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WHY DO THE ELDERLY SAVE? THE ROLE OF MEDICAL EXPENSES

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**ABSTRACT**

This paper constructs a rich model of saving for retired single people. Our framework allows for bequest motives and heterogeneity in medical expenses and life expectancies. We estimate the model using AHEAD data and the method of simulated moments. The data show that out-of-pocket medical expenses rise quickly with both age and permanent income. For many elderly people the risk of living long and requiring expensive medical care is a more important driver of old age saving than the desire to leave bequests. Social insurance programs such as Medicaid rationalize the low asset holdings of the poorest. These government programs, however, also benefit the rich because they insure them against their worst nightmares about their very old age: either not being able to afford the medical care that they need, or being left destitute by huge medical bills.

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# 1 Introduction

Many elderly keep large amounts of assets until very late in life. Furthermore the income-rich run down their assets more slowly than the income-poor (Dynan et al. [22]). Why is this the case?

This paper provides a model of saving for retired elderly singles that addresses both of these questions. Our framework allows for bequest motives, social insurance, risky and heterogenous life expectancy, and risky and heterogenous medical expenses. The important dimensions of observable heterogeneity that we consider are age, sex, a measure of permanent income, and health.

Our estimation proceeds in two steps. Using the Assets and Health Dynamics of the Oldest Old (AHEAD) dataset, we first estimate stochastic processes for mortality and out-of pocket medical expenditures as functions of sex, health, permanent income, and age. In our second step, we estimate our model using the method of simulated moments. In particular, the model's preference parameters are chosen so that the permanent income-conditional age-asset profiles simulated from the model match those in the data, cohort by cohort.

While our estimated values of the coefficient of relative risk aversion and the discount factor are in line with those provided by the previous literature, the additional sources of heterogeneity that we consider allow the model to fit important aspects of the data well. Our estimated structural model is not rejected when we test its over-identifying restrictions. In addition, the distribution of deceased persons' estates generated by our model matches up very well with that observed in the data.

We find that bequests are luxury goods that are potentially quite important for the richest retirees. We also find, however, that our estimates of the bequest motive are very imprecise and that for most of our sample, savings barely change when the bequest motive is eliminated. One reason why the bequest motive is weakly identified is that even in the top permanent income quintile, median assets in our sample of elderly singles never exceed \$200,000; hence we do not have enough "super-rich" individuals to pin down the the bequest motive.

On the other hand, our estimated model implies that medical expenditures are important in explaining the saving of the elderly, including the richer ones, whether or not bequest motives are included. For example, our baseline model predicts that between ages 74 and 84 median assets for those

in the top permanent income quintile fall from \$170,000 to \$130,000. When we eliminate all medical expenses, median assets for this group fall much more, from \$170,000 at age 74 to \$60,000 at age 84.

These results are due to two important features of out-of-pocket medical expenses that we uncover in the first step estimation. First, even in presence of health insurance, out-of-pocket medical and nursing home expenses can be large; uncertain medical needs generate significant net income risk for the elderly.<sup>1</sup> Second, average medical expenditures rise very rapidly with age and income. For example, our model predicts that average out-of-pocket medical expenditures rise from \$1,100 at age 75 to \$9,200 at age 95. While a 95-year-old in the bottom quintile of the permanent income distribution expects to spend \$1,700 on medical expenses, a person of the same age in the top quintile expects to spend \$15,800. Medical needs that rise with age provide the elderly with a strong incentive to save, and medical expenses that rise with permanent income encourage the rich to be more frugal.

We find that medical expenditures have large effects on savings even we make them a choice variable in a model designed to fit both observed asset holdings and observed out-of-pocket medical expenditures. In this version of the model, people derive utility from consumption of medical goods and services, and face medical needs shocks to their preferences. These shocks depend on age, gender, and health, and retirees optimally choose medical and non-medical consumption taking into account the contribution of public and private insurance and their own resources. Importantly, while we do not allow our medical needs shocks to depend on permanent income, our model generates out-of-pocket medical expenditure rising with both permanent income and age, as in the data. This feature is a result of the budget constraint and private and public insurance contributions. High-income seventy-year-olds thus anticipate that if they live into their nineties they will probably choose to make large medical expenditures, like the ninety year olds in our sample do, and choose to save to be able to pay for them. Thus, whether they are exogenous or chosen, it is not surprising that medical expenditures have large effects on savings, as long as medical expenditures fit the data.

An important feature of our model is that it accounts for social insurance programs such as Supplemental Security Income and Medicaid, which insure against catastrophic medical expenses. Social insurance programs are important in explaining why low income individuals have few assets prior

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<sup>1</sup>See Brown and Finkelstein [8].

to retirement (Hubbard et al. [34], Scholz et al. [53]) and why these people do not accumulate assets during retirement. We find, however, that medical expenses are so large that social insurance also affects saving at the top of the income distribution. Although making medical expenses endogenous reduces the effects of social insurance, the effects that remain are stronger at higher income levels than at lower ones.

Our model also allows for differential mortality, because people who are rich, healthy, and female live longer.<sup>2</sup> Such differential life expectancy implies that as a cohort of people grows older its surviving membership becomes increasingly composed of the rich (Shorrocks [54]). The resulting mortality bias makes the surviving elderly seem more thrifty than they actually are. Failure to account for the mortality bias would lead us to understate asset decumulation by over 50% for the 74 year-old in our sample. Our model, which replicates the mortality differences found in the AHEAD data, generates asset profiles consistent with these observations.

In sum, we find that properly accounting for old age expenditure on medical care and for social insurance programs providing a consumption floor are very important to explain the elderly's savings. Hence, they are likely to be key elements to take into account to properly evaluate policy proposals affecting the elderly.

The rest of the paper is organized as follows. In section 2, we review the most closely related literature. In section 3, we introduce our version of the life cycle model, and in section 4, we discuss our estimation procedure. In sections 5 and 6, we describe the data and the estimated shock processes that elderly individuals face. We discuss parameter estimates and model fit in section 7. Section 8 contains some decomposition exercises that gauge the forces affecting saving behavior. In section 9 we develop a version of the model where medical expenses are a choice variable, estimate the model, and use it to perform some robustness checks. We conclude in section 10.

## 2 Related Literature

Our paper is related to a number of papers in the savings literature that consider either uncertain medical expenditures or bequest motives.

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<sup>2</sup>See Attanasio and Emmerson [4], and Deaton and Paxson [16] for evidence on permanent income and mortality. See Hurd et al. [36] for evidence on health status and mortality.

In an early study, Kotlikoff [40] finds that out-of-pocket medical expenditures are potentially an important driver of aggregate saving. However, Kotlikoff also stresses the need for better data on medical expenses and for more realistic modeling of this source of risk.

More recent studies, such as Hubbard et al. [33] and Palumbo [48], find that medical expenses have fairly small effects. In contrast, we find that medical expenses go a long way towards accounting for the observed lack of asset decumulation after retirement, at least for the elderly singles. The cause of these differences is that Hubbard et al. and Palumbo understate the extent to which medical expenditures rise with age and income. As an example, the average medical expense for a 100-year-old generated by Hubbard et al.'s medical expenditure model is about 16% of the average medical expense for a 100-year-old found in our data. We obtain different estimates because we use newer and better data: the AHEAD contains detailed information for a large number of very old individuals. This allows us to estimate a more flexible specification of medical expenses.

Hubbard et al. [34] argue that means-tested social insurance programs (in the form of a minimum consumption floor) provide strong incentives for low income individuals not to save. Their simulations, however, indicate that reducing the consumption floor has little effect on the consumption of college graduates. In contrast, we find that the consumption floor has an effect on saving decisions at all levels of income. Rich people live longer and also face medical expenses that rise rapidly as they age. Therefore, they also value social insurance as a safeguard against catastrophic medical expenses, even if they often end up not using it. This finding is consistent with Brown and Finkelstein's work [8], which finds large effects of Medicaid on the decisions of fairly rich people.

Scholz et al. [53] find that a life cycle model, augmented with realistic income and medical expense uncertainty, does good job of fitting the distribution of wealth at retirement. We add to their paper by showing that a realistic life cycle model can do a good job of fitting the patterns of asset decumulation observed after retirement.

In his seminal paper Hurd [35] estimates a simple structural model of savings and bequest motives in which bequests are normal goods, and does not find support for large bequest motives. De Nardi's [14] calibration exercise shows that modeling bequests as a luxury good is important to explain the savings of the richest few. Lupton and Kopczuk [43] find that a majority of elderly singles have a bequest motive. However, whether the motive is active

or not depends on the individual's financial resources because, consistently with De Nardi, they estimate bequests to be luxury goods. While none of the preceding papers accounted for medical expenses, Dynan et al. [21] argue that the same assets can be used to address both precautionary and bequest concerns. Using responses from an attitudinal survey to separate bequest and medical expense motives, Ameriks et al. [2] find that bequests are important for many people. In this paper we allow bequests to be luxury goods, and we let the AHEAD data speak to both the intensity of bequest motives and the level of wealth at which they become operative.

### 3 The model

Our analysis focuses on people who have retired already. This choice allows us to concentrate on saving and consumption decisions, and to abstract from labor supply and retirement decisions. We restrict our analysis to elderly singles to avoid dealing with household dynamics, such as the transition from two to one family members.

Consider a single person, either male or female, seeking to maximize his or her expected lifetime utility at age  $t$ ,  $t = t_{r+1}, \dots, T$ , where  $t_r$  is the retirement age. These individuals maximize their utility by choosing consumption  $c$ . Each period, the individual's utility depends on its consumption and health status,  $h$ , which can be either good ( $h = 1$ ) or bad ( $h = 0$ ).

The within-period utility function from consumption is

$$u(c, h) = \delta(h) \frac{c^{1-\nu}}{1-\nu}, \quad (1)$$

with  $\nu \geq 0$ . Following Palumbo [48] we model the dependence of utility on health status as

$$\delta(h) = 1 + \delta h, \quad (2)$$

so that when  $\delta = 0$ , health status does not affect utility.

When the person dies, any remaining assets can be left to one's children or other heirs. We denote with  $e$  the estate net of taxes. The household derives utility from leaving the estate (net of estate taxes)  $e$ , to heirs

$$\phi(e) = \theta \frac{(e+k)^{(1-\nu)}}{1-\nu}, \quad (3)$$

where  $\theta$  is the intensity of the bequest motive, while  $k$  determines the curvature of the bequest function and hence the extent to which bequests are a luxury goods.

We assume that non-asset income  $y_t$ , is a deterministic function of sex,  $g$ , permanent income,  $I$ , and age  $t$ :

$$y_t = y(g, I, t). \quad (4)$$

The individual faces several sources of risk, which we treat as exogenous. While this is of course a simplification, we believe that it is a reasonable one, because we focus on older people who have already shaped their health and lifestyle.

1) Health status uncertainty. We allow the transition probabilities for health status to depend on previous health, sex, permanent income and age. The elements of the health status transition matrix are

$$\pi_{j,k,g,I,t} = \Pr(h_{t+1} = k | h_t = j, g, I, t), \quad j, k \in \{1, 0\}. \quad (5)$$

2) Survival uncertainty. Let  $s_{g,h,I,t}$  denote the probability that an individual of sex  $g$  is alive at age  $t + 1$ , conditional on being alive at age  $t$ , having time- $t$  health status  $h$ , and enjoying permanent income  $I$ .

3) Medical expense uncertainty. Medical expenses,  $m_t$ , are defined as out-of-pocket expenses. Since our focus is on understanding the effects of out-of-pocket medical expenses on saving decisions, this version of the model takes medical expenses as exogenous shocks to the household's available resources for our benchmark model, as in Scholz et al. [53], Palumbo [48] and Hubbard et al. [33, 34]. In section 9 we study whether endogenizing medical expenses affects our key results.

We assume that the mean and the variance of the log of medical expenses depend upon sex, health status, permanent income, and age:

$$\ln m_t = m(g, h, I, t) + \sigma(g, h, I, t) \times \psi_t. \quad (6)$$

Following Feenberg and Skinner [25] and French and Jones [30], we assume that the idiosyncratic component  $\psi_t$  can be decomposed as

$$\psi_t = \zeta_t + \xi_t, \quad \xi_t \sim N(0, \sigma_\xi^2), \quad (7)$$

$$\zeta_t = \rho_m \zeta_{t-1} + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_\epsilon^2), \quad (8)$$



where  $\xi_t$  and  $\epsilon_t$  are serially and mutually independent. In practice, we discretize  $\xi$  and  $\zeta$ , using quadrature methods described in Tauchen and Hussey [55].

The timing is the following: at the beginning of the period the individual's health status and medical medical expenses are realized. Then the individual consumes and saves. Finally the survival shock hits. Households who die leave any remaining assets to their heirs.

