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Abstract

Rich people, women, and healthy people live longer. We document that this heterogeneity in life expectancy is large, and we use an estimated structural model to assess its effect on the elderly's saving. We find that the differences in life expectancy related to observable factors such as income, gender, and health have large effects on savings, and that these factors contribute by similar amounts. We also show that the risk of outliving one's expected lifespan has a large effect on the elderly's saving behavior.

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Rich people, women, and healthy people live much longer than their poor, male, and sick counterparts. Two extremes, taken from our analysis of single people in the Assets and Health Dynamics of the Oldest Old (AHEAD) dataset, illustrate this point: an unhealthy 70 year old male at the 20^{th} percentile of the permanent income distribution expects to live only 6 more years, that is to age 76. In contrast, a healthy 70 year old woman at the 80^{th} percentile of the permanent income distribution expects to live 16 more years, thus making it to age 86.[1] Such significant differences in life expectancy could, all else equal, lead to significant differences in saving behavior.

A related observation is that people with high permanent incomes keep large amounts of assets very late in life. Table 1, also based on the AHEAD data, shows percentage changes in median assets between 1995 and 2002 for the single individuals who were still alive in 2002. Table 1 shows the change for each permanent income quintile in two different birth year cohorts. As permanent income grows, asset decumulation declines. In the older cohort, the poorest group consumes over 98 percent of their assets (admittedly a small amount) between 1995 and 2002, while the top group increases their assets by 3 percent.

Table 1—Percentage Change in Median Assets, 1995-2002, by Cohort and Permanent Income Quintile

PI Quintile	Ages 72-81	Ages 82-91
Bottom	-83.4	-98.2
Second	-33.4	-60.1
Third	-23.2	-34.5
Fourth	-27.5	-42.2
Top	-7.7	2.7

Combining these two observations begs the question of how much of the asset accumulation of old rich people is due to longer life expectancy. To study this question, we use a previously developed and estimated model of elderly singles' saving behavior (see Mariacristina De Nardi, Eric French, and John B. Jones (2006)). Using a structural model allows us to disentangle the

[1]For additional evidence on the links between permanent income and mortality, see Orazio P. Attanasio and Carl Emmerson (2003) and Angus Deaton and Christina Paxson (2001). Michael D. Hurd, Daniel McFadden, and Angela Merrill (2001) provide evidence on the links between health status and mortality.

effects of life expectancy from other influences on old age saving, especially medical expenditures, that also vary by sex, age, health and permanent income. Our previous work shows that our model fits the data well, providing reassurance in our model's predictions.

In that paper we also document that an important reason why the income rich elderly run down their assets slowly is the high level of medical expenses faced by these people. In this paper we concentrate on how variations in life expectancy by health, gender, and permanent income affect asset holdings during retirement for a given profile of medical expenditures.[2] We find that all of these effects are important for understanding the saving of the elderly and they are each of roughly the same order of magnitude.

In addition to systematic differences due to gender, health and income, variations in lifespan reflect a significant amount of idiosyncratic risk. For example, while the average lifespan of unhealthy males at the 20$^{\text{th}}$ percentile of the permanent income distribution is 6 years, 8 percent of these individuals will live for at least 15 years. We show that the risk of outliving one's net worth has a large effect on the elderly's saving behavior.

I. The Model

Consider a retired person seeking to maximize expected lifetime utility from consumption c at age t, $t = t_{r+1}, ..., T$, where t_r is the retirement age and T is the maximum lifespan. The flow utility of consumption is given by

$$u(c) = \frac{c^{1-\nu}}{1-\nu}, \quad \nu \geq 0. \tag{1}$$

The two key determinants of the household's ability to spend are its net worth, a_t, and its annuity (non-asset) income, y_t. Annuity income is a deterministic function of sex, g, permanent income, I, and age, t:

$$y_t = y(g, I, t). \tag{2}$$

In this context, permanent income should be thought of as lifetime earnings, or a monotonic

[2]In a complementary exercise that does not account for medical expenses, Li Gan, Guan Gong, Michael Hurd and Daniel McFadden (2004) analyze how differences in self-reported subjective survival probabilities affect the elderly's saving.

transformation thereof; people with higher lifetime earnings will receive higher annuity income upon retirement.

