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Adequacy of Resources in Retirement

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1. Introduction

The discussion of required resources in retirement is often expressed in terms of replacement rates of pre-retirement income. For example, many people think in terms of complete replacement of income or of some fixed fraction such as 80 percent. This kind of thinking is simplistic in that it makes no systematic accounting of

- the differing role of taxes for households at different points in the income distribution;
- work-related expenses;
- financing consumption out of savings;
- the time horizon or survival curve of the household;
- returns to scale in consumption: couples need to assess the risk of increased per capita spending once one of the partners dies;
- the changing consumption profile with age;
- a household's use of its increased leisure in retirement in ways that may either increase or decrease spending. For example some households may want to use their increased leisure time to engage in activities that are associated with elevated expenses such as travel, while some may engage in home production or more efficient shopping to reduce spending;

The overall goal of this paper is to assess economic preparation for retirement in a way that takes into account many of these aspects.[1] We define a wealth replacement rate that shows the amount by which initial bequeathable wealth either exceeds or falls short of the amount needed to finance a lifetime consumption plan. The consumption plan begins at an observed starting value and follows a path whose shape is determined by observed consumption change with age in panel.

The resources are a combination of post-retirement income, housing wealth and nonhousing wealth. The replacement rates account for mortality, and, in the case of couples, the lifetime of the couple and the subsequent loss of returns-to-scale in consumption on the death of the first spouse. It recognizes that consumption need not be constant with age.

Our implementation is a combination of model-based simulations and data-based simulations. The advantage of this approach is that we can account for more economic factors than we could were the analysis completely model based.

2. Conceptual framework

Our starting point is optimal consumption planning over the lifetime. For illustrative purposes, suppose someone begins work at age 20 with zero wealth, and plans and executes an optimal life-cycle consumption path over his or her lifetime. Illustrative consumption and wealth paths are shown in Figure 1. Initially he or she consumes more than income. Thus, wealth (W) soon becomes negative. Eventually income increases, exceeding consumption (C) so that wealth begins to increase at about age 30. Saving continues and wealth becomes positive at about age 40. Consumption begins to decline when mortality risk becomes important. The worker retires at age *R* with maximum

[1] Work similar in spirit to this paper but very different in execution is VanDerhei (2006).

wealth and receives annuity A_t. He or she consumes until T when wealth is exhausted and then consumes A_t. These are the optimal consumption and wealth paths conditional on lifetime earnings and on annuities.

Now suppose that another person maintained the same consumption path but had lower income. Then the entire path of wealth would be lower as shown by the dotted line in Figure 2. At retirement the person would not be able to finance consumption until T but would exhaust wealth at about age 87. We would say that the observed consumption level at retirement is not optimal given the wealth and annuities at retirement.

This outcome is evidence for under saving: wealth is too low to maintain the consumption path associated with observed consumption following retirement. Said differently, given the level of income over the lifetime, this worker over-consumed. We will test for this by finding whether consumption shortly following retirement is consistent with an optimal path over the rest of the lifetime. Assuming that we know the shape of the optimal consumption path, we ask: in our data set how many persons can afford the optimal path associated with the observed consumption level at retirement? And by how much would the initial level of consumption have to change to keep the chance of the household will run out of wealth at the end of the life reasonably low?

3. Data

Our analyses are based on HRS data and data from the Consumption and Activities Mail Survey (CAMS). The HRS is a biennial panel. Its first wave was conducted in 1992. The target population was the cohorts born in 1931-1941 (Juster and Suzman, 1995). Additional cohorts were added in 1993 and 1998 so that in 2000 it represented the population from the cohorts of 1947 or earlier. In 2004 more new cohorts were added making the HRS representative of the population 51 or older.

In September, 2001, CAMS wave 1 was mailed to 5,000 households selected at random from households that participated in HRS 2000. In households with couples it was sent to one of the two spouses at random. The fact that the sample was drawn from the HRS 2000 population allows linking the CAMS data to the vast amount of information collected in prior waves in the core survey on the same individuals and households. In September, 2003, and in October 2005, CAMS wave 2 and wave 3 were sent to the same households.[2] The structure of the questionnaire was almost the same so as to facilitate panel analysis. In this paper we will use data from all three waves. Descriptive statistics of data quality are similar across waves. We will therefore restrict their discussion to the first wave of CAMS.

CAMS wave 1 consists of three parts. In Part A, the respondent is asked about the amount of time spent in each of 32 activities such as time spent watching TV or time spent preparing meals. Part B collects information on actual spending in each of 32 categories, as well as anticipated and recollected spending change at retirement (Hurd and Rohwedder, 2005). Part C asks about prescription drugs and current labor force status.

[2] CAMS 2005 included in addition a sub-sample of the newly added cohort of the Early Baby-Boomers that was first recruited into the HRS sample as part of the HRS 2004 core survey.

The instructions requested that for Part B the person most knowledgeable about the topics be involved in answering the questions. The addressee answered Part B in 88% of households, possibly with the assistance of the spouse; 5% of the cases report explicitly that the spouse answered the questions; 2% had their children or children-in-law of the addressee help out in answering the questions, and the remaining 5% was a mix of miscellaneous responses including nonresponse.

Of the 5,000 mailed-out questionnaires in 2001 there were 3,866 returned questionnaires giving a unit response rate of 77.3 percent. The second wave of CAMS had a unit response rate of 78.3 percent (not adjusted for mortality and undeliverable questionnaires).[3] To account for unit nonresponse, we use weights when calculating population averages.

The Consumer Expenditure Survey (CEX) is the survey in the U.S. that collects the most detailed and comprehensive information on total spending. But CAMS could not ask about spending in as many categories as the CEX, which in the recall component of the survey asks about approximately 260 categories. The design strategy adopted for CAMS was to choose spending categories starting from the CEX aggregate categories that are produced in CEX publications, so as to have direct comparability with the CEX. However, to reduce the burden to respondents the categories had to be aggregated further. The final questionnaire collected information on 6 big-ticket items (automobile; refrigerator; washer or dryer; dishwasher; television; computer) and on 26 non-durable spending categories.

