	13.4		
Fourth Quintile	22.9	22.1		
Fifth Quintile	60.2	57.8		
Top 10%	42.9	40.2		
Top 5%	31.1	31.4		
Top 1%	15.3	15.9		
Social Security Income				
Shares and Means, %	*shares*		*mean*†	
First Quintile	5.7	3.9	8	7
Second Quintile	15.4	14.5	21	25
Third Quintile	20.4	20.7	28	35
Fourth Quintile	24.5	28.2	34	49
Fifth Quintile	34.0	33.3	47	58
Top 10%	8.3	17.8		
Top 5%	8.2	9.5		
Top 1%	3.1	2.0		

† normalized by p.c. income

Table 16: Average Annual Earnings by Permanent Earnings Quintile in the Baseline Model, 2000 dollars

First Quintile	4,201
Second Quintile	14,845
Third Quintile	23,687
Fourth Quintile	39,249
Fifth Quintile	82,058

A.3 Medical Expense Process

The stochastic component of the medical expense process is governed by a four-point discrete Markov chain. Its grid of realizations is $[-5.83, -3.00, -1.70, 0.685]$, the initial distribution of non-nursing home entrants across medical expenses, Γ_h, is $[0.2205, 0.2177, 0.5209, 0.0409]$, and the probability transition matrix conditional on not entering a nursing home next period, $\Lambda_{hh'}$, is

$$\begin{bmatrix} 0.6510 & 0.2290 & 0.1100 & 0.0100 \\ 0.1512 & 0.7427 & 0.0961 & 0.0099 \\ 0.0423 & 0.1668 & 0.7809 & 0.0105 \\ 0.1016 & 0.3244 & 0.4998 & 0.0743 \end{bmatrix}.$$

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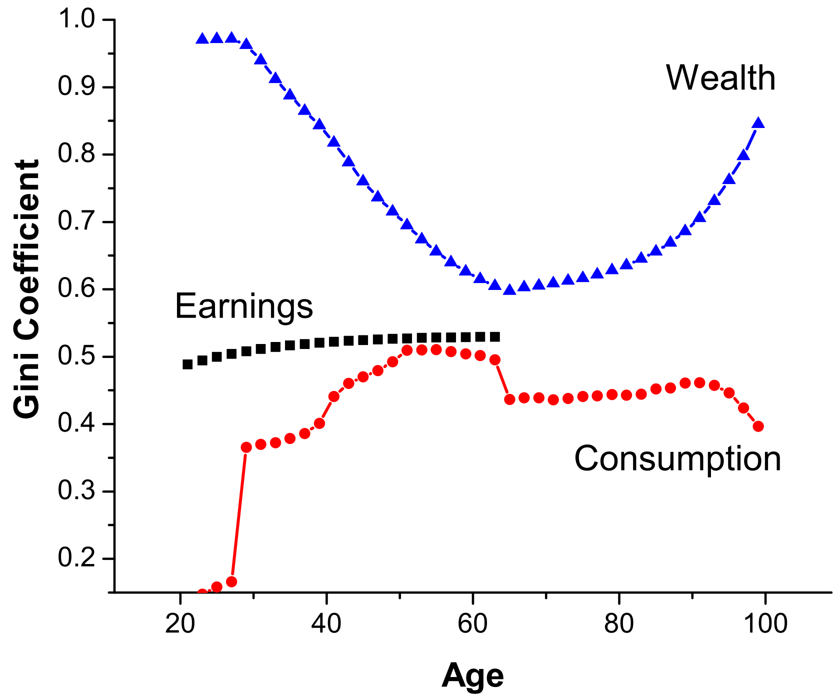
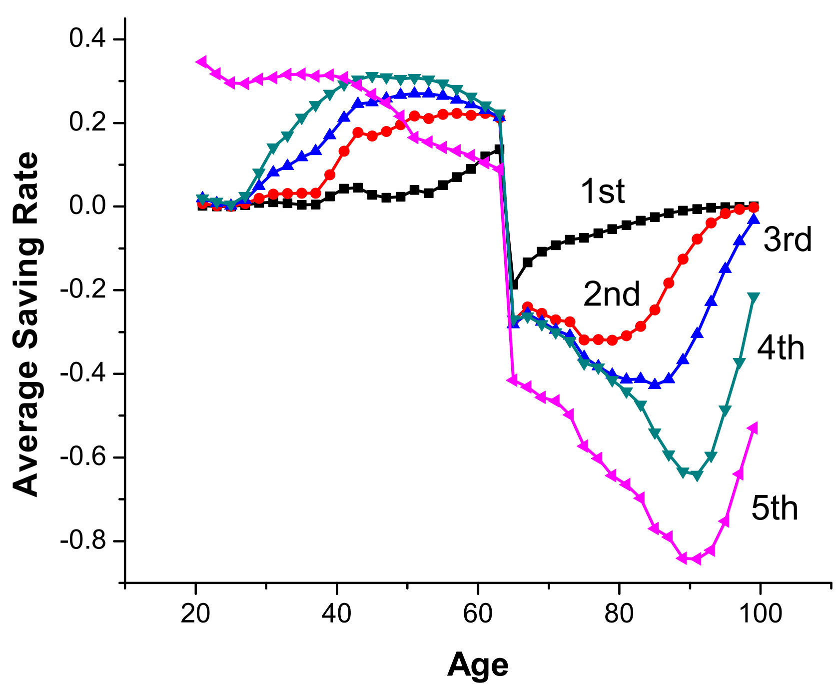
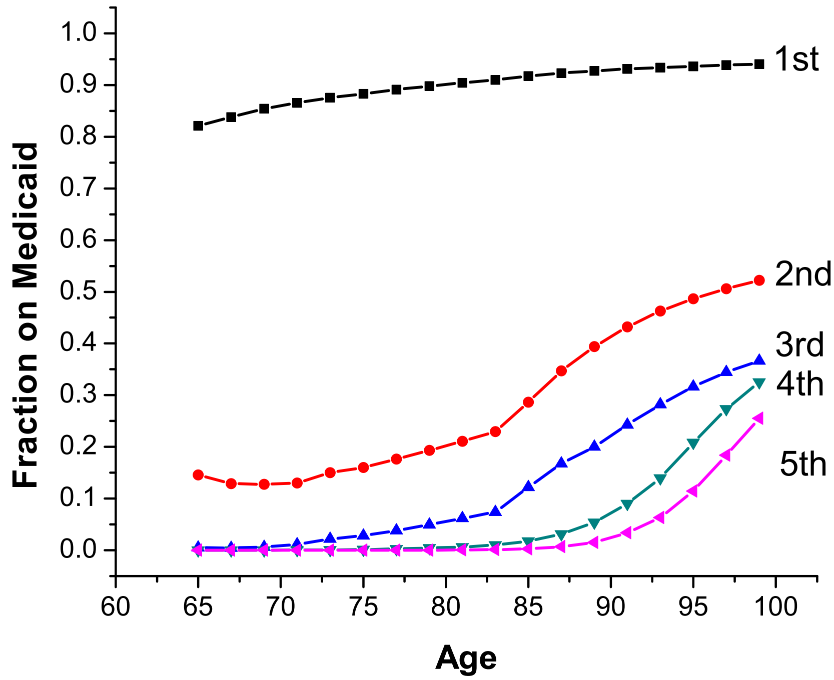