Next period's assets are given by

$$a_{t+1} = a_t + y_n(ra_t + y_t, \tau) + b_t - m_t - c_t, \quad (9)$$

where  $y_n(ra_t + y_t, \tau)$  denotes post-tax income,  $r$  denotes the risk-free, pre-tax rate of return, the vector  $\tau$  describes the tax structure, and  $b_t$  denotes government transfers.

Assets have to satisfy a borrowing constraint:

$$a_t \geq 0. \quad (10)$$

Following Hubbard et al. [33, 34], we also assume that government transfers provide a consumption floor:

$$b_t = \max\{0, \underline{c} + m_t - [a_t + y_n(ra_t + y_t, \tau)]\}, \quad (11)$$

Equation (11) says that government transfers bridge the gap between an individual's "total resources" (i.e., assets plus income less medical expenses) and the consumption floor. To be consistent with logic of asset and means-tested transfers present in public insurance programs, we impose that if transfers are positive,  $c_t = \underline{c}$  and  $a_{t+1} = 0$ .

To save on state variables we follow Deaton [15] and redefine the problem in terms of cash-on-hand: defining cash-on-hand allows us to combine assets and the transitory component of medical expenses into a single state variable.

$$x_t = a_t + y_n(r a_t + y_t, \tau) + b_t - m_t. \quad (12)$$

Note that assets and cash-on-hand follow:

$$a_{t+1} = x_t - c_t, \quad (13)$$

$$x_{t+1} = x_t - c_t + y_n(r(x_t - c_t) + y_{t+1}, \tau) + b_{t+1} - m_{t+1}. \quad (14)$$

To enforce the consumption floor, we impose

$$x_t \geq \underline{c}, \quad \forall t, \quad (15)$$

and to ensure that assets are always non-negative, we require

$$c_t \leq x_t, \quad \forall t. \quad (16)$$

Note that all of the variables in  $x_t$  are given and known at the beginning of period  $t$ . We can thus write the individual's problem recursively, using the definition of cash-on-hand. Letting  $\beta$  denote the discount factor, the value function for a single individual is given by

$$V_t(x_t, g, h_t, I, \zeta_t) = \max_{c_t, x_{t+1}} \left\{ u(c_t, h_t) + \beta s_{g,h,I,t} E_t V_{t+1}(x_{t+1}, g, h_{t+1}, I, \zeta_{t+1}) + \beta(1 - s_{g,h,I,t}) \phi(e_t) \right\}, \quad (17)$$

subject to

$$e_t = (x_t - c_t) - \max\{0, \tilde{\tau} \cdot (x_t - c_t - \tilde{x})\}. \quad (18)$$

and equations (14) - (16). The parameter  $\tilde{\tau}$  denotes the tax rate on estates in excess of  $\tilde{x}$ , the estate exemption level.

## 4 Estimation procedure

### 4.1 The Method of Simulated Moments

To estimate the model, we adopt a two-step strategy, similar to the one used by Gourinchas and Parker [31], Cagetti [10], and French and Jones [29]. In the first step we estimate or calibrate those parameters that can be cleanly identified without explicitly using our model. For example, we estimate mortality rates from raw demographic data. Let  $\chi$  denote the collection of these first-step parameters.

In the second step we estimate the vector of parameters  $\Delta = (\delta, \nu, \beta, \underline{c}, \theta, k)$  with the method of simulated moments (MSM), taking as given the elements of  $\chi$  that were estimated in the first step. In particular, we find the vector  $\hat{\Delta}$  yielding the simulated life-cycle decision profiles that “best match” (as measured by a GMM criterion function) the profiles from the data. Because our underlying motivations are to explain why elderly individuals retain so many assets, and to explain why individuals with high income save at a higher rate, we match permanent income-conditional age-asset profiles.

Consider individual  $i$  of birth cohort  $p$  in calendar year  $t$ . Note that the individual’s age is  $t - p$ . Let  $a_{it}$  denote individual  $i$ ’s assets. Sorting the sample by permanent income, we assign every individual to one of  $Q$  quantile-based intervals. In practice, we split the sample into 5 permanent income quintiles, so that  $Q = 5$ . Suppose that individual  $i$  of cohort  $p$  falls in the  $q$ th interval of the sample income distribution. Let  $a_{pqt}(\Delta, \chi)$  be the model-predicted median asset level in calendar year  $t$  for an individual of cohort  $p$  that was in the  $q$ th income interval. Assuming that observed assets have a continuous density, at the “true” parameter vector  $(\Delta_0, \chi_0)$  exactly half of the individuals in group  $pqt$  will have asset levels of  $a_{pqt}(\Delta_0, \chi_0)$  or less. This leads to a well-known set of moment conditions:<sup>3</sup>

$$E(1\{a_{it} \leq a_{pqt}(\Delta_0, \chi_0)\} - 1/2 | p, q, t, \text{individual } i \text{ alive at } t) = 0, \quad (19)$$

for each  $p, q$  and  $t$  triple. In other words, for each permanent income-cohort grouping, the model and the data have the same median asset levels. Our decision to use conditional medians, rather than means, reflects sample size considerations; in some  $pqt$  cells, changes in one or two individuals can lead to sizeable changes in mean wealth. Sample size considerations also lead us to combine men and women in a single moment condition.

The mechanics of our MSM approach are fairly standard. In particular, we compute life-cycle histories for a large number of artificial individuals. Each of these individuals is endowed with a value of the state vector  $(t, x_t, g, h_t, I, \zeta_t)$  drawn from the data distribution for 1996, and each is assigned a series of health, medical expense, and mortality shocks consistent with the stochastic processes described in section 2 above. When simulating health and mortality shocks, we give each simulated person the entire health and mortality history realized by a person in the AHEAD data with the same initial conditions.<sup>4</sup> Since the data provide health and mortality only during interview years, we simulate it in off-years using our estimated models and Bayes’ Rule. The simulated medical expenditure shocks  $\zeta$  and  $\xi$  are Monte Carlo draws from discretized versions of our estimated shock processes.

Solving numerically the model described in section 3 yields a set of decision rules, which, in combination with the simulated endowments and shocks,

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<sup>3</sup>See Manski [44], Powell [50] and Buchinsky [9]. Related methodologies are applied in Cagetti [10] and Epple and Sieg [24].

<sup>4</sup>This approach ensures that the simulated health and mortality processes are fully consistent with the data, even if our parsimonious models of these processes are just an approximation. We are grateful to Michael Hurd for suggesting this approach.

allows us to simulate each individual’s assets, medical expenditures, health and mortality. We then compute asset profiles (values of  $a_{pqt}$ ) from the artificial histories in the same way as we compute them from the real data.

Finally, we adjust  $\Delta$  until the difference between the data and simulated profiles—a GMM criterion function based on equation (19)—is minimized.

We discuss the asymptotic distribution of the parameter estimates, the weighting matrix and the overidentification tests in Appendix A.<sup>5</sup>

## 4.2 Econometric Considerations

In estimating our model, we face two well-known econometric problems. First, in a cross-section, older individuals will have earned their labor income in earlier calendar years than younger ones. Because wages have increased over time (with productivity), this means that older individuals are poorer at every age, and the measured saving profile will overstate asset decumulation over the life cycle. Put differently, even if the elderly do not run down their assets, our data will show that assets decline with age, as older individuals will have lower lifetime incomes and assets at each age. Not accounting for this effect will lead us to estimate a model that overstates the degree to which elderly people run down their assets (Shorrocks [54]).

Second, wealthier people tend to live longer, so that the average survivor in each cohort has higher lifetime income than the average deceased member of that cohort. This “mortality bias” tends to overstate asset growth in an unbalanced panel. In addition, as time passes and people die, the surviving people will be, relative to the deceased, healthy and female. These healthy and female people, knowing that they will live longer, will tend to be more frugal than their deceased counterparts, and hence have a flatter asset profile in retirement. Not accounting for mortality bias will lead us to understate the degree to which elderly people run down their assets.

A major advantage of using a structural approach is that we can address these biases directly, by replicating them in our simulations. We address the first problem by giving our simulated individuals age, wealth, health, gender and income endowments drawn from the distribution observed in the data. If older people have lower lifetime incomes in our data, they will have

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<sup>5</sup>Major theoretical contributions to the method of simulated moments include Pakes and Pollard [47] and Duffie and Singleton [20]. Other useful references on asymptotic theory include Newey [45], Newey and McFadden [46] and Powell [50].

lower lifetime incomes in our simulations. Furthermore, we match assets at each age, conditional on cohort and income quintile. We address the second problem by allowing mortality to differ with sex, permanent income and health status. As a result our estimated decision rules and our simulated profiles incorporate mortality effects in the same way as the data.

## 5 Data

The AHEAD is part of the Health and Retirement Survey (HRS) conducted by the University of Michigan. It is a survey of individuals who were non-institutionalized and aged 70 or older in 1994. A total of 8,222 individuals in 6,047 households (in other words, 3,872 singles and 2,175 couples) were interviewed for the AHEAD survey in late 1993/early 1994, which we refer to as 1994. These individuals were interviewed again in 1996, 1998, 2000, 2002, 2004, and 2006. The AHEAD data include a nationally representative core sample as well as additional samples of blacks, Hispanics, and Florida residents.

We consider only single retired individuals in the analysis. This leaves us with 3,259 individuals, of whom 592 are men and 2,667 are women. Of these 3,259 individuals, 884 are still alive in 2006. Appendix B gives more details on the data.

Our measure of net worth (or assets) is the sum of all assets less mortgages and other debts. The AHEAD has information on the value of housing and real estate, autos, liquid assets (which include money market accounts, savings accounts, T-bills, etc.), IRAs, Keoghs, stocks, the value of a farm or business, mutual funds, bonds, and “other” assets. We do not use 1994 assets because they were underreported (Rohwedder et al. [51]).

Non-asset income includes the value of Social Security benefits, defined benefit pension benefits, annuities, veterans benefits, welfare, and food stamps. We measure permanent income as the individual’s average income over all periods during which he or she is observed. Because Social Security benefits and (for the most part) pension benefits are a monotonic function of average lifetime labor income, this provides a reasonable measure of lifetime, or permanent income.<sup>6</sup>

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<sup>6</sup>Because annuity income often reflects the earnings of a deceased spouse, our measure of permanent income is not so much a measure of the individual’s own lifetime income as it is a measure of the income of his or her household.

Medical expenses are the sum of what the individual spends out of pocket on insurance premia, drug costs, and costs for hospital, nursing home care, doctor visits, dental visits, and outpatient care. It includes medical expenses during the last year of life. It does not include expenses covered by insurance, either public or private. French and Jones [30] show that the medical expense data in the AHEAD line up very well with the aggregate statistics. For our sample, mean medical expenses are \$3,712 with a standard deviation of \$13,429 in 1998 dollars. Although this figure is large, it is not surprising, because Medicare did not cover prescription drugs for most of the sample period, requires co-pays for services, and caps the number of reimbursed nursing home and hospital nights.

In addition to constructing moment conditions, we also use the AHEAD data to construct the initial distribution of permanent income, age, sex, health, medical expenses, and cash-on-hand that starts off our simulations. In particular, each simulated individual is given a state vector drawn from the joint distribution of state variables observed in 1996.

## 6 Data profiles and first step estimation results

In this section we describe the life cycle profiles of the stochastic processes (e.g., medical expenditures) that are inputs to our dynamic programming model, and the asset profiles we want our model to explain.

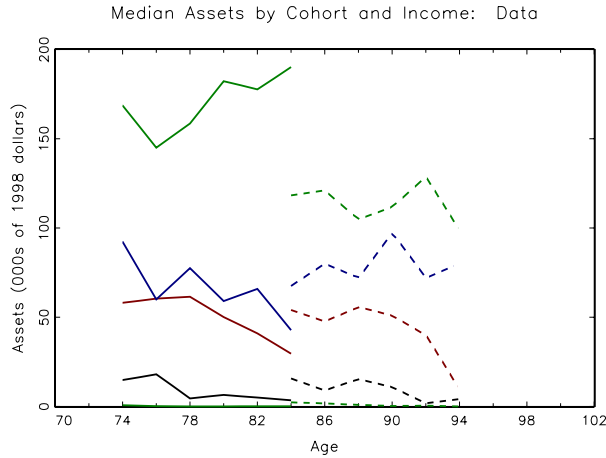
### 6.1 Asset profiles

We construct the permanent-income-conditional age-asset profiles as follows. We sort individuals into permanent income quintiles, and we track birth-year cohorts. We work with 5 cohorts. The first cohort consists of individuals that were ages 72-76 in 1996; the second cohort contains ages 77-81; the third ages 82-86; the fourth ages 87-91; and the final cohort, for sample size reasons, contains ages 92-102. We use asset data for 6 different years; 1996, 1998, 2000, 2002, 2004 and 2006. To construct the profiles, we calculate cell medians for the survivors for each year assets are observed.