The individual faces several exogenous sources of risk.

1) Health status uncertainty, with transition probabilities that depend on previous health, sex, permanent income and age.

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 costs, m_t, are defined as out-of-pocket costs. They depend upon sex, health status, permanent income, age and an idiosyncratic component, ψ_t:

$$\ln m_t = m(g,h,I,t) + \sigma(g,h,I,t) \times \psi_t. \tag{3}$$

Following Daniel Feenberg and Jonathan Skinner (1994) and Eric French and John B. Jones (2004), we assume

$$\psi_t = \zeta_t + \xi_t, \quad \xi_t \sim N(0, \sigma_\xi^2), \tag{4}$$

$$\zeta_t = \rho_m \zeta_{t-1} + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma_\epsilon^2), \tag{5}$$

where ξ_t and ϵ_t are serially and mutually independent.

Timing: at the beginning of the period the individual's health status and medical costs are realized. The individual then consumes and saves. Finally the survival shock hits.

The evolution of net worth is given by

$$a_{t+1} = a_t + y_n(ra_t + y_t, \tau) + b_t - m_t - c_t, \tag{6}$$

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

The consumer faces a standard borrowing constraint: $a_{t+1} \geq 0$. Following Glenn R. Hubbard, Jonathan Skinner, and Stephen P. Zeldes (1994, 1995), we assume that government transfers bridge the gap between an individual's total resources and the "consumption floor" $\underline{c}$:

$$b_t = \max\{0, \underline{c} + m_t - [a_t + y_n(ra_t + y_t, \tau)]\}, \tag{7}$$

If $b_t > 0$, then $c_t = \underline{c}$ and $a_{t+1} = 0$.

To save on state variables, we follow Angus Deaton (1991) and redefine the problem in terms of cash-on-hand:

$$x_t = a_t + y_n(r\, a_t + y_t, \tau) + b_t - m_t. \tag{8}$$

All of the variables in x_t are given and known at the beginning of period t.

Letting β denote the discount factor, the value function for a single individual is

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

subject to

$$x_{t+1} = x_t - c_t + y_n\big(r(x_t - c_t) + y_{t+1}, \tau\big) + b_{t+1} - m_{t+1}. \tag{9}$$

To enforce the consumption floor and borrowing constraint, we have

$$x_t \geq \underline{c}, \quad c_t \leq x_t. \tag{10}$$

II. Data, Estimation, and Preference Parameter Values

The AHEAD is a sample of non-institutionalized individuals, aged 70 or older in 1993. The survivors in the sample were interviewed again in 1995, 1998, 2000, and 2002.

The AHEAD has information on the value of housing and real estate, automobiles, privately-held businesses, IRAs, Keoghs, and other financial assets. Our measure of net worth is the sum of these items, less mortgages and other debts. The AHEAD also provides a measure of annuity income (the sum of social security payments, defined benefit payments, veteran's benefits and food stamps). We define permanent income as average annuity income over all periods the individual is observed. Our health status indicator is taken from the AHEAD's self-reported subjective health measure. Medical expenses are total out-of-pocket expenditures, including insurance premia and nursing home care. Attrition for reasons other than death is relatively rare, hence we can use the AHEAD data to estimate mortality rates.

In De Nardi, French, and Jones (2006), we estimated the model using a two-step strategy. In the first step, we estimated those parameters that could be cleanly identified without explicitly using the model, such as the mortality, health transition, annuity income, and medical expense profiles.