The reference period for the big-ticket items is “last 12 months.” For the non-durables it varied: the respondent could choose the reference period between “amount spent monthly” and “amount spent yearly” for regularly occurring expenditures like mortgage, rent, utilities, insurance, property taxes where there is little or no variation in amounts, and “amount spent last week,” ” amount spent last month,” and “amount spent in last 12 months” for all other categories.[4] For all non-durable categories there was a box to tick if “no money spent on this in last 12 months.” The questionnaire had no explicit provision for “don’t know” or “refuse” so as not to invite item nonresponse.

Table 1 shows the spending categories and the rate of item response. Item response in CAMS is much higher than it is for typical financial variables such as the components of wealth or income where it can be as low as 60%. A consequence of the high response rates is that 54% of households in CAMS wave 1 were complete reporters over all 32 categories of spending. An additional 26% had just one or two nonresponse items. Ninety percent of the sample were complete reporters of 26 categories or more. Furthermore, in the spending categories with the highest rate of nonresponse, we have information from the HRS core that we can use for imputation. For example, rent has almost the highest rate of nonresponse. However, we have responses in the HRS about homeownership which we can use with considerable confidence to impute rent. Of the 512 who were nonrespondents to the rent query, 427 owned a home in HRS 2000. We believe we can confidently impute

[3] A total of 4,156 questionnaires were mailed out for the second wave of CAMS in 2003, resulting in 3,254 returned questionnaires. The remainder of the original sample was lost due to death (n=372), due to loss to follow-up (n=173), and some respondents (n=298) participated in another HRS supplemental study and were therefore excluded from CAMS wave 2.

[4] In CAMS wave 2 and 3 the “last week” option was eliminated to reduce the risk of observing outliers that arise from unusually high values reported as “last week” that are subsequently multiplied by 52 to arrive at annualized values.

zero rent to these households. Similarly among nonrespondents to the question about homeowners insurance and who owned a home with mortgage in 2000, 66% reported that their insurance was included in their mortgage payment. Apparently they did not respond in CAMS because they had already included that amount in the mortgage report.

Using the HRS core data we imputed (mostly zeros) for some households in up to 18 spending categories. The number of households imputed in a particular category ranged from just a few to 470. Based on these and similar imputations that use HRS core data to provide household-level information, 63.5% of CAMS respondents are complete reporters over all 32 categories of spending.[5]

A natural validation exercise for the spending data in CAMS is to compare them to the CEX. Table 2 has comparisons between spending in CAMS and spending in the CEX. The totals are almost identical among those 55-64, which is somewhat surprising in view of the great disparity in the number of spending items queried.[6] At older ages CAMS shows greater spending. There are at least three possible reasons for this difference: (1) Differences in the survey instruments, but this is unlikely because of the close agreement in the lowest age band. (2) The reference person. The CEX and the CPS interview one person in the household (the reference person) who answers for everyone in the household. The HRS interviews both spouses in the case of a couple. However, the very close agreement between HRS and CPS income suggests that using a reference person is unlikely to be the explanation. (3) Differential unit nonresponse with age. That is, higher consuming households do not respond to the CEX. Almost by elimination we come to this explanation. In addition it is clear that spending in the CEX in the highest age band is too low because, when compared with HRS or CPS income, it implies a high rate of saving.[7] Such a high rate of saving is not consistent with either theoretical predictions or with observed rates of change in wealth.[8]

We applied the same cleaning and imputation methods to all three waves of CAMS. Descriptive statistics of data quality are similar to those shown in wave one: item non response is just slightly lower in wave 2 and wave 3, while the overall unit response rate in wave 3 was lower (71 percent vs. 78 percent).

4. Methods

Our approach relies on simulating consumption paths over the remaining life cycle for a sample of households observed shortly after retirement. For this purpose we need the initial level of consumption, which we observe directly in the CAMS data, and

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[5] Because of the small amount of item nonresponse that remains we used simple imputation methods from the mean of the reported amount. See Hurd and Rohwedder (2005) for further details.

[6] A common view in survey methodology is that the more detailed are the categories, the higher the total will be. Thus we would expect that CEX totals would be substantially greater than CAMS totals.

[7] Income in the CEX is not reliable because it is only reported for "complete reporters;" that is, those who give answers to all income questions. Only starting with the 2004 data does the CEX impute missing values on income to produce statistics computed over the entire sample as opposed to just over complete reporters.

[8] Panel wealth change shows approximately constant wealth among couples until the oldest spouse reaches his/her 80s when wealth declines slowly. Among single persons, wealth declines after about age 70 at increasing rates with age. CEX spending when combined with HRS after-tax income would, in contradiction, predict steadily increasing wealth.

the slope of the consumption path which we estimate from observed panel transitions based on CAMS wave 1 to 2 and CAMS wave 2 to 3.

For the simulations we construct life-cycle consumption paths for each household: we begin with the observed consumption level at retirement age and then apply the observed rates of change to trace out a life-cycle path whose slope is given by the estimated rates of change. Whereas a model would specify that the slope of the consumption path depends on the interest rate, the subjective time-rate of discount, mortality risk and utility function parameters, we estimate these slopes directly from the data. Practically all model estimation uses the constant-relative-risk-aversion utility which specifies that the slope of log consumption is independent of the level. The observed paths do not necessarily have that shape and we do not impose that.

In this paper we propose two related methods for finding replacement rates: (a) wealth-based replacement rates; and (b) consumption-based replacement rates. We will start out by illustrating the approach for singles.

We observe the resources at retirement of a single person. We ask: can the resources support the projected consumption path. The consumption path is anchored at the initial post-retirement consumption level and follows the path given by the slopes of consumption paths that we have estimated from the CAMS panel. If the consumption path cannot be supported by the economic resources we find the level of bequeathable wealth that would permit the person to follow the optimal path. The wealth replacement rate is the ratio of actual wealth to this required wealth. If the replacement rate is greater than one, actual wealth is more than sufficient to finance the consumption path. If it is less than one, there is a wealth shortfall.