To fix ideas, consider Figure 1, which plots median assets by age and income quintile for two birth-year cohorts for those that are still alive at each moment in time. The lines at the far left of the graph are for the

youngest cohort, whose members in 1996 were aged 72-76, with an average age of 74. The other set of lines are for the cohort aged 82-86 in 1996.

There are five lines for each cohort because we have split the data into permanent income quintiles. Unsurprisingly, assets turn out to be monotonically increasing in income, so that the bottom line shows median assets in the lowest income quintile, while the top line shows median assets in the top quintile. For all permanent income quintiles in these cohorts, the assets of

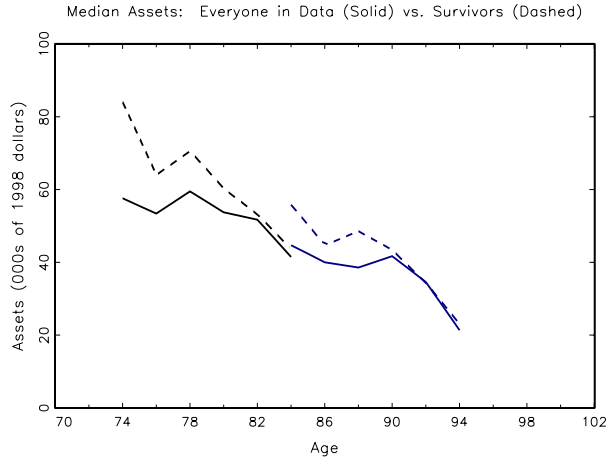


**Figure 1:** Median assets by cohort and PI quintile: data. Solid line: cohort aged 74 in 1996. Dashed line, cohort aged 85 in 1996.

surviving individuals neither rise rapidly nor decline rapidly with age. If anything, those with high income tend to have increases in their assets, whereas those with low income tend to have declines in assets as they age. The profiles for other cohorts, which are shown in Appendix B, are also similar.

Our finding that the income rich elderly run down their assets at a very slow rate complements and confirms those by Dynan et al. [22] who look both at younger as well as older households but do not have as many observations as we do on the very elderly.

Figure 2 compares asset profiles that are aggregated over all the income quintiles. The solid line shows median assets for everyone observed at a given point in time, even if they died in a subsequent wave, i.e., the unbalanced panel. The dashed line shows median assets for the subsample of individuals who were still alive in the final wave, i.e., the balanced panel. It shows that the asset profiles for those that were alive in the final wave—the balanced



**Figure 2:** Median assets by birth cohort: everyone in the data (solid lines) vs. survivors (dashed lines).

panel—have much more of a downward slope. The difference between the two sets of profiles confirms that the people who died during our sample period tended to have lower assets than the survivors.

Failure to account for the mortality bias would lead us to understate asset decumulation by over 50% for the 74 year-olds in 1996. In 1996 median assets of the 74 year olds who survived to 2006 were \$84,000. In contrast, in 1996 median assets of all of the 74 year olds alive in that year were \$60,000. Median assets of those in the same cohort who survived to 2006 were \$44,000. The implied drops in median assets between 1996 and 2006 for that cohort are therefore vastly different depending on what population we look at: only \$16,000 if we look at the unbalanced panel, but \$40,000 for the balanced panel of the survivors who made it to 2006. This is consistent with the findings of Love et al. [42]. Sorting the data by permanent income reduces, but does not eliminate, mortality bias.

Since our model explicitly takes mortality bias and differences in permanent income into account, it is the unbalanced panels that we use in our MSM estimation procedure.



## 6.2 Medical expense profiles

The mean of logged medical expenses is modeled as a function of: a quartic in age, sex, sex interacted with age, current health status, health status interacted with age, a quadratic in the individual's permanent income ranking, and permanent income ranking interacted with age. We estimate these profiles using a fixed-effects estimator.<sup>7</sup>

We use fixed effects, rather than OLS, for two reasons. First, differential mortality causes the composition of our sample to vary with age. In contrast, we are interested in how medical expenses vary for the same individuals as they grow older. Although conditioning on observables such as permanent income partly overcomes this problem, it may not entirely. The fixed-effects estimator overcomes the problem completely. Second, cohort effects are likely to be important for both of these variables. Failure to account for the fact that younger cohorts have higher average medical expenditures than older cohorts will lead the econometrician to understate the extent to which medical expenses grow with age. Cohort effects are automatically captured in a fixed-effect estimator, as the cohort effect is merely the average fixed effect for all members of that cohort.

The combined variance of the medical expense shocks ( $\zeta_t + \xi_t$ ) is modeled with the same variables and functional form as the mean (see equation 6).

Our estimates indicate that average medical expenses for men are about 20% lower than for women, conditional on age, health and permanent income. Average medical expenses for healthy people are about 50% lower than for unhealthy people, conditional on age, sex and permanent income. These differences are large, but the differences across permanent income groups are even larger.

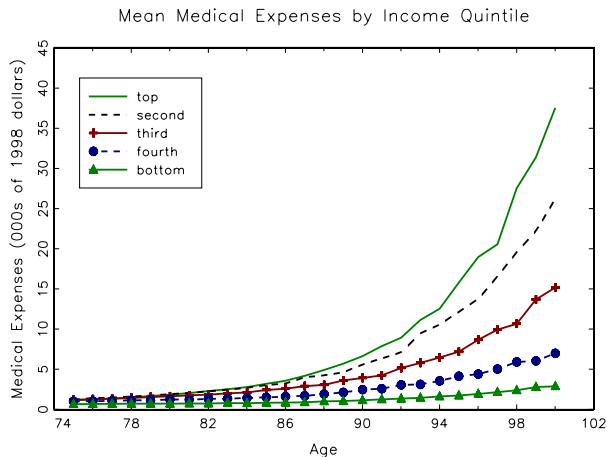
To better interpret our estimates, we simulate medical expense histories for the AHEAD birth-year cohort whose members were ages 72-76 (with an average age of 74) in 1996. We begin the simulations with draws from the joint distribution of age, health, permanent income and sex observed in 1996.

Figure 3 presents average medical expenses, conditional on age and permanent income quintile for a balanced sample of people. We rule out attrition in these simulations because it is easier to understand how medical expenses evolve over time when tracking the same individuals. The picture

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<sup>7</sup>Parameter estimates for the data generating process for medical expenses, income, health, and mortality, and a guide to using these data, are available at: [http://www.chicagofed.org/economic\\_research\\_and\\_data/economists\\_preview.cfm?autID=29](http://www.chicagofed.org/economic_research_and_data/economists_preview.cfm?autID=29).

with mortality bias, however, is similar. Permanent income has a large ef-



**Figure 3:** Average medical expenses, by permanent income quintile.

fect on average medical expenses, especially at older ages. Average medical expenses are less than \$1,000 a year at age 75, and vary little with income. By age 100, they rise to \$2,900 for those in the bottom quintile and of the income distribution, and to almost \$38,000 for those at the top of the income distribution. Mean medical expenses at age 100 are \$17,700.

Mean medical expenses implied by our estimated processes line up well with the raw data. We have 58 observations on medical expenses for 100-year-old individuals, averaging \$15,603 (with a standard deviation of \$33,723 and a standard error of \$4,428) per year, with 72% of these expenses coming from nursing home care. Between ages 95 and 100, we have 725 person-year observations on medical expenses, averaging \$9,227 (with a standard deviation of \$19,988 and standard error of \$737). Therefore, the data indicate that average medical expenses for the elderly are high.

Medical expenses for the elderly are volatile as well as high. We find that the average variance of log medical expenses is 2.53. This implies that medical expenses for someone with a two standard deviation shock to medical expenses pays 6.8 times the average, conditional on the observables.<sup>8</sup> The variance of medical expenses rises with age, bad health, and income.

<sup>8</sup>We assume that medical expenses are log-normally distributed, so the predicted level of medical expenses are  $\exp(m + \frac{1}{2}\sigma^2)$ , where  $m$  denotes predicted log medical expenses and  $\sigma^2$  denotes the variance of the idiosyncratic shock  $\psi_t$ . The ratio of the level of

French and Jones [30] find that a suitably-constructed lognormal distribution can match average medical expenses and the far right tail of the distribution. They also find that medical expenses are highly correlated over time. Table 1 shows estimates of the persistent component  $\zeta_t$  and the transitory component  $\xi_t$ . The table shows that 66.5% of the cross sectional variance of medical expenses are from the transitory component, and 33.5% from the persistent component. The persistent component has an autocorrelation coefficient of 0.922, however, so that innovations to the persistent component of medical expenses have long-lived effects. Most of a household’s *lifetime* medical expense risk comes from the persistent component.

Parameter	Variable	Estimate
$\rho_m$	autocorrelation of persistent component	0.922
$\sigma_\epsilon^2$	innovation variance of persistent component	0.0503
$\sigma_\xi^2$	innovation variance of transitory component	0.665

**Table 1:** Persistence and variance of innovations to medical expenses (variances as fractions of total cross-sectional variance).

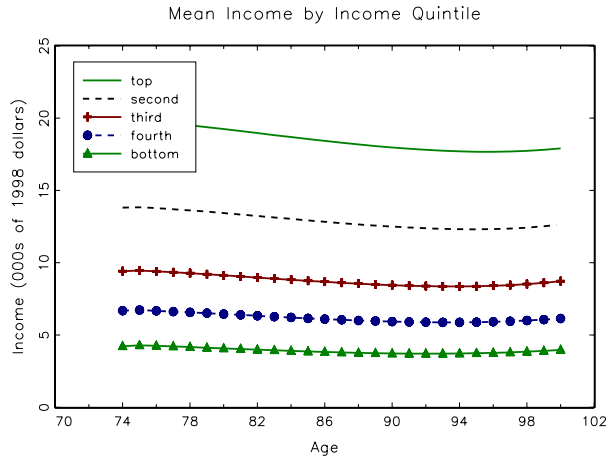
Our estimates of medical expense risk indicate greater risk than found in other studies (see Hubbard, et al. [33] and Palumbo [48]). However, our estimates still potentially understate both the level and risk of the medical expenses faced by older Americans, because our measure of medical expenditures does not include the value of Medicaid contributions. As equation (11) shows, some of the medical expenses ( $m_t$ ) in our model may be paid for by the government through the provision of the consumption floor. Therefore, the ideal measure of  $m_t$  drawn from the data would include both the out-of-pocket expenditures actually made by the consumer and the expenditures covered by Medicaid. The AHEAD data, however, do not include Medicaid expenditures.

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medical expenses two standard deviations above the mean to average medical expenses is  $\frac{\exp(m+2\sigma)}{\exp(m+\sigma^2/2)} = \exp(2\sigma - \sigma^2/2) = 6.80$  if  $\sigma = \sqrt{2.53}$ .

### 6.3 Income profiles

We model mean income in the same way as mean medical expenses, using the same explanatory variables and the same fixed-effects estimator.



**Figure 4:** Average income, by permanent income quintile.

Figure 4 presents average non-asset income profiles, conditional on permanent income, computed by simulating our model. For those in the top permanent income quintile, annual income averages \$20,000 per year. Figure 1 shows that median wealth for the high income younger cohort is slightly under \$200,000, or about 10 years worth of income for this group.

### 6.4 Mortality and health status

We estimate the probability of death and bad health as logistic functions of a cubic in age; sex; sex interacted with age; previous health status; health status interacted with age; a quadratic in permanent income rank; and permanent income rank interacted with age. A detailed description of our estimates can be found in De Nardi et al. [18].

Using the estimated health transitions, survival probabilities, and the initial joint distribution of age, health, permanent income and sex found in our AHEAD data, we simulate demographic histories. Table 2 presents predicted life expectancies.<sup>9</sup> Rich people, women, and healthy people live much longer

<sup>9</sup>Our predicted life expectancy is lower than what the aggregate statistics imply. In

Income Quintile	Healthy Male	Unhealthy Male	Healthy Female	Unhealthy Female	All <sup>†</sup>
bottom	7.6	5.9	12.8	10.9	11.1
second	8.4	6.6	13.8	12.0	12.4
third	9.3	7.4	14.7	13.2	13.1
fourth	10.5	8.4	15.7	14.2	14.4
top	11.3	9.3	16.7	15.1	14.7
By gender: <sup>‡</sup>					
Men					9.7
Women					14.3
By health status: <sup>◇</sup>					
Healthy					14.4
Unhealthy					11.6

Note: life expectancies calculated through simulations using estimated health transition and survivor functions. <sup>†</sup> Calculations use the gender and health distributions observed in each permanent income quintile. <sup>‡</sup> Calculations use the health and permanent income distributions observed for each gender. <sup>◇</sup> Calculations use the gender and permanent income distributions observed for each health status group.