In the second step, we estimated the remaining parameters with the method of simulated moments, by matching simulated and observed asset medians over the period 1995-2002. Grouping individuals by birth-year and permanent income, we calculated the median net worth of the surviving individuals in each cohort-income cell in each year. Our parameter estimates were the values that produced the best fit between the cell medians produced by model simulations and the cell medians found in the data.

Updating the model in De Nardi, French, and Jones (2006) with newer versions of the AHEAD data, we find the following parameter values. The coefficient of relative risk aversion (ν) is 4.77, the discount factor (β) is 0.955, and the consumption floor ($\underline{c}$) is \$2,729. The interest rate (r) is calibrated to 2 percent.

III. Results

A. *Life Expectancy*

Using the AHEAD data, we estimate the probability of being alive, and if alive, the probability of being in good health, conditional on health status last year, permanent income and sex. Beginning at age 70 with the empirical distribution of health, permanent income and sex, we use these estimated processes to simulate demographic histories. Table 2 presents our estimated life expectancies.

Permanent income, health and gender have similar effects on life expectancy. A typical person at the 80^{th} permanent income percentile on average lives 3.1 years longer than a person at the 20^{th} percentile. Healthy people on average live 3.2 years longer than unhealthy people, and women on average live 4.6 years longer than men.[3]

With incomplete annuitization, one potential reason why some elderly run down their assets slowly is uncertainty over their lifespans. Table 3 shows the probability of living to ages 85 and 95, conditional on being alive at age 70. For example, a healthy woman at the 80^{th} percentile of

[3] Our predicted life expectancy is lower than what the aggregate statistics imply. These differences are an artifact of using data on singles only: when we re-estimate the model for both couples and singles we find that our predicted life expectancy is very close to the aggregate statistics.

Table 2—Life Expectancy in Years, Conditional on Being Alive at Age 70

Income Percentile	Healthy Male	Unhealthy Male	Healthy Female	Unhealthy Female	All
20	8.1	6.3	13.4	11.7	11.7
40	8.9	7.0	14.3	12.7	12.6
60	9.9	7.9	15.4	13.8	13.6
80	10.9	9.0	16.4	15.0	14.8
By gender:					
Men					10.0
Women					14.6
By health status:					
Healthy					14.8
Unhealthy					11.6

the permanent income distribution, who expects to live to age 86 on average, faces a 14 percent chance of living 25 years, to age 95. Even an unhealthy man at the 20^{th} percentile faces an 8 percent chance of living to age 85, more than twice his expected lifespan of 6.3 years. The risk of living far past one's expected lifespan is large.

B. *Net Worth*

To better understand how variation in life expectancy affects saving, we simulate the net worth of the AHEAD birth-year cohort whose members were ages 72-76 (with an average age of 74) in 1995. We take the initial distribution of net worth, permanent income, health status, medical expenses, and sex from the 1995 AHEAD data. Thus in our simulations those with high permanent income are likely to begin with high net worth and good health, just as in the data. We then use the estimated processes and decision rules to project out the median net worth of everyone in the sample until the last period the model allows them to be alive, age 99.

Because those with low wealth and income have higher mortality rates, and because we model this explicitly, attrition from our simulated sample would not be random. Instead, we construct profiles with no attrition, so that the composition of the simulated sample is fixed over

Table 3—Percent Living to Ages 85 and 95, Conditional on Being Alive at Age 70

Income Percentile	Healthy Male	Unhealthy Male	Healthy Female	Unhealthy Female	All
			Percent living to age 85		
20	12.3	8.2	39.2	32.5	31.4
40	15.8	10.8	44.0	37.6	36.3
60	20.3	14.5	49.9	43.5	41.6
80	26.0	19.4	55.8	49.7	47.5
			Percent living to age 95		
20	0.8	0.5	7.2	6.0	5.4
40	1.1	0.8	8.7	7.5	6.9
60	1.7	1.2	10.9	9.4	8.7
80	2.5	1.9	13.8	12.3	10.9

the entire sample period. This allows us to track the saving of the same people over time. Thus, the asset profiles we show are those of agents who have realistic mortality expectations—and save on the basis of these expectations—but do not die until age 100.