(a) Gini Coefficients

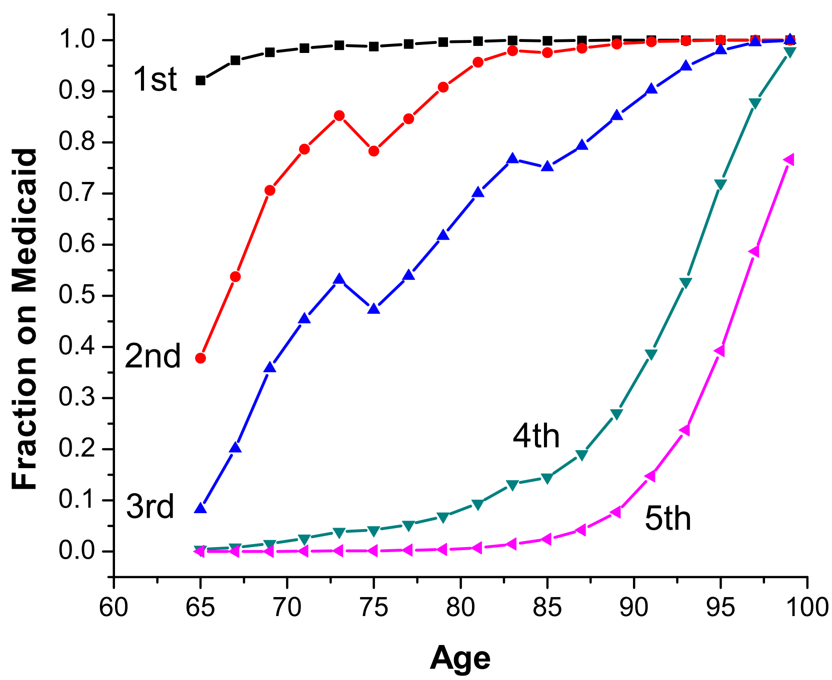


(b) Saving Rates

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

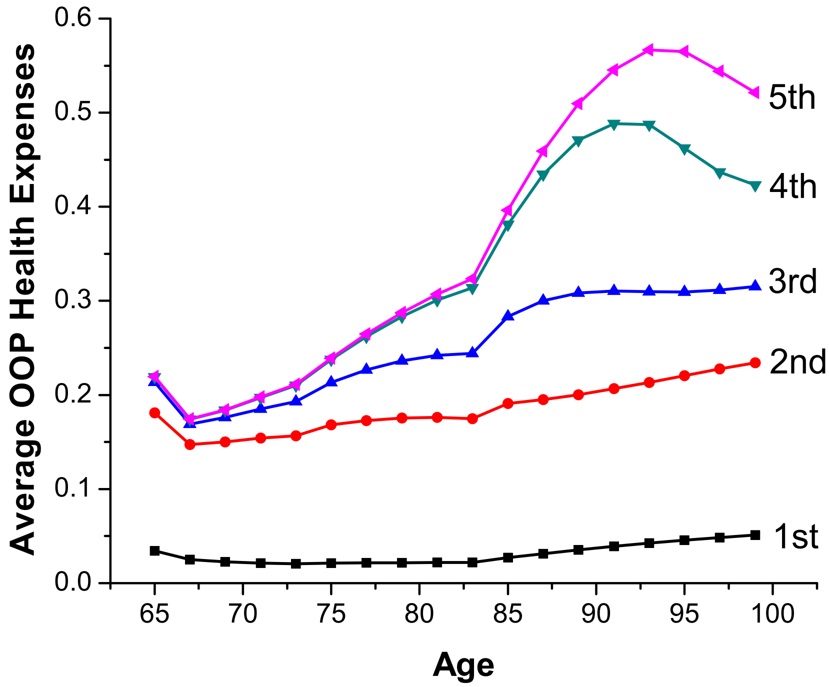


(a) Fraction on Medicaid

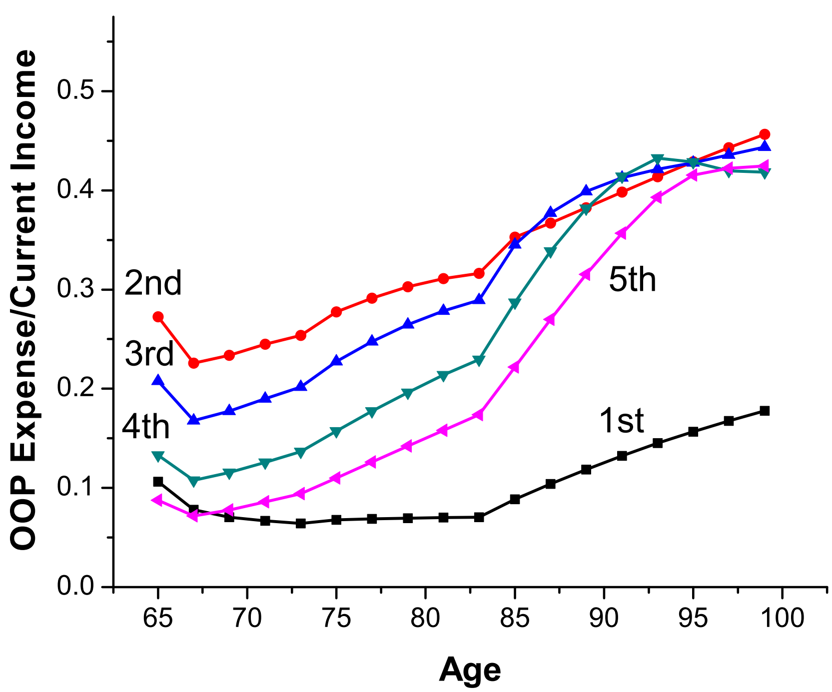


(b) Fraction of Nursing Home Residents on Medicaid