Because lifetime is uncertain, and wealth is not typically annuitized, we also find the resources that will permit the consumption path to be followed with a high degree of probability. Here the uncertainty is length of life, so the question is equivalent to finding whether the resources will sustain the path until advanced old age where the probability of survival is very small. Someone with a moderate level of pre-retirement consumption could sustain post-retirement consumption with a moderate level of Social Security benefits, some pension income and a moderate amount of wealth. Someone with low pre-retirement consumption may only need Social Security and a small amount of savings. These requirements are likely to differ substantially from what would be required to consume at the pre-retirement *income* level.

We do this calculation for each single person in our CAMS sample who is in his or her early retirement years.

For couples the basic method is similar. However, the consumption path followed while both spouses survive will differ from the consumption path of single persons, so it is separately estimated from the CAMS data. The couple will follow that consumption path as long as both spouses survive, and then the surviving spouse will switch to the consumption path of a single person. The shape of the single's path is estimated as described above, but the level of consumption by the surviving spouse will depend on returns-to-scale in consumption by the couple. At the death of the first spouse, the surviving spouse reduces consumption to the level specified by the returns-to-scale parameter. We assume a returns-to-scale parameter that is consistent with the literature and with practice. For example, the poverty line specifies that a couple with 1.26 times the income of a single person who is at the poverty line will also be at the poverty line.

This implies that consumption by the surviving spouse should be 79% of consumption by the couple to equate effective consumption.[9]

Knowing the consumption path of the surviving spouse we find the expected present value of consumption for the lifetime of the couple and surviving spouse. We compare population averages of the expected present value of consumption with average resources at retirement to find whether the cohort can finance the expected consumption path. We also determine the fraction of households that can finance with, say, 95% probability their expected consumption path, and by how much a household would have to adjust consumption to keep the chances of running out of wealth towards the end of the life cycle reasonably small.

5. Model for singles

In this section we develop the ideas discussed previously more formally. Suppose a single person retires at age R. Call that $t = 0$. He or she retires with real annuity S and nominal annuity P_0, the inflation rate is f, and the nominal interest rate F, which implies a real interest rate $r = F - f$. Then the real annuity at some later time t is $A_t = S_0 + \frac{P_0}{(1+f)^t}$. When the only source of uncertain is mortality risk and ignoring any bequest motive, a single person will choose optimal consumption to satisfy

(1) $$\frac{d \ln c_t}{dt} = \frac{1}{\gamma_t}(r - \rho - h_t)$$

as long as bequeathable wealth is positive, where γ_t is risk aversion (which in general need not be constant), r is the fixed real interest rate, ρ is the subjective time rate of discount, and h_t is mortality risk. Because h_t is approximately exponential, at some (relatively young) age consumption will decline with age. The consumption level will be determined by adjusting the consumption path so that at the age when consumption has declined to equal annuity income, bequeathable wealth is zero. If, in Figure 3, the area under the consumption path but above the annuity path were equal to initial bequeathable wealth, the consumption path would be optimal.

We construct the consumption path $\{c_t\}$ such that initial consumption, c_0, is given by observed consumption at or near retirement and the change in consumption from one period to the next, $\frac{\Delta c}{c}$, is observed in the CAMS panel data by age band. The situation is illustrated in Figure 3 for $R = 65$. Consumption will follow this path until consumption equals annuities, $c_T = A_T$. If the consumption path is optimal wealth will be zero at T and consumption will remain at the level of annuities at greater ages.

The present value of spending in excess of annuities is $PV_c = \sum_{t=1}^{T} \frac{c_t - A_t}{(1+r)^t}$. If PV_T equals initial wealth we say the consumption path is the "optimal" consumption path although the shape is not derived from any utility function. By this we mean that the

[9] We discuss later the sensitivity of our analysis to this returns-to-scale parameter.

level and shape are consistent with economic resources and spending change in panel data.[10]

We ask whether PV_c is less than or greater than initial wealth. If it is greater than initial bequeathable wealth, the optimal consumption path is not feasible. The wealth replacement ratio is $\frac{w}{PV_c} = \frac{\text{actual initial wealth}}{\text{necessary initial wealth}}$ and if the optimal consumption is feasible the wealth replacement rate is greater than 1.0.

We define a consumption replacement rate which is similar to the income replacement rate: what fraction of initial consumption can be afforded by economic resources? To find the consumption replacement rate we find $\hat{c}_0$ such that the consumption path $\{c_t(\hat{c}_0)\}$ with initial consumption $\hat{c}_0$ is optimal; that is, the associated wealth replacement ratio is 1.0. $\hat{c}_0$ is found by searching: given some initial guess c^* find PV_{c^*} of the associated consumption path. If $PV_{c^*} > w$ reduce c^* and search again until $PV_{c^*} = w$. Once we have found the optimal consumption $\hat{c}_0$ conditional on initial wealth we calculate the consumption replacement ratio

$$\frac{\hat{c}_0}{c_0}$$

If this ratio is less than 1.0 the person cannot afford the optimal consumption path.

Calculating the consumption replacement rate in this way ignores the fact that someone may die before exhausting wealth even if on an unsustainable consumption path. We can find the probability that someone survives to the age when wealth is exhausted by finding τ such that

$$\sum_{t=1}^{\tau} \frac{c_t(c_0) - A_t}{(1+r)^t} = w$$

τ is the age when wealth is exhausted. In a life table we find the probability of surviving to τ conditional on initial age R. This will give the probability of exhausting wealth before dying.

6. Model for Couples

The life-cycle model for couples is considerably more complicated. Under the same assumptions as for the singles model the first-order condition for consumption by a couple is

$$\frac{d \ln C_t}{dt} = \frac{1}{\gamma}(r - \rho - h_t) + \frac{1}{\gamma}\frac{\Omega_t}{C_t^{-\gamma}}$$

where $h_t =$ the couple's mortality risk (the probability density that one of them will die at t given that neither has died before t), C_t is consumption by the couple, γ is the risk aversion parameter in the couple's CRRA utility function, r is the fixed real interest rate, and ρ is the subjective time rate of discount of the couple. The last term accounts for

[10] The path which is illustrated in Figure 3 is similar to a path derived from the assumption of CRRA utility and estimated over wealth change data (Hurd, 1989).