**Table 2:** Life expectancy in years, conditional on reaching age 70.

than their poor, male, and sick counterparts. Two extremes illustrate this point: an unhealthy male at the bottom quintile of the permanent income distribution expects to live only 6 more years, that is, to age 76. In contrast, a healthy woman at the top quintile of the permanent income distribution expects to live 17 more years, thus making it to age 87. Such significant

2002, life expectancy at age 70 was 13.2 years for men and 15.8 years for women, whereas our estimates indicate that life expectancy for men is 9.7 years for men and 14.3 years for women. These differences stem from using data on singles only: when we re-estimate the model for both couples and singles we find that predicted life expectancy is within 1/2 year of the aggregate statistics for both men and women.

differences in life expectancy should, all else equal, lead to significant differences in saving behavior. In complementary work, (De Nardi et al. [19]), we show this is in fact the case.

We also find that for rich people the probability of living to very old ages, and thus facing very high medical expenses, is significant. For example, using the same simulations used to construct Table 2, we find that a healthy 70-year-old woman in the top quintile of the permanent income distribution faces a 14 percent chance of living 25 years, to age 95.

## 7 Second step estimation results

Table 3 presents preference parameter estimates for several specifications. The first column presents results for a parsimonious model with no bequest motives and no health preference shifter. The second column reports estimates for a model in which health can shift the marginal utility of consumption. In the third column, the bequest motive is activated, and in the final column, both the bequest motive and the preference shifter are active. In all cases, we set the interest rate to 2%.

Table 3 shows that the bequest parameters are never statistically significant and, as shown by the overidentification statistics, have little effect on the model's fit.

When considered in isolation, the health preference parameter is not significant either. However, the final column shows that this parameter is statistically significant when bequest motives are included. An appropriate test, however, is the joint test based on the change in the overidentification statistic (Newey and McFadden [46], section 9). Comparing the first and last columns of Table 3 shows that the test statistic decreases by 4.8, while 3 degrees of freedom are removed. With a  $\chi^2(3)$  distribution, this change has a  $p$ -value of 18.7%, implying that we cannot reject the parsimonious model.

In short, the bequest and health preference parameters are (collectively) not statistically significant, do not help improve the fit of the model, and, moreover, have little effect on any of the other parameter estimates. We thus use the parsimonious model as our benchmark specification and only briefly discuss the other configurations.

	Benchmark	With health- dependent preferences	With bequests	All
$\nu$ : relative risk aversion coeff.	3.81 (0.50)	3.75 (0.47)	3.84 (0.55)	3.66 (0.55)
$\beta$ : discount factor	0.97 (0.04)	0.97 (0.05)	0.97 (0.05)	0.97 (0.04)
$\delta$ : preference shifter	0.0 NA	-0.21 (0.18)	0.0 NA	-0.36 (0.14)
$\theta$ : bequest intensity	0.0 NA	0.0 NA	2,360 (8,122)	2,419 (1,886)
$k$ : bequest curvature (in 000s)	NA NA	NA NA	273 (446)	215 (150)
$\underline{c}$ : consumption floor	2,663 (346)	2,653 (337)	2,665 (353)	2,653 (337)
Overidentification test	82.3	80.6	81.5	77.5
Degrees of freedom	98	97	96	95
$p$ -value	87.4%	88.5%	85.4%	90.5%

**Table 3:** Estimated structural parameters. Standard errors are in parentheses below estimated parameters. NA refers to parameters fixed for a given estimation.

## 7.1 The benchmark model

The first column of table 3 shows that the estimated coefficient of relative risk aversion is 3.8, the discount factor is .97, and the consumption floor is \$2,663. These estimates are well within the range of those provided in the previous literature.

Our estimated coefficient of relative risk aversion, 3.8, is higher than the coefficients found by fitting non-retiree consumption trajectories, either through Euler equation estimation (e.g., Attanasio et al. [3]) or through the method of simulated moments (Gourinchas and Parker [31]). It is, however, at the lower end of the estimates found by Cagetti [10], who matched wealth

profiles with the method of simulated moments over the whole life cycle. It is much lower than those produced by Palumbo [48], who matched consumption data for retirees using maximum likelihood estimation. Given that our out-of-pocket medical expenditure data indicate more risk than that found by Palumbo, it is not surprising that we can match observed precautionary and life-cycle savings with a lower level of risk aversion.

The consumption floor that we estimate (\$2,700 in 1998 dollars) is similar to the value that Palumbo [48] uses (\$2,000 in 1985 dollars). However, our estimate is about half the size of the value that Hubbard et al. [33] use, and is also about half the average value of Supplemental Security Income (SSI) benefits.

Our consumption floor proxies for Medicaid health insurance (which almost eliminates medical expenses to the financially destitute) and SSI. Given the complexity of these programs, and the fact that many potential recipients do not fully participate in them, it is tricky to establish a priori what the consumption floor should be. Individuals with income (net of medical expenses) below the SSI limit are usually eligible for SSI and Medicaid. However, some individuals with income well above the SSI level can receive Medicaid benefits, depending on the state they live in. On the other hand, many eligible individuals do not draw SSI benefits and Medicaid, suggesting that the value of the consumption floor is much lower than the statutory benefits.<sup>10</sup> Our estimates likely provide an “effective” consumption floor, one which combines the complexity and variety of the statutory rules with people’s perceptions and attitudes toward welfare eligibility. In appendix C, we show that fixing the consumption floor at \$5,000 significantly worsens the model’s fit.

The Euler Equation can give some intuition for the estimates and their identification. Ignoring taxes and bequest motives, the Euler Equation is given by

$$(1 + \delta h_t) c_t^{-\nu} = \beta(1 + r) s_t E_t(1 + \delta h_{t+1}) c_{t+1}^{-\nu}. \quad (20)$$

Log-linearizing this equation shows that expected consumption growth follows:

$$\begin{aligned} E_t(\Delta \ln c_{t+1}) &= \frac{1}{\nu} [\ln(\beta(1 + r) s_t) + \delta E_t(h_{t+1} - h_t)] \\ &+ \frac{\nu + 1}{2} Var_t(\Delta \ln c_{t+1}). \end{aligned} \quad (21)$$

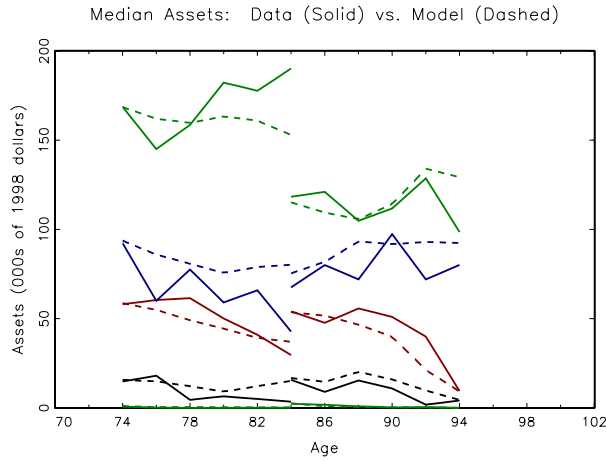
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<sup>10</sup>For example, Elder and Powers [23] (Table 2), find that less than 50 percent of those eligible for SSI receive benefits.



The coefficient of relative risk aversion is identified by differences in saving rates across the income distribution, in combination with the consumption floor. Low income households are relatively more protected by the consumption floor, and will thus have lower values of  $Var_t(\Delta \ln c_{t+1})$  and thus weaker precautionary motives. The parameter  $\nu$  helps the model explain why individuals with high permanent income typically display less asset decumulation. Appendix C discusses the identification of the coefficient of relative risk aversion and the consumption floor in more detail.

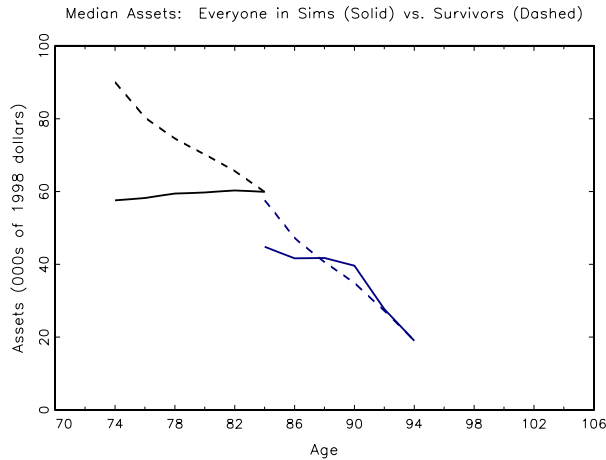
Table 3 also reveals that our model fits the data well. A way to assess the goodness of fit of our model is to compute the  $p$ -value of the overidentification statistics. It is 87.3% for our baseline specification. This is a good result for an estimated structural model, as many such models are rejected.



**Figure 5:** Median assets by cohort and PI quintile: data and model.

Figure 5 provides a visual measure of fit, by showing how the baseline model fits a subset of the data profiles, using unbalanced panels. (The model fits equally well for the cells that are not shown.) The model does a very good job at matching the key features of the data that we are interested in: both in the model and in the observed data individuals with high permanent income tend to increase their wealth with age, whereas individuals with low income tend to run down their wealth with age.

Because our model uses income-, health- and sex-adjusted mortality profiles, the profiles it generates should exhibit mortality biases similar to those



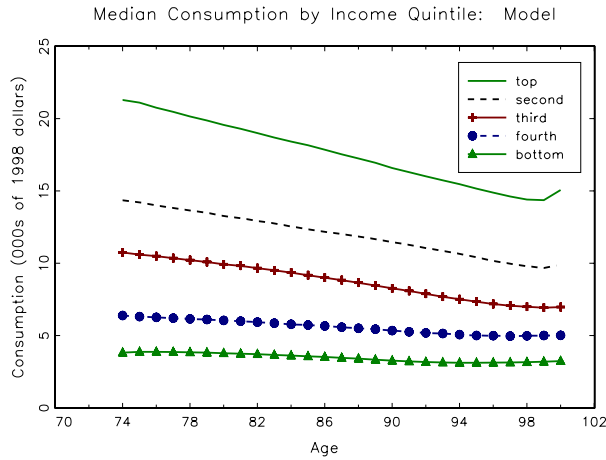
**Figure 6:** Median assets by birth cohort: everyone in the simulations vs. survivors.

found in the data. Figure 6 shows simulated asset profiles, first for all simulated individuals alive at each date, and then for the individuals surviving the entire simulation period. As in the data, restricting the profiles to long-term survivors reveals much more asset decumulation. The mortality bias generated by the model is large.

Given that the survival rate,  $s_t$ , is often much less than 1, it follows from equation (21) that the model will generate downward-sloping, rather than flat, consumption profiles, unless the discount factor  $\beta$  is fairly large. Figure 7 shows simulated consumption profiles for ages 74-100. Except for the last two years of life, consumption falls with age. This general tendency is consistent with many empirical studies of older-age consumption. For example, Fernandez-Villaverde and Krueger find that non-durable consumption declines about one percent per year between ages 70 and 90. (Also see Banks, Blundell, and Tanner [5].)

## 7.2 The model with health-dependent preferences

The second and fourth columns of Table 3 show point estimates of  $\delta = -.21$  or  $\delta = -.36$ : holding consumption fixed, being in good health lowers the marginal utility of consumption by 21-36%. This implies that an anticipated change from good to bad health leads consumption to increase by 6 to



**Figure 7:** Median consumption by PI quintile: simulations.

10%, depending on the specification (see equation (21)). Previous empirical studies disagree on whether  $\delta$  is greater than or less than 0. (See Lillard and Weiss [41], Rust and Phelan [52], Viscusi and Evans [56] and Finkelstein et al. [26] as examples.)

This parameter, however, is not statistically significant (if considered jointly with bequests), and none of the other parameter estimates are affected by its inclusion.