The solid line in Figure 1 displays the net worth profiles generated by our baseline parameterization. Consistent with the evidence presented in Table 1, the net worth of the lowest permanent income quintile is close to zero and hence does not even show up on the graph. The households in this permanent income group rely on their annuitized income and the government consumption floor to finance their retirement. All other households seem to decumulate their net-worth very slowly, with those in the highest permanent income group starting off at $160,000 in median net worth at age 74, and retaining over $100,000 until well over age 90. Again, this is consistent with the evidence. Our finding that the income rich elderly run down their net worth at a very slow rate complements and confirms those of Karen E. Dynan, Jonathan Skinner, and Stephen P. Zeldes (2004), who look both at younger and older households but do not have as many observations as we do on the very elderly.

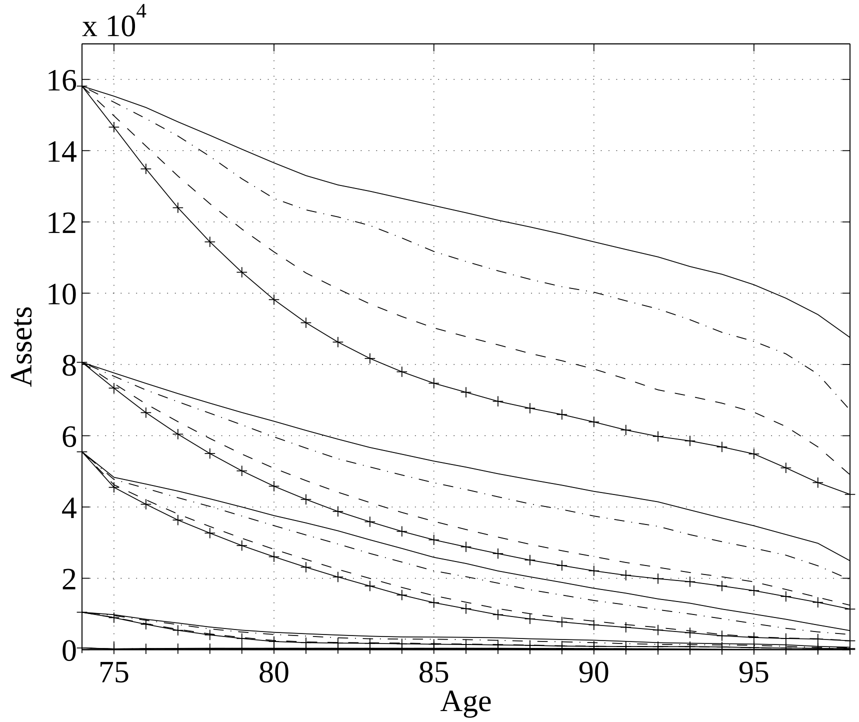

Figure 1. Median Net Worth under Different Mortality Assumptions

Notes: —-: baseline. − · −: everyone in bad health. − −: everyone male and in bad health. −+—+−: everyone low permanent income, male, and in bad health.

C. *The Effects of Heterogenous Mortality and Lifespan Risk on Net Worth*

The other lines in Figure 1 make more and more pessimistic assumptions about how long people expect to live, allowing us to isolate the effect of the cross-sectional heterogeneity in mortality rates on saving. We do this by changing the survival probabilities $s_{g,h,I,t}$ used to find the individuals' decision rules, but leaving everything else unchanged.

The dashed-dot line adjusts each individual's survival probabilities to those of someone who is always in bad health and has no chance of going back to good health. The implied drop in life expectancy is 2-4 years, depending on gender and PI. This lower life expectancy generates a noticeable fall in net worth. The largest effect in terms of asset accumulation is for the highest PI households. For people aged 90 and older who are in the highest permanent income quintile, assets decrease around \$15,000.