“bequests” to the surviving spouse: Ω_t is the expected marginal utility of wealth should one of the spouses die. It is composed of two terms: the marginal utility of wealth of the widower weighted by the morality hazard of the wife and the marginal utility of wealth of the widow weighted by the mortality hazard of the husband. Ω_t varies from couple to couple according to the marginal utility of wealth of the survivor should one of the spouses die. The marginal utility of wealth of the survivor varies by the wealth of the couple (which the survivor will “inherit”), the mortality risk of the survivor, and the level of pension and Social Security benefits that the survivor will have. Predictions about the slope and level of the consumption path are complex because of Ω_t. But consumption should decline if both spouses are old because the marginal utility of wealth will be small for an old surviving spouse. The slope of the consumption path should be greater algebraically when one spouse is young because the marginal utility of wealth is large for a young spouse.

To find the predicted consumption path of a couple we begin with C_0, which is observed consumption by a couple at baseline. Then we project consumption to the next period by $C_{t+1} = C_t(1+G_t)$ where G_t is the annual growth rate of consumption by couples as estimated by age and education bands between waves 1 and 2, and between waves 2 and 3 of CAMS. The associated wealth path is $W_{t+1} = W_t(1+r) - C_t + A_t$ where r is an assumed real rate of interest. The couples model differs from the singles model in that one spouse will die before the other and the surviving spouse will continue to consume, but the consumption level will change according to returns-to-scale. Suppose the husband dies. Then the widow will “inherit” the wealth of the couple, an annuity which is some fraction f_a of A_t, and an optimal consumption level that reflects returns-to-scale. According to the poverty line, the widow would need 1/1.26 = 0.794 of the consumption of the couple; according to scaling of the wife’s and widow’s benefits in Social Security, the widow would need 1/1.5 = 0.667. From that point on the widow will follow the singles model taking as initial conditions the inherited wealth, the reduced annuities and the reduced consumption level.

Figure 4 has an example under the assumption that both spouses are initially 65 and that the husband dies at age 80. Initial wealth is 500. Prior to age 80 consumption by the couple follows $C_{t+1} = C_t(1+G_t)$. Consumption declines when the husband dies because of returns-to-scale, and then it follows the path of singles. In the case shown, the couple and surviving spouse could just exactly afford the initial consumption of 54.15. Should the widow survive to 94 or beyond, wealth would be exhausted.

Now suppose initial consumption is slightly greater at 55.5 as shown in Figure 5. Then the surviving spouse runs out of money at about 87. The present value of spending out of bequeathable wealth is given by the area between the consumption curve (both couple and widow) and the annuity curve (both couple and widow). In this case the excess present value of spending to age 94 is about 21.7 more than initial wealth so that the wealth shortfall rate is 21.7/500 = 4.3%.

The foregoing assumes widowing at 80, but we need to allow random widowing. Take the same couple where both are initially 65. Randomly choose whether both, one or neither spouse survives with probabilities given by life table survival hazards. If both survive continue calculating the couple's consumption and wealth path. If the husband dies, we switch to the widow's consumption and wealth path and follow that as in the case of a single. We find the expected present value of spending in excess of annuities. If the wife dies we perform the same calculation. If both die, we stop the calculations.

The outcomes of one simulation are: Did the household die with positive wealth? If so, how much compared with initial wealth. If not, what is the wealth shortfall?

By repeating the simulations a number of times for the same household we can find the probability that the household will die with positive wealth or negative wealth and the distribution of those excesses or shortfalls in wealth.

As described for the case of singles, we will also compute the consumption replacement rate for couples based on multiple simulations.

7. Differential Mortality

A large literature on the gradient between socioeconomic status (SES) and health documents that individuals with high SES such as high education live longer than those with low SES. Because households are not fully annuitized, long-lived households have to be prepared to finance consumption over a longer remaining time horizon. We take this into account in our simulations by applying survival probabilities that differentiate by education as well as by age, sex and marital status. Given the extended time horizon high SES households may also follow different consumption paths than low SES households. Economic theory predicts a flatter consumption path when mortality risk is lower. We therefore also stratify by education when estimating the consumption paths for singles and couples.

Estimation of differential mortality

We obtain our estimates of differential mortality based on seven waves of HRS data spanning the years 1992 to 2004. We estimate the probability of survival at time *t+1* conditional on being alive at time *t*, pooling the six transitions we observe in the HRS. The logit model yields the estimates shows in Table 3 for separate estimations for males and females as a function of age, marital status and education. For males the odds of survival between waves for college graduates is 79% higher than the odds of survival for high school dropouts. For both men and women the survival odds increase in education, but the profiles are different: for men there is a large gain from completing college, much larger than the gain for women.

From these estimates we construct survival curves by sex, marital status and education and normalize these to life tables so that the average survival probability given age and sex equals that given in the life tables. Figures 6 and 7 show the resulting survival curves for males and females.

Estimation of consumption path

Because survival differs by age, sex and education the slope of the consumption path should vary by those characteristics. Furthermore, there is no reason to impose the constancy of γ that would be required were we to base our estimation on wealth alone. Therefore we estimate the model

$$\frac{c_{t+1} - c_t}{c_t} = \alpha_i + \beta_j + \theta_k + u$$

where i indicates age category, j indicates education category and k indicates sex. We have four education categories: less than high school, high school, some college and college graduate. For singles we have five age categories 65-69, 70-74, 75-79, 80-84 and 85 or over. We observed 781 consumption transitions among singles 65 or older between the three waves of CAMS. For couples we have just four age categories because of small sample size in the top age category. But in addition we entered categorical variables for the age of the spouse. We observed 2817 consumption transitions among couples where both spouses were 62 or older. We estimated by median regression because observation error on consumption produces large outliers in the left-hand variable which makes OLS estimates unreliable.