### 7.3 The model with bequest motives

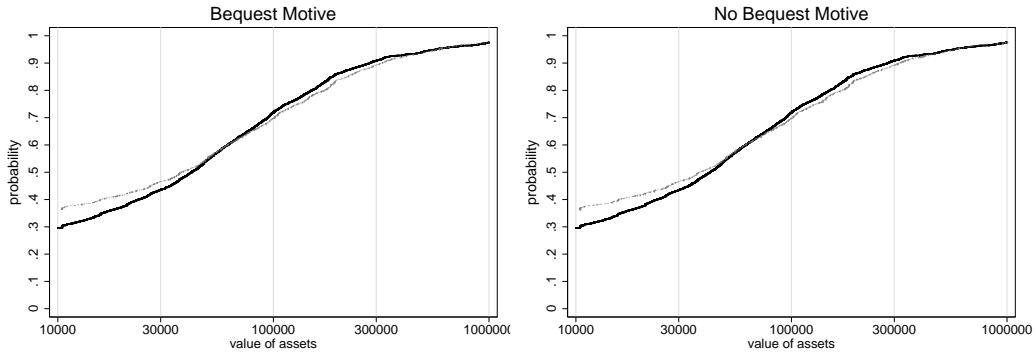
The third and fourth columns of Table 3 show parameter estimates for models that include a bequest motive. Because the two specifications deliver similar parameter estimates, we focus on the results in the third column.

The point estimates of  $\theta = 2,360$  and  $k = 273,000$  indicate that the consumption level above which the bequest motive becomes operative is about \$36,000 per year. (See Appendix D for a derivation.) By way of comparison, individuals in the top permanent income quintile have an average annuity income of about \$20,000 and hold less than \$200,000 of assets. This suggests that most people in our sample do not have a strong bequest motive. Not surprisingly, we find that bequest motives are not very important for fitting our data; none of the estimated bequest parameters are statistically significant, and adding bequests does not significantly improve the model's

fit.

For those sufficiently rich, however, the marginal propensity to bequeath above that consumption level is also high, with 88 cents of every extra dollar above the threshold being left as bequests. (See Appendix D.) Hence one can interpret our estimates as suggesting that the bequest motive could be present for the richest people in our sample.

To show the model’s implications for bequests, Figure 8 displays the distribution of assets that individuals hold one period before their deaths.<sup>11</sup> Comparing the two panels of Figure 8 highlights that the models with and without the estimated bequest motive generate very similar distributions of bequests. Both versions of the model also do a good job of matching the distribution of assets before death found in the data, although both versions slightly under-estimate the probability of having less than \$10,000 in the year before death.



**Figure 8:** Cumulative distribution function of assets held 1 period before death: data and model. Model with bequest motive in the left panel, and without on the right panel. Legend: solid line is model, lighter line is data.

Our findings should not be interpreted as a rejection of bequest motives

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<sup>11</sup>When AHEAD respondents die, their descendants are asked about the value of the estate. However, problems of non-response are severe – 49% of all estate values are imputed. Furthermore, it is unclear whether reported estates also include the value of the deceased individual’s home. For these reasons we report the distribution of assets one year before death rather than estates. Estates are somewhat lower than assets one year before death; mean and median assets 1 year before death are \$162,000 and \$37,000, whereas mean and median estates are \$132,000 and \$20,000.

in general. Our sample is composed of elderly singles. It is well known that singles are poorer than couples (see for example Díaz-Giménez et al. [17]), and other evidence indicates that bequests are a luxury good (De Nardi [14], and Dynan et al. [22]). Our sample of singles may not contain enough rich households to reveal strong bequest motives. Moreover, and importantly, a significant fraction of our sample is composed of people who have already lost their partner, and it is possible that some of the estate was already split between the surviving spouse and other heirs.

## 7.4 Summary

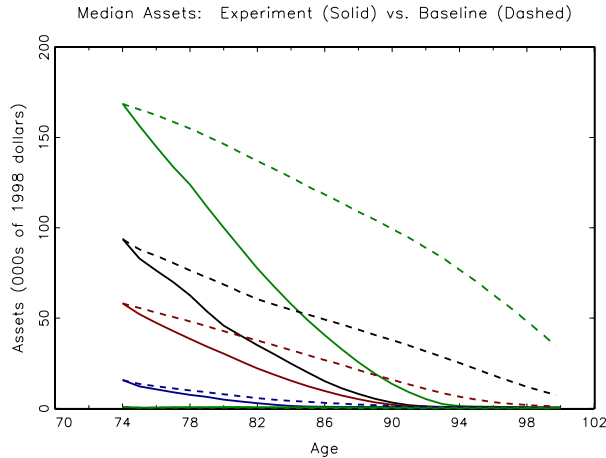
Our main results from the second step estimation can be summarized as follows. First, our estimates of the coefficient of relative risk aversion, time discount factor, and consumption floor are reasonable and within the range of the literature. Second, we do not find that health-dependent preferences are important for understanding retirees' saving behavior. Third, we do not find that bequest motives significantly affect savings in our sample. Fourth, the model fits the data well, both in terms of the moment conditions that we match, and in terms of the mortality bias in the asset and bequests distribution that it generates. Finally, the model's consumption implications are consistent with previous empirical evidence. Put together, these findings give us confidence that we can use our benchmark model (without bequests and preference shocks) to study how savings depend on medical expenses and the consumption floor.

## 8 What are the important determinants of savings?

To determine the importance of the key mechanisms in our model we fix the estimated parameters at their benchmark values and then change one feature of the model at a time. For each of these different economic environments we compute the optimal saving decisions, simulate the model, and compare the resulting asset accumulation profiles to the asset profiles generated by the baseline model.

We display asset profiles for the AHEAD birth-year cohort whose members were ages 72-76 (with an average age of 74) in 1996. To focus on underlying changes in saving, we rule out attrition and assume every individual

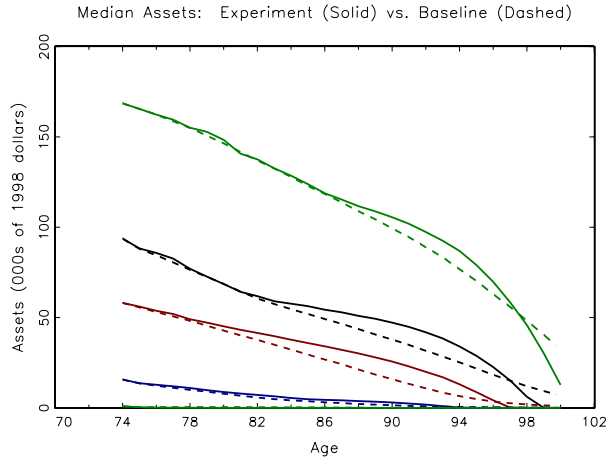
lives to age 100. People will face the same risks and have the same expectations as before (except for the particular aspect changed in each experiment), but in their realized lives they do not die and drop out of the simulations until age 100. None of our conclusions would change if we were to also allow for mortality bias.



**Figure 9:** Median assets by cohort and PI quintile: baseline and model with no medical expenses.

First, we ask whether the out-of-pocket medical expenditures that we estimate from the data are important drivers of old age savings. To answer this question, we zero out all medical out-of-pocket medical expenditures for everyone and look at the corresponding profiles. This could be seen as an extreme form of insurance provided by the government.

Figure 9 shows that medical expenses are a big determinant of the elderly's saving behavior, especially for those with high permanent income, for whom those expenses are especially high, and who are relatively less insured by the government-provided consumption floor. These retirees are reducing their current consumption in order to pay for the high out-of-pocket medical expenses they expect to bear later in life. For given initial wealth, if there were no out-of-pocket medical expenses, individuals in the highest permanent-income quintile would deplete their net worth by age 94. In the baseline model with medical expenses they keep almost \$40,000 to pay for out-of-pocket medical expenses in the last few years of life. The risk of living long and having high medical expenses late in life increases savings. This



**Figure 10:** Median assets by cohort and PI quintile: baseline and model with no medical expense risk.

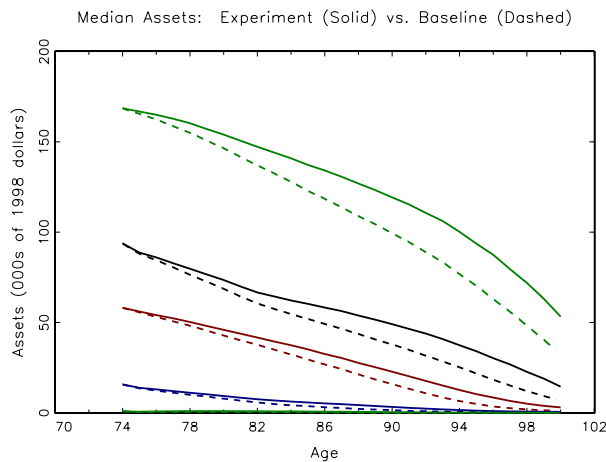
decomposition indicates that modeling out-of-pocket medical expenses is important in evaluating policy proposals that affect the elderly.

We next shut down out-of-pocket medical expense risk (the shocks  $\zeta$  and  $\xi$ ), while keeping average medical expenditure constant (conditional on all of the relevant state variables). Figure 10 shows the results. Interestingly, and consistently with Hubbard, Skinner and Zeldes [33], we find that, conditional on average medical expenses, the risk associated with the volatility of medical expenses has only a small effect on the profiles of median wealth. Our results are also consistent with Palumbo’s [48] finding that eliminating medical expense risk generates small effects on consumption and assets.<sup>12</sup>

One reason why medical expense risk might not have a large effect is that the consumption floor limits the effects of catastrophic medical expenses. To explore this effect further, we reduce the consumption floor to 80% of its value, that is from \$2,663 to \$2,100. One could interpret this as a reform reducing the government-provided consumption safety net. The effects of

<sup>12</sup>Figure 10 shows that eliminating medical expense risk sometimes causes assets to increase. One reason for the increase is that when the variance of medical expenses is reduced, the frequency of large medical expenses is also reduced, which in turn reduces the fraction of medical expenses covered by Medicaid. Eliminating volatility in  $m_t$  can thus raise the average medical expense borne by retirees. Because this cost increase will be highest at oldest ages, individuals will respond by accumulating more assets.

this change are quite evident. Individuals respond to the increase in net income uncertainty by rapidly accumulating assets to self-insure. Figure 11 shows that reducing the consumption floor affects the savings profiles of both low- and high-permanent-income singles. The consumption floor matters for wealthy individuals as well as poor ones. This is perhaps unsurprising given the size of our estimated medical expenses for the old and income-rich; even wealthy households can be financially decimated by medical expenses in very old age.



**Figure 11:** Median assets by cohort and PI quintile: baseline and model with 80% of the consumption floor.

## 9 Endogenous medical spending

To check the sensitivity of our findings to the assumption that medical expenses are exogenous, we consider a more complex model in which retirees optimally choose how much to spend on medical goods and services, as well as on non-medical consumption. Our findings are robust to this extension.

We assume that retirees derive utility from consumption of both non-medical and medical goods, with the relative weights on the two goods varying with age, health, and an idiosyncratic “medical needs” shock.

A complementary approach is that of Grossman [32], in which medical expenses represent investments in health capital, which in turn decreases



mortality. While this is an appealing mechanism, the existing empirical literature suggests that these effects are particularly small for the U.S elderly for two reasons. First, the expenditures that we are considering are supplementing Medicaid, Medicare, and insurance-provided medical goods and services, which cover most life-threatening conditions. Second, the stock of health carried by an elderly person is in large part determined by the health investments that were made in the past, including those made by the person's parents in his or her childhood and even before birth. Hence, for our sample of people aged 70 and older, the effects of additional health investments are not as large as, for example, in infancy.

A key piece of empirical evidence comes from the RAND Health Insurance Experiment, where a random set of individuals were given co-payment-free health insurance over a 3- to 5-year period, while a control group faced standard co-payments. Brook et al. [7] found that even though the group with free health care utilized medical services much more intensively than the control group, the additional treatments had only a “minimal influence” on subsequent health outcomes.

Surprisingly, some empirical studies show that even programs such as Medicare, which likely help paying for some life-threatening conditions, have little effects on extending life-expectancy. For example, Finkelstein and McKnight [27] “find no compelling evidence that, in its first 10 years, Medicare reduced overall elderly mortality.” They also note that, more in general, the literature on the effects of health insurance “points strongly to no or only very modest health benefits.” Fisher et al. [28] study regional variations in Medicare spending, and conclude that individuals in high-spending regions “do not have better health outcomes.” More in line with what one might expect, a paper by Card et al. [11] finds a small reduction in mortality for 65 year old who are admitted through the emergency room for “non-deferrable” conditions which are covered by Medicare for people at that age.

For these reasons some recent structural models have supplemented Grossman's mechanism with the direct utility effects we use. For example Khwaja [38] finds that “medical utilization would only decline by less than 20% over the life cycle if medical care was purely mitigative and had no curative or preventive components.” (Also see Blau and Gilleskie [6].)

Given that the existing evidence indicates that the effect of additional medical spending on life expectancy is small (and especially so for the elderly) and that allowing for this additional effect would complicate the model and require the estimation of many additional parameters, we focus on the utility

effects of medical expenditures.