Figure 2: Life Cycle Profiles In the Benchmark Economy: Medicaid

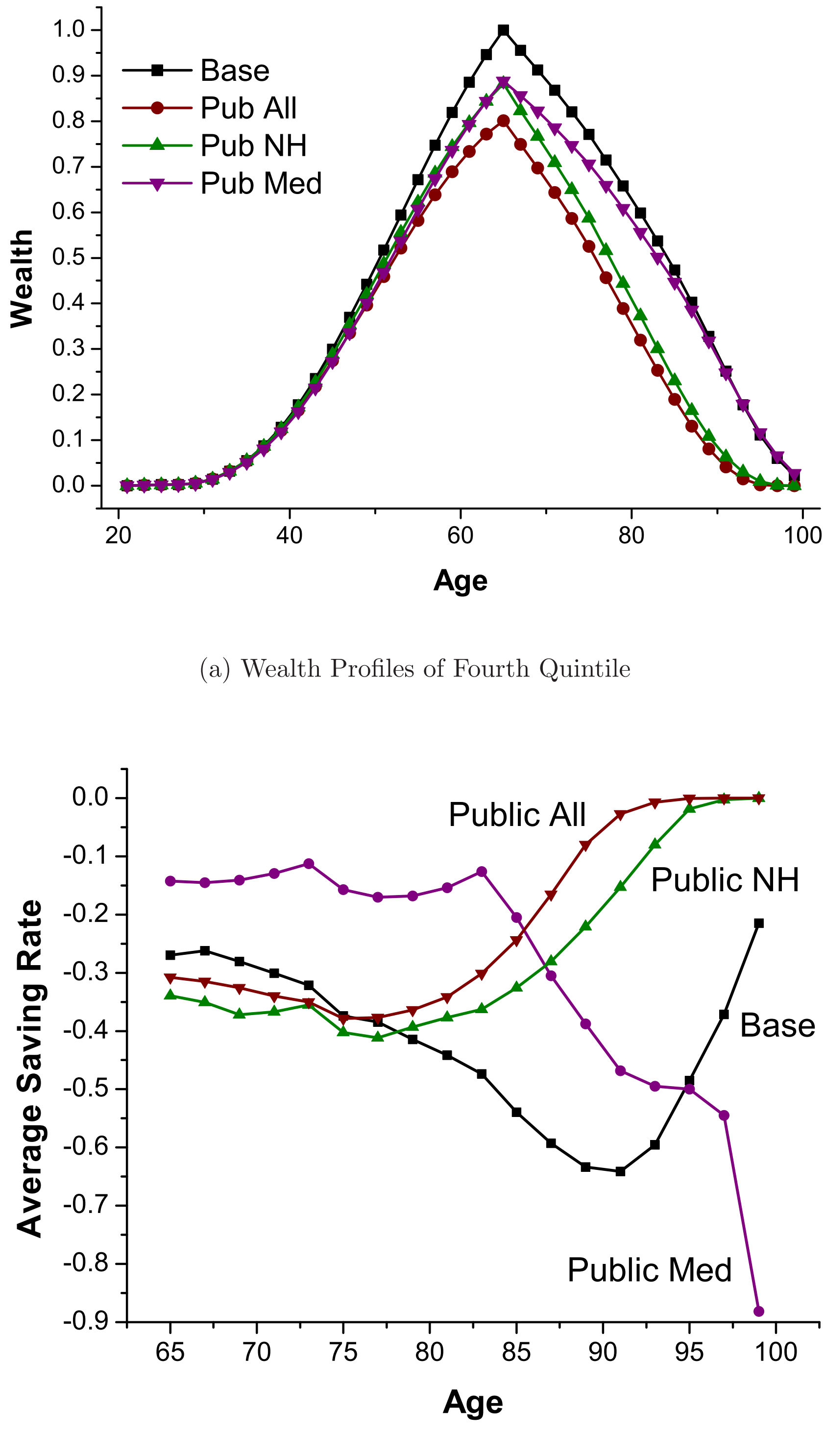


(a) Average OOP Health Expenses



(b) Relative to Average Current Income

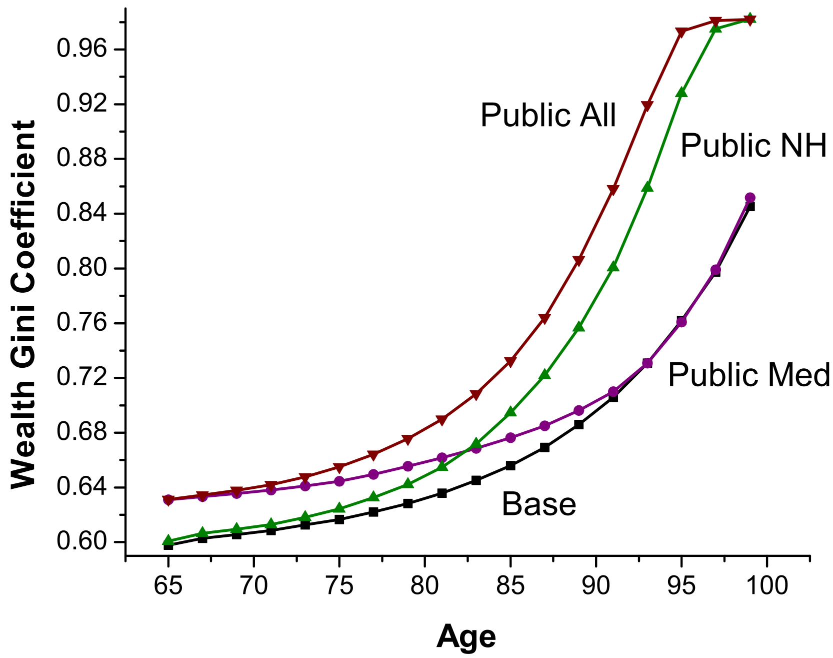
Figure 3: OOP Health Expenses by PI Quintiles in the Benchmark Economy