Examples of fitted consumption paths for single women from these estimates are in Figure 8.[11] The paths are normalized at 100 at age 65. College graduates have much flatter consumption paths than those with less education where there is little difference. For comparison we have graphed the optimal consumption path based on CRRA utility where the path is generated by equation (1). We use mortality risk of women. Risk aversion, γ, is 1.12 which Hurd (1989) estimated on wealth change data in the RHS. In this simulation $r = \rho$. The paths generated by the CAMS consumption change are remarkably similar to the path generated by the model.

Figure 9 shows consumption paths of couples where both spouses are the same age. The most obvious difference from the consumption paths of single women is that consumption by couples shows much less decline. This is to be expected because the couples has a strong desire to leave wealth to a surviving spouse as reflected in substantial marginal utility of wealth to the survival spouse. There is little difference in the paths by education.[12]

8. Other sources of uncertainty

The model we have outlined only explicitly includes mortality risk. However, the estimates implicitly account for other uncertainties although they are not separately identified. To see this consider the second-order approximation to the first-order condition for lifetime utility maximization for singles when there is uncertainty (Carroll, 2001). It is

$$E(\Delta \ln c_t) = \delta_t - \frac{1}{\gamma_t} h_t + \frac{\gamma_t}{2} V(\Delta \ln c_t)$$

where $\Delta \ln c_t$ is the change in log consumption; h_t is mortality risk; γ_t is risk aversion (which in general need not be constant); δ_t is a combination of the (fixed) interest rate, the subjective time rate of discount and risk aversion, and $V(\Delta \ln c_t)$ is the variance in the change in the log of consumption. The expectation operator on $\Delta \ln c_t$ arises because when choosing consumption at time t an individual can only have an expectation about consumption at time $t+1$: for example, a large health shock may lead the individual to choose greater than average spending, or the lack of any shock at all may permit less than average spending.

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[11] The paths for single men are approximately the same as so we do not show them.
[12] Education is the education of the respondent to the CAMS survey

In the absence of uncertainty, the variance term is zero, and the consumption path will be downward sloping because h_t becomes large at old age. Spending will exceed income so that wealth will decline. With uncertainty the path is flattened and consumption must initially be reduced to meet the lifetime budget constraint. Therefore wealth will be decumulated at a slower rate. The resulting greater amount of wealth is buffer stock saving.

In our estimations $V(\Delta \ln c_t)$ is a left-out variable. Because our right-hand variables are categorical variables its effect on reducing the slope of the (downward sloping) consumption path will be absorbed into our estimated effects of those categorical variables. Thus, to the extent that individuals reduce initial consumption in the face of uncertainty our estimated consumption path will flattened. We do not, of course, separately identify any flattening due to uncertainty.

9. Results

Because we want to observe Social Security and pension income we select a sample shortly after retirement and of a sufficient age that they are likely to be receiving Social Security if they are eligible. We select couples where one spouse is 66, 67, 68 or 69, and the other is 62 or older; they were respondents in CAMS wave 1, 2 or 3; and they were a couple in the HRS surrounding waves. We make the age restriction on the younger spouse because spouses younger than 62 would not yet be receiving Social Security benefits and so we would miss a significant fraction of retirement resources. We select singles who were 66-69.

Table 4 gives the initial conditions for couples and Table 5 gives them for singles. The tables show the distributions of initial consumption, Social Security income, pension income, and annuity income (Social Security plus pension income). Note that these are population distributions of each variable. However, excess income is the difference between the quantiles of consumption and total annuity income. This is a better measure of the amount of consumption that will have to be financed out of wealth than the quantiles of excess income: households tend to occupy similar points on the distributions of consumption, annuity income and wealth whereas that is not the case with excess income. For example, the 25 percentile of excess income is -$17 thousand (not shown) which could be someone with considerable wealth. The last column is the distribution of total wealth which includes housing wealth.[13]

We can already see that on average and for most of the distribution, couples have adequate resources to finance their consumption in retirement. For example, average consumption is $42.0 thousand, average annuity income (Social Security + pensions) is $37.9 thousand leaving just $4.1 thousand per year to be financed out of wealth, which is $652 thousand. At the median the numbers are smaller but just $6.6 thousand per year needs to be financed out of $291 thousand of wealth. Even at the 25th percentile consumption is just $5.3 thousand more than income, so a small adjustment to spending or a small draw-down of wealth would permit consumption to be maintained.

The situation with singles is very different. At the mean wealth is adequate to finance excess spending, but at the median wealth could only finance about 10 years of

[13] Future work will make a distinction between housing and nonhousing wealth.

excess spending. At the 25th and 10th percentiles consumption would have to be reduced substantially from their initial low levels.

We perform 20 simulations of the consumption and wealth paths of each married person who is in the age range 66-69.[14] By consumption we mean the consumption by the couple as long as both spouses survive and also the consumption by the survivor. Although we begin with 757 households as shown in Table 4, we only have 924 married persons who are age eligible (66-69), the other spouses being outside the given age range. The economic circumstances of the 924 age-eligible persons will enter the tables. In these simulations we use the poverty line returns-to-scale and assume that the annuity of the survivor is 0.67 times the annuity of the couple.

The tables 6 and onward show the results of the simulations, incorporating differential mortality by education level and differential rates of consumption change by education level. Because we are interested in the fraction of individuals that runs out of resources at the end of the lifecycle we have arranged all subsequent tables at the individual level. They show the characteristics and results for 66-69 year olds living in couple households and in single households at baseline.

Table 6 shows that initial average wealth, the average present value of earnings and the average present value of annuities for couples total about $1.1 million. The present value of consumption is about $474 thousand so that average excess wealth is $669 thousand. At least on average couples are well prepared financially for retirement. The median of the household-level amount of excess wealth is about $324 thousand, indicating that the household of the median person is also well prepared. As would be expected, the measures increase strongly with education but even those with less than a high school education are at the median adequately prepared. In about 87% of the simulations, the surviving spouse dies with positive wealth.

For singles the results are much less optimistic (Table 7). Median excess wealth is just $74 thousand, and in the lowest education band it is essentially zero. In 68% of the simulations the single person dies with positive wealth.