## 9.1 The endogenous medical expenditure model

At the beginning of each period the individual's health status and medical needs shocks are realized and need-based transfers are given. The individual then chooses consumption, medical expenditure, and saves. Finally the survival shock hits. If the person dies, the estate is passed on to one's heir.

The flow utility from consumption is given by

$$u(c_t, m_t, h_t, \zeta_t, \xi_t, t) = \frac{1}{1-\nu} c_t^{1-\nu} + \mu(t, h_t, \zeta_t, \xi_t) \frac{1}{1-\omega} m_t^{1-\omega}, \quad (22)$$

where  $t$  is age,  $c_t$  is consumption of non-medical goods,  $m_t$  is total consumption of medical goods,  $h_t$  is health status, and  $\mu(\cdot)$  is the medical needs shock, which affects the marginal utility of consuming medical goods and services. The consumption of both types of goods is expressed in dollar values. The substitution elasticities for the two goods, however, can differ.

As before, we allow the need for medical services to have a temporary ( $\xi_t$ ) and a persistent ( $\zeta_t$ ) component; we recycle the variable names to save on notation. We assume that these shocks follow the same processes as in equations (7) and (8), with potentially different parameters. It is worth stressing that we not allow any of these shocks to depend on permanent income; income affects medical expenditures solely through the budget constraint.

We model two important features of the health care system:

1. Private and public insurance pay the share  $1 - q(t, h_t)$  of the total cost of the medical services incurred by the retiree. Its complement,  $q(t, h_t)$ , is the out-of-pocket share paid by the retiree. We estimate  $q(t, h_t)$  as part of our first-stage estimation. (See Appendix B for details.)
2. Social insurance, such as Medicaid and SSI, provide monetary transfers that vary with financial resources and medical needs. We model these transfers as providing a flow *utility* floor. The transfers thus depend on the retirees' state variables, not least their medical needs shocks. For a given utility floor and state vector, we find the transfer  $b^*(\cdot) = b^*(t, a_t, g, h_t, I, \zeta_t, \xi_t)$  that puts each retiree's utility at the floor. Transfers then kick in to provide the minimum utility level to retirees who lack the resources to afford it

$$b(t, a_t, g, h_t, I, \zeta_t, \xi_t) = \max\{0, b^*(t, a_t, g, h_t, I, \zeta_t, \xi_t)\}. \quad (23)$$

As before, we impose that if transfers are positive, the individual consumes all of his resources (by splitting them optimally between the two goods), so that  $a_{t+1} = 0$ .

The retiree's value function is given by

$$V(t, a_t, g, h_t, I, \zeta_t, \xi_t) = \max_{c_t, m_t, a_{t+1}} \left\{ \frac{1}{1-\nu} c_t^{1-\nu} + \mu(t, h_t, \zeta_t, \xi_t) \frac{1}{1-\omega} m_t^{1-\omega} \right. \\ \left. + \beta s_{g,h,I,t} E_t \left( V(t+1, a_{t+1}, g, h_{t+1}, I, \zeta_{t+1}, \xi_{t+1}) \right) \right. \\ \left. + \beta (1 - s_{g,h,I,t}) \phi(e) \right\}, \quad (24)$$

subject to equations (23), (18), (10), and

$$a_{t+1} = a_t + y_n (ra_t + y_t) + b(t, a_t, g, h_t, I, \zeta_t, \xi_t) - c_t - m_t q(t, h_t). \quad (25)$$

## 9.2 Estimation

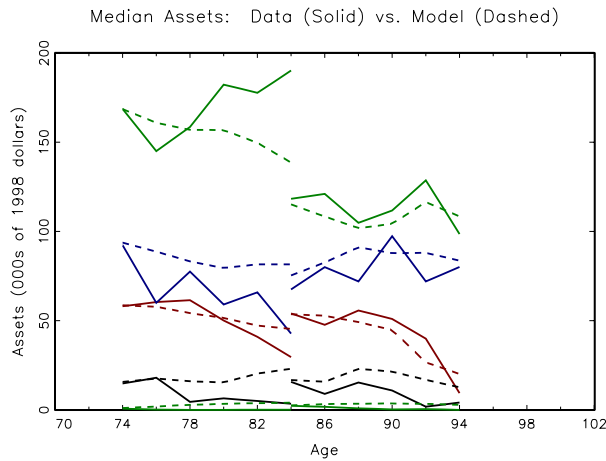
The log of the medical needs shifter  $\mu_t$  is modeled as a function of: a cubic in age; current health status; and health status interacted with age. The combined variance of the shocks  $\zeta_t + \xi_t$  is modelled as a quadratic in age; current health status; and health status interacted with age. To identify these parameters, we expand the moment conditions described by equation (19) to include moments relating to: mean medical expenses by age and birth cohort, for each half of the permanent income distribution; the 90th percentile of medical expenses in the same cells; and the first and second autocorrelations for medical expenses in each cell.<sup>13</sup> Detailed moment conditions can be found in Appendix A. In all other respects our MSM procedure is the same as before.

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<sup>13</sup>When a simulated individual receives a transfer from the government ( $b_t > 0$ ), we calculate the medical expenses the individual would have made if there were no transfer. This measure of out-of-pocket medical expenses is netted out of any social insurance payments. Our model thus replicates the censoring of out-of-pocket medical expenditures caused by Medicaid transfers that are already subtracted from the AHEAD medical expenditures data.

### 9.3 Results

The preference parameter estimates for the endogenous medical expenditure model are shown in Appendix C. The new estimate of  $\beta$ , the discount factor is 0.99, is slightly higher than the benchmark estimate of 0.97. The estimate of  $\nu$ , the coefficient of relative risk aversion for “regular” consumption is 2.15, while the estimate of  $\omega$ , the coefficient of relative risk aversion for medical goods is 3.19, so that the demand for medical goods is less elastic than the demand for consumption. Both coefficients are similar to, but somewhat smaller than, the benchmark estimate of 3.82.

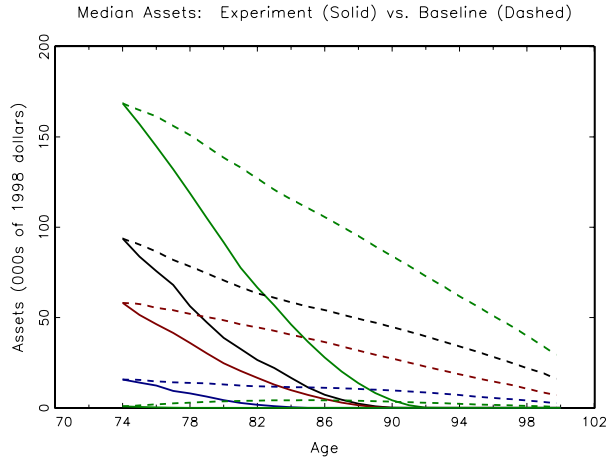


**Figure 12:** Median assets by cohort and PI quintile: data and endogenous medical expenditure model.

The model also requires parameter estimates for the mean of the logged medical needs shifter  $\mu(t, h_t, \zeta_t, \xi_t)$  and the process for the shocks  $\zeta_t$  and  $\xi_t$ . The estimates for these parameters (available from the authors on request) show that the demand for medical services rises rapidly with age.

Although the overidentification test statistic shows that the model with endogenous medical expenditure is rejected by the data, the model does a reasonable job in matching the main patterns of the asset profiles (see Figure 12). Furthermore, the model fits the medical expense distribution rather well: see Appendices B and C.

Out-of-pocket (and total) medical expenses in the endogenous medical expenditure model can be eliminated by setting the medical needs parameter  $\mu_t$



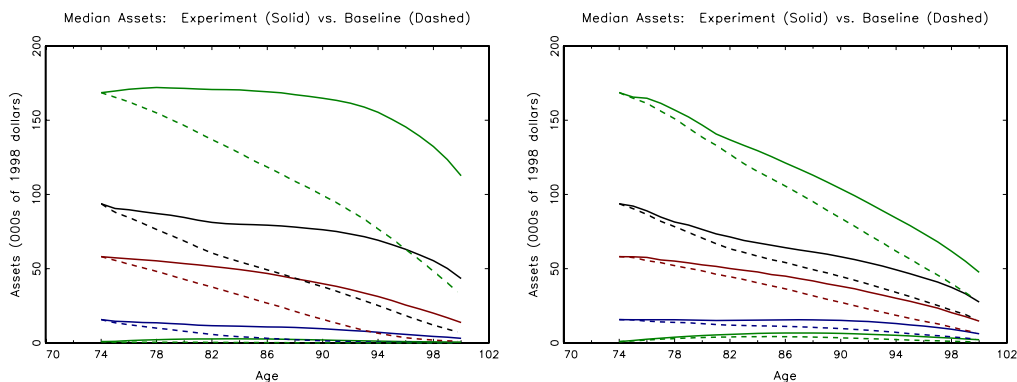
**Figure 13:** Median assets: baseline endogenous medical expense model and model with no medical expenses.

to zero. Figure 13 shows that the effects of eliminating medical expenses are similar to those found in the exogenous medical expense model (Figure 9). Given that the consumer must prepare for the same pattern of medical expenditures in either model, this is not surprising. Retirees will save for high medical expenditures at old ages whether the expenditures are exogenous shocks estimated from the data or medical expenditure choices consistent with the same data.

Figure 14 shows the effects of reducing the generosity of social insurance by 50% for both the exogenous medical expenses model and the endogenous one with a utility floor.<sup>14</sup> As in the exogenous medical expenditure model, a change in social insurance has an effect on the savings of everyone, including the richest elderly. The effects are of course smaller, because retirees in the endogenous medical expense model can adjust medical expenditures as well as consumption.

In sum, the endogenous medical expense model confirms and reinforces our conclusion that medical expenses are a major savings motive, and that social insurance affects the saving of the income-rich as well as that of the income-poor. Our main findings appear thus robust to the way in which we

<sup>14</sup>In the endogenous medical expense model, we index the estimated utility floor by the consumption level that provides the floor when  $\mu = 1$ . To run the counterfactual, we cut that consumption level in half.



**Figure 14:** Median assets: baseline and model with 50% of the consumption floor for the exogenous (left panel) and endogenous (right panel) medical expense models.

model the medical expenditure decision.

## 10 Conclusions

In this paper, we construct, estimate and analyze a rich model of saving for retired single people. Our paper provides several contributions.

First, we estimate the out-of-pocket medical expenses faced by the elderly using a better data set and more flexible functional forms. As a result, we find that medical expenses are much higher and more volatile than previously estimated, that they rise very fast with age, and that at very advanced ages (that is starting from about age 80), medical expenses are very much a luxury good; i.e., they are much higher for individuals with higher permanent income.

Second, we carefully estimate mortality probabilities by age as a function of health, sex, and permanent income and find large variations along all three dimensions. We find that in an unbalanced panel, mortality bias—the tendency of rich people to live longer—is significant.

Third, we construct and estimate a structural model of saving using the method of simulated moments. As a result of our careful first step-estimation and of the richer sources of heterogeneity that we include in our model, we find that our parameter estimates are very reasonable, and that our model provides a better fit to the data than that previously obtained in the litera-

ture. In particular, our estimated structural model fits saving profiles across the entire income distribution, and reproduces the observation that elderly people with high permanent income have a smaller dissaving rate than elderly people with low permanent income.

Using our model and estimated processes and parameters we draw several conclusions. We find that the pattern of out-of-pocket medical expenses by age and permanent income is a key determinant of savings. If single households live to very advanced ages, they are almost sure to need very expensive medical care, and they thus need to keep a large amount of assets (an amount increasing in permanent income, as medical expenses also increase) to self-insure against this risk.

We find that bequests are luxury goods and thus have little effect on saving for most of our sample of elderly singles: in our data, median net worth in the top permanent income quintile is less than \$200,000. The parameter values for this bequest motive are imprecisely estimated as well, probably because we don't have enough rich people in our sample. As a result, our model fits almost equally well with or without bequest motives. In contrast, medical expenses are crucial whether or not bequest motives are included.

Finally, we find that a publicly-provided consumption floor has a large effect on the asset profiles of all people, even those with high income.

Our main conclusion is that out-of-pocket medical expenditures, and the way in which they interact with the consumption floor, go a long way toward explaining the elderly's saving decisions and are very important elements that should be included in models evaluating old-age policy reforms. Our conclusions are robust to endogenizing medical expenditure in an empirically realistic way.