The dashed line assumes that, besides being always sick, everyone has the life expectancy of a male, which at age 70 is 4-5 years less than that of a female. This change in life expectancy generates a large drop in asset holdings for the three highest PI quintiles, again, with the richest quintile experiencing the largest drop. For people aged 90 and older that are in the top quintile, being always sick and male generates an average drop of over $30,000.

Finally, the crossed line adds the effect of being at the lowest possible PI level to all of the other effects on life expectancy. This implies that every 70-year-old expects to live 5 more years, although he still faces the risk of living much longer, producing another large drop in assets. For people aged 90 and older who are in the highest permanent income quintile, having the mortality rates of a sick, low-income male generates an average drop of over $50,000, which is about one-third of their initial assets.

In summary, differences in life expectancy related to health, gender, and permanent income are important to understanding savings patterns across these groups, and the effect of each factor is of a similar order of magnitude.

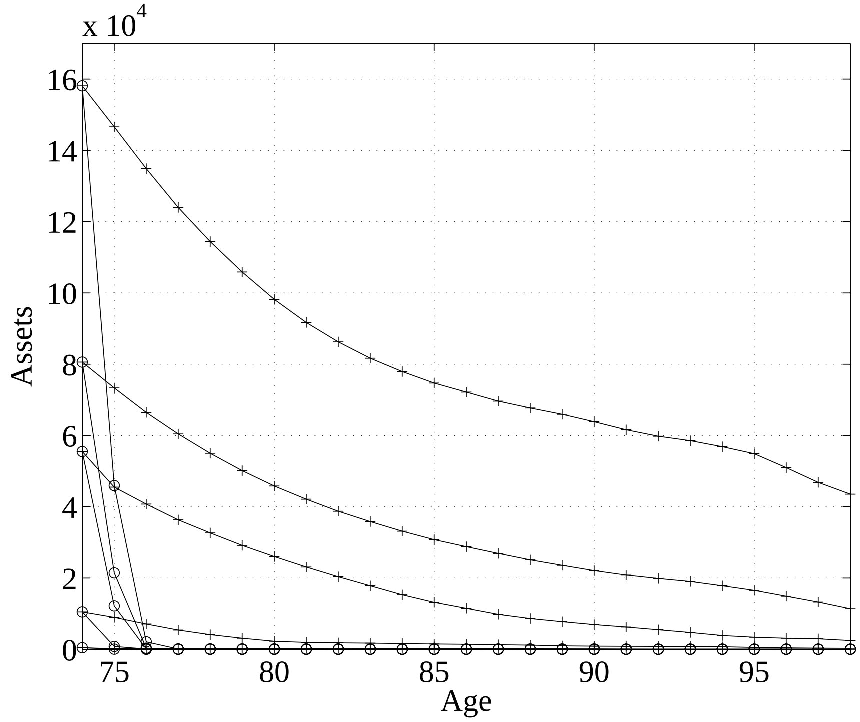

Figure 2. Median Net Worth under Different Mortality Assumptions
Notes: –+—+–: everyone low permanent income, male, and in bad health. –⊖–: everyone low permanent income, male, in bad health, and with a certain lifespan.

To assess the effects of lifespan uncertainty, Figure 2 shows two sets of simulations. The crossed line shows predicted net worth when everyone faces the mortality rates of a man with low permanent income who is in bad health. This man has an expected lifespan of 5 years, but faces the risk of living much longer. The circle-dash line eliminates this risk; all individuals in these simulations expect to live exactly 5 years, then die. When the risk of living longer than 5 years is eliminated, so is the value of having assets after 5 years, and individuals deplete their net worth by the end of their fifth year. In contrast, most individuals facing uncertain lifespans still have significant asset holdings after 5 years, even when facing the most pessimistic survival prospects. This comparison shows that at realistic levels of annuitization the risk of living beyond one's expected lifespan has huge effects on saving.