Our individual-level metric for the probability of dying with positive wealth is based on the fraction of simulations for which an individual in a couple or a single person dies with positive wealth. In this metric we say that the individual is adequately prepared if the chances are 95% or greater. Table 8 shows that overall about 83% of married persons are adequately prepared. The average for males and females is the same, which is somewhat surprising because husbands typically die before wives, so that they are more likely to die before assets have been depleted. However, it should be kept in mind that there are 757 households in our sample, yet just 924 individuals. The implication is that in 77% of these households only one of the spouses meets our selection criteria for age, 66-69. Thus, the males and females generally come from different households which have different economic resources and have chosen different initial consumption levels.

Among singles about 64% are adequately prepared (Table 9). In the lowest education band only 43% of women are adequately prepared compared with 63% of men.

The preceding tables measured adequate preparation for retirement in terms of residual wealth at death. This measure does not distinguish whether the required adjustment to a household's consumption path is big or small relative to current

[14] We have also run previous versions with 100 simulations and results were closely comparable.

consumption. For example, a household with generous annuities, say of eighty thousand dollars per year, may have similar shortfalls in excess wealth as a household with very low annuity entitlements. Yet, the consumption floor that either of these households faces is very different and so are the welfare implications. If a household with a consumption level of 10 thousand dollars per year has to reduce consumption by a thousand dollars to keep the probability of running out of wealth sufficiently low this implies a drop in consumption of 10 percent at an already very low level of consumption. For a household with a consumption level of 80 thousand dollars per year a drop in consumption by a thousand dollars is equivalent to a drop of only 1.25 percent at a much higher level of consumption. Due to the concavity of the utility function the welfare loss for the latter household will be even smaller in comparison. In the next tables we will answer the question:

> *By how much does the household have to adjust initial consumption compared to current initial consumption to keep the probability of running out of wealth at the end of life below a desired threshold?*

This measure will reflect the changes to standard of living required for a household to achieve adequate preparation for retirement.

Table 10 shows that for all couples, the average affordable consumption is $98 thousand, yet average initial consumption is just $42 thousand. Thus on average couples could increase their consumption substantially. The average of the ratios of affordable consumption to initial consumption (mean ratios in the table) is 2.32, but this ratio is heavily influenced by the wealthy and/or those with very low initial consumption possible the result of measurement error. Even the median of the individual ratios of affordable consumption to actual consumption, which is relatively robust to measurement error, is 1.84.

Among singles, consumption could be increased on average at all education levels, but the median of the affordable consumption ratio in the lowest education band is just 1.02 (Table 11). This indicates that the typical person in that education band could just afford initial consumption in about half the simulations.

As with the wealth simulations we reported on earlier, we now put consumption shortfalls or excesses in a probabilistic framework. We say that an individual is inadequately prepared if initial consumption of the household would have to be reduced by 15 percent or more to keep the individual's chance of running out of wealth at 5 percent or less. Table 12 shows that for married persons about 88.6% are adequately prepared, and that females are slightly more likely to be prepared than men. Even among high school drop-outs about 81% are adequately prepared. Among singles (Table 13) the overall rate is 74%. An especially inadequately prepared group is females in the lowest education category: just 52% are adequately prepared.

Our definition of adequate preparation makes some ad hoc choices regarding the cut off points. It is not clear how small the chances of running out of wealth should be kept. We have presented results for a cut off of 5 percent or less, but some might argue that this could also be higher or possibly smaller. Similarly we have chosen a required reduction of initial consumption by 15 percent or more to signal inadequate preparedness. We have tested the sensitivity of our results with respect to these cut offs. Tables 14 and

15 show a matrix for couples and singles, respectively, with different cut off points. The results are not very sensitive to these definitions. The reason is that most households either fall substantially short of the thresholds of adequacy or they exceed them by a large margin, resulting in floor and ceiling effects in the statistics for preparedness.

Returns-to-scale

We performed sensitivity analyses to our assumption about returns-to-scale. Because our estimates of preparation for retirement by couples show that most couple are very well prepared we anticipated that the results would not be sensitive. In addition widowing occurs on average about 10 years after the start of the simulations so that the consumption level of the surviving spouse is discounted fairly heavily. We used two alternatives: the implicit returns-to-scale in the Social Security survivors benefit where the benefit of the surviving spouse is 2/3 of the couple's benefit, and the observed consumption change in the CAMS panel at widowing, which is close to the poverty line returns-to-scale. Both alternative returns-to-scale assumptions produced results that are similar to our main results.

Taxes

Taxes influence economic preparation for retirement via three routes. The first is federal and state tax paid on ordinary income such as earnings, capital income and pension income. The second is that Social Security income is only partially counted as taxable income and the fraction depends on the level of other taxable income and on the amount of Social Security income. The third is that withdrawals from tax-advantaged accounts such as IRAs are taxed. We have accounted for these taxes in a somewhat simplified manner, which, nonetheless addresses all of these elements.[15] Accounting for taxes reduces economic preparation for retirement among single persons from 74.1% as shown in Table 13 to 70.1% (not shown). The reason for this insensitivity to taxes is that economically vulnerable single persons pay little if any taxes. For example, the median tax rate among those in the lowest annuity income quartile (pension plus Social Security) is zero, and it is just 1% in the second annuity income quartile. Our estimates for couples are not yet available, but we expect a similar (small) effect.

10. Future research

Our method of assessing the adequacy of retirement resources involves comparing resources with spending levels and spending patterns that we observe in today's data. If spending requirements increase substantially faster than they have in the past, then resources *ex post* will look inadequate whereas *ex ante* they looked adequate. Out-of-pocket spending on health care is an obvious area where this could happen. Accounting for this would require the estimation of a model of consumption that includes health care expenses, and, most importantly, a sound method of forecasting what future health care expenses will be. Although the first type of model can be specified and possibly

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[15] We use standard deductions and estimate the relationship between federal and state income taxes for each household based on the NBER tax calculator, TAXSIM. We use this relationship to estimate state taxes.

estimated from current economic theory and data, the second type of model is, to say the least, a daunting task. However, as shown in Figure 10, we do not yet see any dramatic increase in the share of the budget of the retired population that is spent on health care. Among those 65-74, the share has remained fairly constant at approximately 10.5%. For those 75 or over there has possibly been an upward trend, although it is small: in 1989 the share was 14.8% and in 2004 it was 15.5%. The implication is that a model that relies on historical data on budget shares would not forecast any dramatic increase in spending on health care.