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## Appendix A: Moment conditions and asymptotic distribution of parameter estimates

### Benchmark model

In the model with exogenous medical expenses, our estimate,  $\hat{\Delta}$ , of the “true”  $M \times 1$  preference vector  $\Delta_0$  is the value of  $\Delta$  that minimizes the (weighted) distance between the estimated life cycle profiles for assets found in the data and the simulated profiles generated by the model. For each calendar year  $t \in \{t_0, \dots, t_T\} = \{1996, 1998, 2000, 2002, 2004, 2006\}$ , we match median assets for 5 permanent income quintiles in 5 birth year cohorts.<sup>15</sup> The 1996 (period- $t_0$ ) distribution of simulated assets, however, is bootstrapped from the 1996 data distribution, and thus we match assets to the data for 1998, ..., 2006. In addition, we require each cohort-income-age cell have at least 10 observations to be included in the GMM criterion. In the end we have a total of  $J = 101$  moment conditions.

Suppose that individual  $i$  belongs to birth cohort  $p$ , and his permanent income level falls in the  $q$ th permanent income quintile. Let  $a_{pqt}(\Delta, \chi)$  denote the model-predicted median asset level for individuals in individual  $i$ ’s group at time  $t$ , where  $\chi$  includes all parameters estimated in the first stage (including the permanent income boundaries). Assuming that observed assets have a continuous conditional density,  $a_{pqt}$  will satisfy

$$\Pr(a_{it} \leq a_{pqt}(\Delta_0, \chi_0) | p, q, t, \text{individual } i \text{ observed at } t) = 1/2.$$

The preceding equation can be rewritten as a moment condition (Manski [44], Powell [50] and Buchinsky [9]). In particular, applying the indicator function produces

$$E(1\{a_{it} \leq a_{pqt}(\Delta_0, \chi_0)\} - 1/2 | p, q, t, \text{individual } i \text{ observed at } t) = 0. \quad (26)$$

Equation (26) is merely equation (19) in the main text, adjusted to allow for “missing” as well as deceased individuals. Continuing, we can convert this conditional moment equation into an unconditional one (e.g., Chamberlain [12]):

$$\begin{aligned} & E\left( [1\{a_{it} \leq a_{pqt}(\Delta_0, \chi_0)\} - 1/2] \times 1\{p_i = p\} \right. \\ & \left. \times 1\left\{ \frac{q-1}{Q} \leq I_i < \frac{q}{Q} \right\} \times 1\{\text{individual } i \text{ observed at } t\} \mid t \right) = 0, \quad (27) \end{aligned}$$

---

<sup>15</sup>Because we do not allow for macro shocks, in any given cohort  $t$  is used only to identify the individual’s age.

for  $p \in \{1, 2, \dots, P\}$ ,  $q \in \{1, 2, \dots, Q\}$ ,  $t \in \{t_1, t_2, \dots, t_T\}$ .

Suppose we have a data set of  $I$  independent individuals that are each observed at up to  $T$  separate calendar years. Let  $\varphi(\Delta; \chi_0)$  denote the  $J$ -element vector of moment conditions described immediately above, and let  $\hat{\varphi}_I(\cdot)$  denote its sample analog. Letting  $\widehat{\mathbf{W}}_I$  denote a  $J \times J$  weighting matrix, the MSM estimator  $\hat{\Delta}$  is given by

$$\operatorname{argmin}_{\Delta} \frac{I}{1 + \tau} \hat{\varphi}_I(\Delta; \chi_0)' \widehat{\mathbf{W}}_I \hat{\varphi}_I(\Delta; \chi_0),$$

where  $\tau$  is the ratio of the number of observations to the number of simulated observations.

In practice, we estimate  $\chi_0$  as well, using the approach described in the main text. Computational concerns, however, compel us to treat  $\chi_0$  as known in the analysis that follows. Under regularity conditions stated in Pakes and Pollard [47] and Duffie and Singleton [20], the MSM estimator  $\hat{\Delta}$  is both consistent and asymptotically normally distributed:

$$\sqrt{I} \left( \hat{\Delta} - \Delta_0 \right) \rightsquigarrow N(0, \mathbf{V}),$$

with the variance-covariance matrix  $\mathbf{V}$  given by

$$\mathbf{V} = (1 + \tau) (\mathbf{D}' \mathbf{W} \mathbf{D})^{-1} \mathbf{D}' \mathbf{W} \mathbf{S} \mathbf{W} \mathbf{D} (\mathbf{D}' \mathbf{W} \mathbf{D})^{-1},$$

where:  $\mathbf{S}$  is the variance-covariance matrix of the data;

$$\mathbf{D} = \left. \frac{\partial \varphi(\Delta; \chi_0)}{\partial \Delta'} \right|_{\Delta = \Delta_0} \quad (28)$$

is the  $J \times M$  gradient matrix of the population moment vector; and  $\mathbf{W} = \operatorname{plim}_{I \rightarrow \infty} \{\widehat{\mathbf{W}}_I\}$ . Moreover, Newey [45] shows that if the model is properly specified,

$$\frac{I}{1 + \tau} \hat{\varphi}_I(\hat{\Delta}; \chi_0)' \mathbf{R}^{-1} \hat{\varphi}_I(\hat{\Delta}; \chi_0) \rightsquigarrow \chi_{J-K}^2,$$

where  $\mathbf{R}^{-1}$  is the generalized inverse of

$$\begin{aligned} \mathbf{R} &= \mathbf{P} \mathbf{S} \mathbf{P}, \\ \mathbf{P} &= \mathbf{I} - \mathbf{D} (\mathbf{D}' \mathbf{W} \mathbf{D})^{-1} \mathbf{D}' \mathbf{W}. \end{aligned}$$

The asymptotically efficient weighting matrix arises when  $\widehat{\mathbf{W}}_I$  converges to  $\mathbf{S}^{-1}$ , the inverse of the variance-covariance matrix of the data. When

$\mathbf{W} = \mathbf{S}^{-1}$ ,  $\mathbf{V}$  simplifies to  $(1 + \tau)(\mathbf{D}'\mathbf{S}^{-1}\mathbf{D})^{-1}$ , and  $\mathbf{R}$  is replaced with  $\mathbf{S}$ . This is the matrix we use for all the results shown in this paper.

But even though the optimal weighting matrix is asymptotically efficient, it can be biased in small samples. (See, for example, Altonji and Segal [1].) To check for robustness, we also use a “diagonal” weighting matrix, as suggested by Pischke [49]. This diagonal weighting scheme uses the inverse of the matrix that is the same as  $\mathbf{S}$  along the diagonal and has zeros off the diagonal of the matrix. This matrix delivers parameter estimates very similar to our benchmark estimates.

We estimate  $\mathbf{D}$ ,  $\mathbf{S}$  and  $\mathbf{W}$  with their sample analogs. For example, our estimate of  $\mathbf{S}$  is the  $J \times J$  estimated variance-covariance matrix of the sample data. When estimating this matrix, we use sample statistics, so that  $a_{pqt}(\Delta, \chi)$  is replaced with the sample median for group  $pqt$ .

One complication in estimating the gradient matrix  $\mathbf{D}$  is that the functions inside the moment condition  $\varphi(\Delta; \chi)$  are non-differentiable at certain data points; see equation (27). This means that we cannot consistently estimate  $\mathbf{D}$  as the numerical derivative of  $\hat{\varphi}_I(\cdot)$ . Our asymptotic results therefore do not follow from the standard GMM approach, but rather the approach for non-smooth functions described in Pakes and Pollard [47], Newey and McFadden [46] (section 7) and Powell [50].

To find  $\mathbf{D}$ , it is helpful to rewrite equation (27) as

$$\Pr\left(p_i = p \ \& \ \frac{q-1}{Q} \leq I_i \leq \frac{q}{Q} \ \& \ \text{individual } i \text{ observed at } t\right) \times \left[ \int_{-\infty}^{a_{pqt}(\Delta_0, \chi_0)} f\left(a_{it} \mid p, \frac{q-1}{Q} \leq I_i \leq \frac{q}{Q}, t\right) da_{it} - \frac{1}{2} \right] = 0, \quad (29)$$

It follows that the rows of  $\mathbf{D}$  are given by

$$\Pr\left(p_i = p \ \& \ \frac{q-1}{Q} \leq I_i \leq \frac{q}{Q} \ \& \ \text{individual } i \text{ observed at } t\right) \times f\left(a_{pqt} \mid p, \frac{q-1}{Q} \leq I_i \leq \frac{q}{Q}, t\right) \times \frac{\partial a_{pqt}(\Delta_0; \chi_0)}{\partial \Delta'}. \quad (30)$$

In practice, we find  $f(a_{pqt}|p, q, t)$ , the conditional p.d.f. of assets evaluated at the median  $a_{pqt}$ , with a kernel density estimator written by Kong [39].



## The model with endogenous medical expenditures

To estimate the model with endogenous medical expenses, we add several moment conditions relating to medical expenses. We first simulate medical expenses at an annual frequency, and then take two-year averages to produce a measure of medical expenses comparable the one contained in the AHEAD.

Because we are interested in the possibility of catastrophic medical expenses, especially at very old ages, it is important that each cohort-income-age cell have a fairly large number of observations. To ensure this we split the income distribution in half, rather than into quintiles, so that that the quintile index  $q$  lies in  $\{1, 2\}$ . As before, we divide individuals into 5 cohorts, and match data from 5 waves covering the period 1998-2006.

To fit the upper tail of the medical expense distribution, we require the model to match the 90th percentile of out-of-pocket medical expenditures in each cohort-income-age cell. Let  $m_{pqt}^{90}(\Delta, \chi)$  denote the model-predicted 90th percentile for individuals in cohort  $p$  and permanent income half  $q$  at time (age)  $t$ . Letting  $i$  index individuals, and proceeding as before, we have the following moment condition:

$$E\left([1\{m_{it} \leq m_{pqt}^{90}(\Delta_0, \chi_0)\} - 0.9] \times 1\{p_i = p\} \times 1\left\{\frac{q-1}{Q} \leq I_i < \frac{q}{Q}\right\} \times 1\{\text{individual } i \text{ observed at } t\} \mid t\right) = 0, \quad (31)$$

for  $p \in \{1, 2, \dots, P\}$ ,  $q \in \{1, 2\}$ ,  $t \in \{t_1, t_2, \dots, t_T\}$ .

We also require the model to match mean medical expenses (in levels, not logs) in each cell. Let  $\bar{m}_{pqt}(\Delta, \chi)$  denote the model-predicted mean. The associated moment condition is

$$E\left([m_{it} - \bar{m}_{pqt}(\Delta_0, \chi_0)] \times 1\{p_i = p\} \times 1\left\{\frac{q-1}{Q} \leq I_i < \frac{q}{Q}\right\} \times 1\{\text{individual } i \text{ observed at } t\} \mid t\right) = 0, \quad (32)$$

Finally, to pin down the autocorrelation coefficient for  $\zeta$  ( $\rho_m$ ), and its contribution to the total variance  $\zeta + \xi$ , we require the model to match the first and second autocorrelations of logged medical expenses. Define the residual  $R_{it}$  as

$$R_{it} = \ln(m_{it}) - \overline{\ln m_{pqt}},$$

$$\overline{\ln m_{pqt}} = E(\ln(m_{it}) \mid p_i, q_i, t),$$

and define the standard deviation  $\sigma_{pqt}$  as

$$\sigma_{pqt} = \sqrt{E(R_{it}^2 | p_i = p, q_i = q, t)}.$$

Both  $\overline{\ln m_{pqt}}$  and  $\sigma_{pqt}$  can be estimated non-parametrically as elements of  $\chi$ . Using these quantities, the autocorrelation coefficient  $AC_{pqtj}$  is:

$$AC_{pqtj} = E \left( \frac{R_{it} R_{i,t-j}}{\sigma_{pqt} \sigma_{pq,t-j}} \middle| p_i = p, q_i = q \right).$$

Let  $AC_{pqtj}(\Delta, \chi)$  be the autocorrelation coefficient implied by the model, calculated using model values of  $\overline{\ln m_{pqt}}$  and  $\sigma_{pqt}$ . The resulting moment condition for the first autocorrelation is

$$E \left( \left[ \frac{R_{it} R_{i,t-1}}{\sigma_{pqt} \sigma_{pq,t-1}} - AC_{pqt1}(\Delta_0, \chi_0) \right] \times 1\{p_i = p\} \times 1\left\{ \frac{q-1}{Q} \leq I_i < \frac{q}{Q} \right\} \right. \\ \left. \times 1\{\text{individual } i \text{ observed at } t \text{ \& } t-1\} \middle| t \right) = 0, \quad (33)$$

The corresponding moment condition for the second autocorrelation is

$$E \left( \left[ \frac{R_{it} R_{i,t-2}}{\sigma_{pqt} \sigma_{pq,t-2}} - AC_{pqt2}(\Delta_0, \chi_0) \right] \times 1\{p_i = p\} \times 1\left\{ \frac{q-1}{Q} \leq I_i < \frac{q}{Q} \right\} \right. \\ \left. \times 1\{\text{individual } i \text{ observed at } t \text{ \& } t-2\} \middle| t \right) = 0, \quad (34)$$

To summarize, the moment conditions used to estimate model with endogenous medical expenses consist of: the moments for asset medians described by equation (27); the moments for the 90th percentile of medical expenses described by equation (31); the moments for mean medical expenses described by equation (32); and the moments for the autocorrelations of logged medical expenses described by equations (33) and (34). The GMM criterion function, standard errors, and overidentification test statistic are straightforward extensions of those used in the baseline model.