D. *How Do Medical Expenses Affect Our Results?*

Our previous work has shown that medical expenses rise with age, and much more so for retirees with high permanent income. For example, in our current model the average medical expenses of an unhealthy woman at the 80^{th} percentile of the permanent income distribution rise from $1,000 a year at age 70 to $18,000 a year at age 95. This feature of the data proves crucial to explaining the asset decumulation of the elderly. One might wonder whether medical expenses also affect how assets vary with life expectancy.

Figure 3 shows the asset profiles when there is lifespan uncertainty but no medical costs. The solid line displays asset profiles for the baseline life expectancy case, while the crossed line refers to the case in which everyone has the life expectancy of a sick, poor, and male person. For the richest people this amounts to a reduction in life expectancy of more than 7 years. Comparing Figure 3 to Figure 1 reveals two notable changes. First, the model with no medical costs implies a much faster rate of asset decumulation. Second, when there are no medical expenses the effects of changing life expectancy are much smaller in absolute terms, but much larger in relative terms. In absence of medical expenses giving the richest people the mortality rates of a sick, low-income male reduces assets at age 85 by $32,000. Figure 1 shows that with medical expenses the reduction is $50,000. The $32,000 reduction, however, translates into a decrease of over 70 percent, while the $50,000 reduction translates into a decrease of 40 percent.

Medical expenses increasing with age and permanent income prop up old age savings for the richest. When life expectancy is decreased the rich retirees are less likely to survive to very old age and face very large medical expenses. This has a large effect on their level of savings.

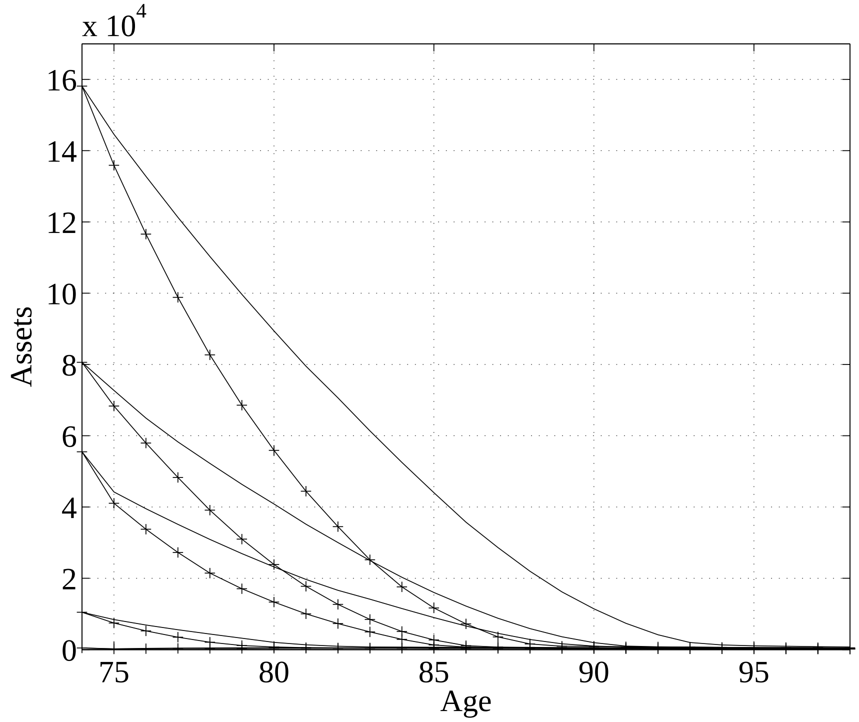

Figure 3. Median Net Worth under Different Mortality Assumptions when There Are No Medical Expenses

Notes: —-: baseline. −+—+−: everyone low permanent income, male, and in bad health.

On the other hand, removing medical expenses altogether greatly reduces total savings, which were used to insure against both life span risk and medical costs. For this reason, the change in life expectancy has a larger impact in percentage terms then when there are no out-of-pocket medical expenses.

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