In addition, as we discussed earlier, our estimates of the slopes of the consumption paths include past increases in health care spending between 2001 and 2005, a period of high and increasing health care spending. Future health care spending would have to accelerate for our results to be inaccurate.

We have treated housing wealth in the same manner as nonhousing wealth. However, available evidence suggests that housing wealth is decumulated more slowly than nonhousing wealth. This is not an important issue as long as a household has nonhousing wealth to decumulate to maintain the desired consumption path. But if some households are reluctant to downsize or to otherwise monetize the value of their house they may be forced to deviate from their desired consumption path. In future work we will separate out housing wealth and develop trajectories of home equity.

11. Conclusions

We have found that on average those just past the usual retirement age are adequately prepared for retirement in that they will be able to follow a path of consumption that begins at their current level of consumption and then follows an age-pattern similar to that of current retirees. Among singles, that pattern is similar to what would be found from a theoretically derived and estimated life-cycle model based on a CRRA utility function and historical wealth change data. Thus we do not find inadequate preparation for retirement on average or even at the median. This is not true, however, for all groups in the population. In particular, singles lacking a high school education are likely to be forced to reduce consumption: some 43% would have had to reduce initial consumption by 15 percent or more to keep the probability of running out of wealth small (5 percent or less).

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Table 1
Item response rates (percent) in CAMS wave 1

Spending Category	
Big ticket item purchases	
Automobile or truck	96.4
Refrigerator	96.6
Washing machine/dryer	97.8
Dishwasher	97.7
Television	97.2
Computer	97.4
Payments	
Mortgage	92.2
Homeowner's or renter's insurance	88.7
Property tax	88.8
Rent	86.7
Electricity	92.4
Water	89.7
Heating fuel for the home	86.3
Telephone, cable, internet	93.9
Vehicle finance charges	86.2
Vehicle insurance	92.0
Health insurance	91.1
Spending	
Housekeeping, yard supplies	93.8
Home repairs and maintenance	93.9
Food and beverages	94.8
Dining/drinking out	94.8
Clothing and apparel	94.2
Gasoline	93.4
Vehicle maintenance	93.3
(Non-)Prescription medications	94.5
Health care services	93.7
Medical Supplies	92.1
Trips and Vacations	94.7
Tickets to movies, events etc.	95.0
Hobbies	94.2
Contributions	94.5
Cash or gifts to family/friends	94.2

Source: Authors’ calculations.

Table 2
Comparison of CAMS and CEX spending and pre-tax income comparisons (dollars in thousands)

	55-64	65-74	75 or over
Spending CAMS	39.6	35.5	29.6
Spending CEX	40.9	31.7	22.8
Income HRS	60.1	43.3	27.1
Income CEX	52.0	32.4	22.3
Income CPS	63.5	42.0	28.3

Notes: CEX and CPS income for year 2001; CEX income full reporters only; HRS income for year 2001; spending for CAMS and CEX October, 2000-September, 2001.
Sources: CAMS: Authors' calculations; CEX: various tables found at http://www.bls.gov/cex/home.htm#tables

Table 3: Logit estimates of differential mortality based on seven waves of HRS

	Males		Females	
Covariates	Odds ratio	P-value	Odds ratio	P-value
married	1.31	0	1.26	0
less than high school	--	--	--	--
high school	1.15	0.02	1.3	0
some college	1.18	0.02	1.46	0
college graduate	1.79	0	1.59	0

Reference group: single, less than high school
Source: Authors' calculations

Table 4
Initial conditions among couple households, thousands of 2004$
Number of households = 757

Percentile	Consumption	Social Security	Pension	Total annuity	Excess income	Wealth
10%	19.1	9.3	0.0	14.2	-4.9	34.6
25%	25.6	15.4	0.0	20.3	-5.3	114.8
50%	35.2	20.4	5.7	28.6	-6.6	290.9
75%	48.5	24.8	20.0	40.9	-7.6	617.8
90%	69.3	28.9	40.2	61.9	-7.5	1,304.8
Mean	42.0	20.3	17.6	37.9	-4.1	652.3

Source: Authors' calculations.

Table 5
Initial conditions among single household, thousands of 2004$
N = 478

Percentile	Consumption	Social Security	Pension	Total annuity	Excess income	Wealth
10%	9.9	4.1	0.0	5.4	-4.4	0.0
25%	14.6	7.3	0.0	8.7	-5.9	11.3
50%	21.6	10.5	0.0	12.4	-9.2	87.2
75%	29.9	13.2	7.0	19.8	-10.0	276.1
90%	40.9	16.0	17.6	30.0	-10.9	594.1
Mean	24.6	10.3	5.8	16.1	-8.5	205.5

Source: Authors' calculations.

Table 6
Married persons, initial wealth, present value of earnings, annuities, and consumption, and excess wealth, (thousands 2004$)

	N	percent positive	mean initial wealth	mean PV of future earnings	mean PV annuities	mean PV consumption	mean excess wealth	median excess wealth
< high-school	165	79.8	220.8	19.6	248.5	278.8	210.1	137.2
High-school	406	86.2	437.4	23.5	406.4	394.1	473.3	271.8
Some college	175	91.8	1021.3	35.8	494.4	536.0	1015.4	413.6
College	178	91.1	1253.1	89.3	633.3	778.0	1197.7	700.0
All	924	87.1	666.5	37.8	438.6	474.3	668.5	324.0

Source: Authors' calculations.
Note: PV = present value

Table 7
Single persons, initial wealth, present value of earnings, annuities, and consumption, and excess wealth, (thousands 2004$)

	N	percent positive	mean initial wealth	mean PV of future earnings	mean PV annuities	mean PV consumption	mean excess wealth	median excess wealth
< high-school	129	52.2	51.3	8.6	102.9	154.7	8.1	2.1
High-school	188	73.8	202.7	15.3	182.9	210.5	190.3	90.7
Some college	98	73.9	274.4	26.7	190.9	256.8	235.3	152.6
College	63	76.1	422.6	33.1	274.6	413.5	316.8	202.6
All	478	68.3	205.5	18.2	175.0	231.7	167.0	74.4

Source: Authors' calculations.
Note: PV = present value

Table 8
Percent of married persons adequately prepared: 95 to 100 percent chance of dying with positive wealth

	N	All	Males	Females
Less than high-school	165	75.8	76.6	75.0
High-school	406	82.0	82.4	81.8
Some college	175	86.9	77.9	92.5
College and above	178	88.8	90.2	87.2
All	924	83.1	82.3	83.7

Source: Authors' calculations.