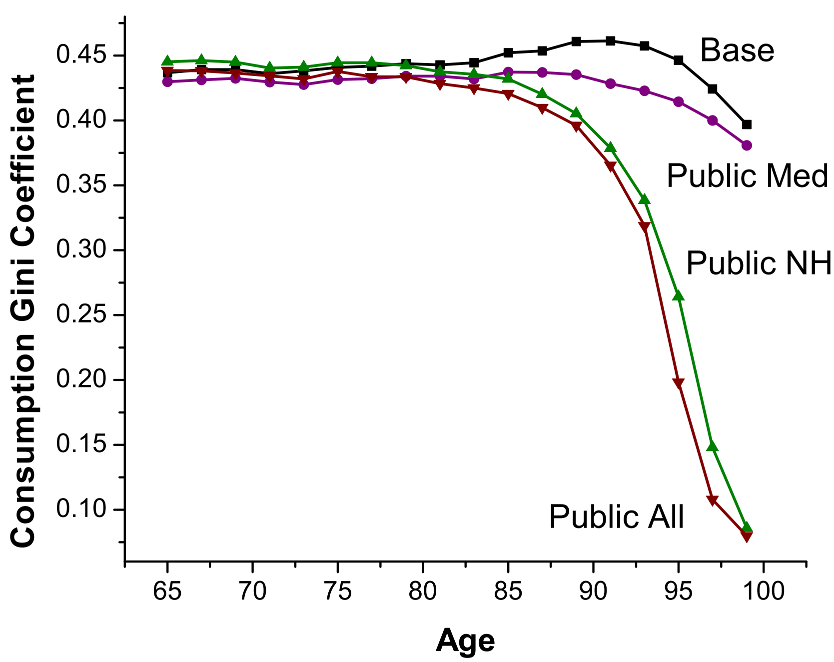
(a) Wealth Profiles of Fourth Quintile

(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

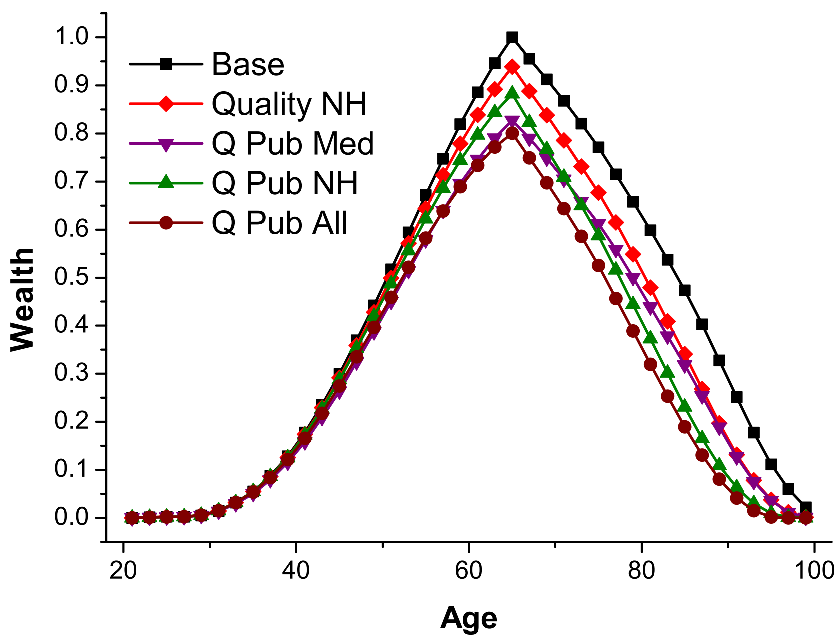


Figure 6: Quality Nursing Home Care and Public Health Care Policies