## Appendix B: Data and first-stage results

## Overview of the AHEAD data

The AHEAD data provides high quality information on, amongst other things, mortality, medical expenses, income, and wealth.

If it is discovered that a sample member dies, this is recorded and verified using the National Death Index. Attrition for reasons other than death is relatively rare. Furthermore, the mortality rates we estimate from the AHEAD are very similar to the aggregate statistics, giving us confidence in the data.

We consider only single retired individuals in the analysis. We drop all individuals who were either married or co-habiting at any point in the analysis (so we include individuals who were never married with those who were divorced or widowed by wave 1), which leaves us with 3,498 individuals. After dropping individuals with missing wave 1 labor income data and individuals with over \$3,000 in labor income in any wave, we are left with 3,259 individuals, of whom 592 are men and 2,667 are women. Of these 3,259 individuals, 884 are still alive in 2006.

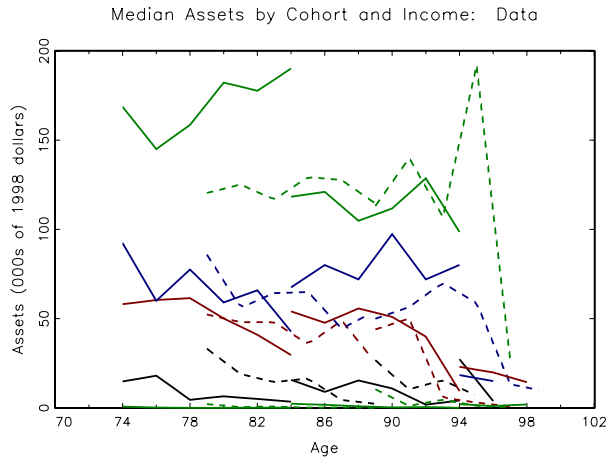
We use the RAND release of the data for all variables, although we augment the RAND medical expense data. Parameter estimates and documentation for out-of-pocket medical expenses, mortality rates, and health transition probabilities are available at: [http://www.chicagofed.org/economic\\_research\\_and\\_data/economists\\_preview.cfm?autID=29](http://www.chicagofed.org/economic_research_and_data/economists_preview.cfm?autID=29).

## Assets

One problem with asset data is that the wealthy tend to underreport their wealth in all household surveys (Davies and Shorrocks [13]). This leads to understating asset levels at all ages. However, Juster et al. [37] show that the wealth distribution of the AHEAD matches up well with aggregate values for all but the richest 1% of households. However, problems of wealth underreporting seem particularly severe for 1994 AHEAD wave (see Rohwedder et al. [51]). As a result, we do not use the 1994 wealth data in our estimation procedure. (We use other 1994 data, however, in constructing the income, health, and mortality profiles.) Given that, and the fact that we are matching median assets (conditional on permanent income), the underreporting by the very wealthy should not significantly affect our results.

Figure 15 shows the full set of asset profiles we use in the analysis.

## Medical expenses



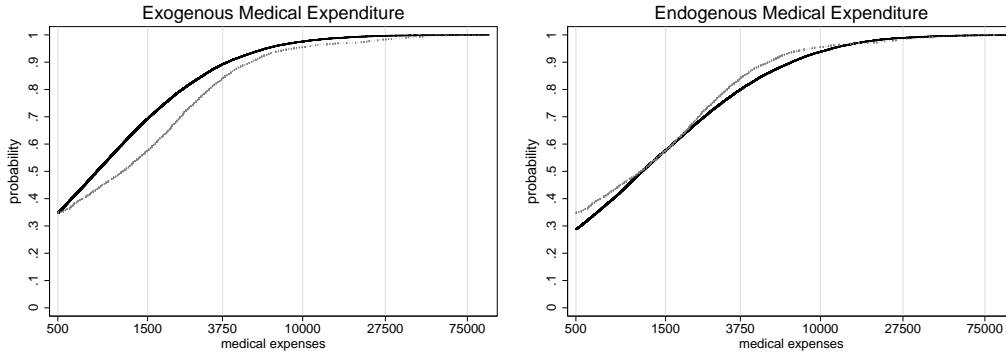
**Figure 15:** Median assets by cohort and PI quintile: data.

The measure of medical expenditures contained in the AHEAD is average medical expenditures over the last two years. For surviving individuals, we use the RAND release of medical expense data. RAND has not coded medical expenses that people incur in their last year of life. However, the AHEAD data include follow-up interviews of the deceased’s survivors. These follow-up interviews include information on medical expenses in the last year of life. Because AHEAD respondents were asked only a limited set of questions about their medical spending in 1994, we use medical expense data from 1996 onwards.

Because medical expenditures in the AHEAD are two-year averages, while our model operates at an annual frequency, we multiply the two-year variance residual variance by 1.424. This adjustment, based on the “Standard Lognormal” Model shown in Table 7 of French and Jones [30], gives us the variance in one-year medical expenditures that would, when averaged over two years, match the variance seen in the two-year data.<sup>16</sup>

Figure 16 compares the cumulative distribution function (CDF) of out-of-pocket medical expenditures found in the data with that produced by the models with exogenous and endogenous medical expenditures. Both models fit the data well.

<sup>16</sup>To keep mean medical expenses (as opposed to their log) constant, this variance adjustment is accompanied by an adjustment to the log mean. A description of this adjustment can be found in our on-line documentation.



**Figure 16:** Cumulative distribution function of medical expenses: data and the exogenous (left panel) and endogenous (right panel) medical expenditure models. Legend: solid line is model, lighter line is data.

The CDF for the model with exogenous medical expenses lies slightly above the CDF for the data until about \$40K, and thus understates the probability of large medical expenditures. This is not surprising because, due to the nature of the AHEAD data, the exogenous medical expense process is estimated on out-of-pocket expenditures net of Medicaid payments that, ideally, should have been included.

The model with endogenous medical expenditures, in contrast, explicitly models this kind of censoring. As a result, the moment conditions used to estimate the process for the “medical needs” shocks use model-generated and actual data that are both net of Medicaid payments. This should and in fact does increase the estimated probability of large medical expenses, relative to the exogenous medical expense model. The second panel of Figure 16 shows that the CDF for the endogenous model understates the probability of low medical expenses, but fits the upper tail of the distribution (beginning around \$20K) quite well.

## Co-insurance rates

We also use the AHEAD data to estimate the co-insurance rate  $q(t, h_t)$ . Recall that in all waves AHEAD respondents are asked about what medical expenses they paid out of pocket. In 1998, 2000, and 2002 they were also asked about total billable medical expenses (including what is paid for by insurance). We measure the co-insurance rate as the amount spent out of pocket (less insurance premia) divided by the total billable medical expenses.

Following Yogo (2009) we regress the log of this on an age polynomial and health status, and health status interacted with age. We find that the co-insurance rate falls with age and for people in bad health.

## Appendix C: More estimation results

The first column of results in Table 4 reports the estimates from our benchmark model.

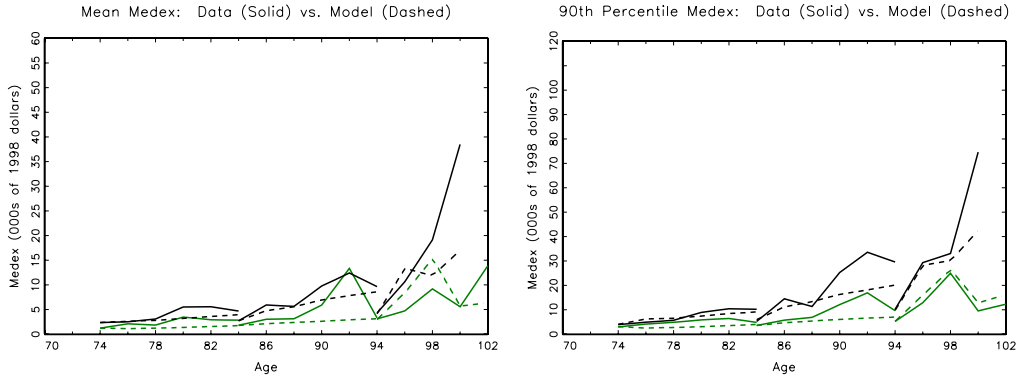
The second column of Table 4 estimates a version of the benchmark model with an exogenously fixed consumption floor. This is meant to further investigate whether the risk aversion parameter and the consumption floor are separately identified. Raising the consumption floor to \$5,000 exposes consumers to less risk: the model compensates by raising the estimated value of  $\nu$  to 6.0. This adjustment to  $\nu$ , however, is not enough to prevent a significant worsening of the model's fit. When the consumption floor is set exogenously to \$5,000, the  $p$ -value for the overidentification statistic is only 20.7%, compared to 87.4% for the baseline specification. Such a large worsening of fit suggests that  $\nu$  and  $\underline{c}$  are in fact identified. The estimated discount factor is marginally lower.

	Benchmark	$\underline{c} =$ \$5,000	Endogenous medical expenditures
$\nu$ : RRA coefficient, consumption	3.81 (0.50)	6.04 (1.01)	2.15 (0.055)
$\omega$ : RRA, medical expenditures	NA NA	NA NA	3.19 (0.054)
$\beta$ : discount factor	0.97 (0.04)	0.96 (0.06)	0.99 (0.01)
$\underline{c}$ : consumption floor	2,663 (346)	5,000 NA	NA NA
$\underline{c}$ : utility floor <sup>†</sup>	NA NA	NA NA	202 (23.4)
Overidentification test	82.3	110.2	667.0
Degrees of freedom	98	99	242
$p$ -value overidentification test	87.4%	20.7%	0.0%

<sup>†</sup> In the endogenous medical expense model, the estimated utility floor is indexed by the consumption level that provides the floor when  $\mu = 1$ . This consumption value is *not* comparable to the consumption floor.

**Table 4:** Estimated preference parameters. Standard errors are in parentheses below estimated parameters. NA refers to parameters fixed for a given estimation or to a case in which a given parameter does not apply.

The final column of Table 4 shows the preference parameters for the model with endogenous medical expenses. These results have been discussed in the main text. Estimating the model with endogenous medical expenditures also requires us to find the parameters of the log of the medical needs shifter  $\mu(t, h_t, \zeta_t, \xi_t)$ . Figure 17 shows that, at the estimated parameter values, the model fits the medical expenditure data well. Figure 17 compares observed and simulated profiles for the mean and the 90th percentile of the medical expenditure distribution, by cohort and permanent income. The figure shows that the model slightly under-predicts medical expenditures, but captures well the way in which expenditures rise with both age and permanent income.



**Figure 17:** Medical expenditures: data and endogenous medical expenditure model. Left panel: means. Right panel: 90th percentile.

## Appendix D: Interpreting the size of the bequest motive

To get a sense of the size of the bequest motive, consider a person who starts the period with cash-on-hand  $x$ , dies for sure the next period without incurring any medical expenses, and is in good health. Assume further that this person's assets are well below the estate taxation exemption level. The budget constraint for such a person is given by  $e = (1 + r)(x - c)$ , where  $e$  is the bequest (estate) left. The first order condition for an interior solution implies that the marginal utility of consumption today equals the appropriately discounted marginal utility of bequests. Using the budget constraint and our first order condition we can solve for optimal bequests:

$$e = \frac{1 + r}{1 + r + f}(fx - k), \quad (35)$$



where  $k$  is the shift parameter introduced in equation (3), and  $f$  is a function of several preference parameters. Since bequests cannot be negative, the expression for  $e$  reveals that  $x$  has to be large ( $> k/f$ ) before the person will leave any bequests. If  $x$  is not sufficiently large, then  $c = x$  and the solutions just derived do not apply. Assuming that  $x$  is in fact large enough, the marginal propensity to bequeath out of an extra dollar today is  $\frac{\partial}{\partial x} \left( \frac{e}{1+r} \right) = \frac{f}{1+r+f}$ .

Using the parameter values in the third column of Table 3, we find that marginal propensity to bequeath is 0.88, and the bequest motive becomes operative at  $x = \$36,000$ . In a dynamic model, where the odds of dying in any given period are low,  $x$  should be interpreted not as the total stock of wealth, but as its annuity or consumption value. The bequest motive appears to be strong, but only at very high levels of wealth.