Table 9
Percent of single persons adequately prepared:
95 to 100 percent chance of dying with positive wealth

	N	All	Males	Females
Less than high-school	129	47.3	63.0	43.1
High-school	188	71.8	70.0	72.5
Some college	98	70.4	68.2	71.1
College and above	63	66.7	56.3	70.2
All	478	64.2	66.1	63.6

Source: Authors' calculations

Table 10
Married persons, initial consumption and affordable consumption, thousands 2004$

	N	mean initial wealth	mean PV of future earnings	mean PV annuities	Mean initial consump-tion	Mean affordable consump-tion	Mean Ratio: affordable / initial consump-tion	Median ratio: affordable/ initial consump-tion
< high-school	165	220.8	19.6	248.7	29.7	50.8	1.94	1.57
High-school	406	437.4	23.5	406.8	37.3	80.7	2.32	1.81
Some college	175	1,021.30	35.8	495.1	49.2	135.4	2.54	1.95
College and above	178	1,253.10	89.3	634.3	59.1	146.6	2.46	2.20
All	924	666.5	37.8	439.1	42.4	98.4	2.32	1.84

Source: Authors' calculations

Table 11
Single persons, initial consumption and affordable consumption, thousands 2004$

	N	mean initial wealth	mean PV of future earnings	mean PV annuities	Mean initial consump-tion	Mean affordable consump-tion	Mean Ratio: affordable / initial consump-tion	Median ratio: affordable/ initial consump-tion
< high-school	129	51.3	8.6	102.9	18.9	23.8	2.00	1.02
High-school	188	202.7	15.3	182.9	23.5	54.1	2.33	1.58
Some college	98	274.4	26.7	190.9	26.8	62.1	2.41	1.82
College and above	63	422.6	33.1	274.6	36.5	80.1	2.23	1.58
All	478	205.5	18.2	175.0	24.6	51.0	2.24	1.46

Source: Authors' calculations

Table 12
Percent of married persons adequately prepared
Chances are 5 percent or less that household would need to reduce consumption by more than 15 percent

	N	All	Males	Females
Less than high-school	165	80.6	80.5	80.7
High-school	406	87.7	87.2	88.0
Some college	175	94.9	91.2	97.2
College and above	178	92.1	92.4	91.9
All	924	88.6	87.8	89.2

Source: Authors' calculations

Table 13
Percent of single persons adequately prepared.
Chances are 5 percent or less that household would need to reduce consumption by more than 15 percent

	N	All	Males	Females
Less than high-school	129	56.6	74.1	52.0
High-school	188	81.4	78.0	82.6
Some college	98	80.6	86.4	78.9
College and above	63	77.8	68.8	80.9
All	478	74.1	77.4	73.0

Source: Authors' calculations

Table 14
Percent of married persons adequately prepared;
Chances are x percent or less that household would need to reduce consumption by more than y percent
Number of persons = 924

	Drop in consumption		
Chances	< 5 percent	< 10 percent	< 15 percent
<=5 percent	85.0	87.0	88.6
<=10 percent	85.5	87.4	89.2
<=15 percent	85.6	87.9	89.4
<=20 percent	85.7	88.2	89.8

Source: Authors' calculations

Table 15
Percent of single persons adequately prepared
Chances are x percent or less that household would need to reduce consumption
by more than y percent
Number of persons = 478

	Drop in consumption		
Chances	< 5 percent	< 10 percent	< 15 percent
<=5 percent	67.6	70.9	74.1
<=10 percent	67.6	71.3	74.3
<=15 percent	68.2	71.5	74.5
<=20 percent	68.2	72.0	74.7

Source: Authors' calculations

Figure 1

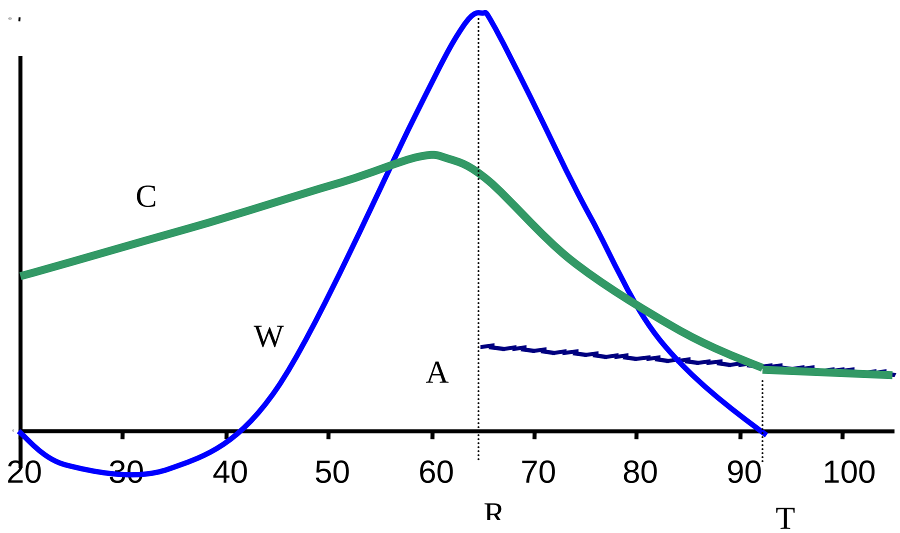
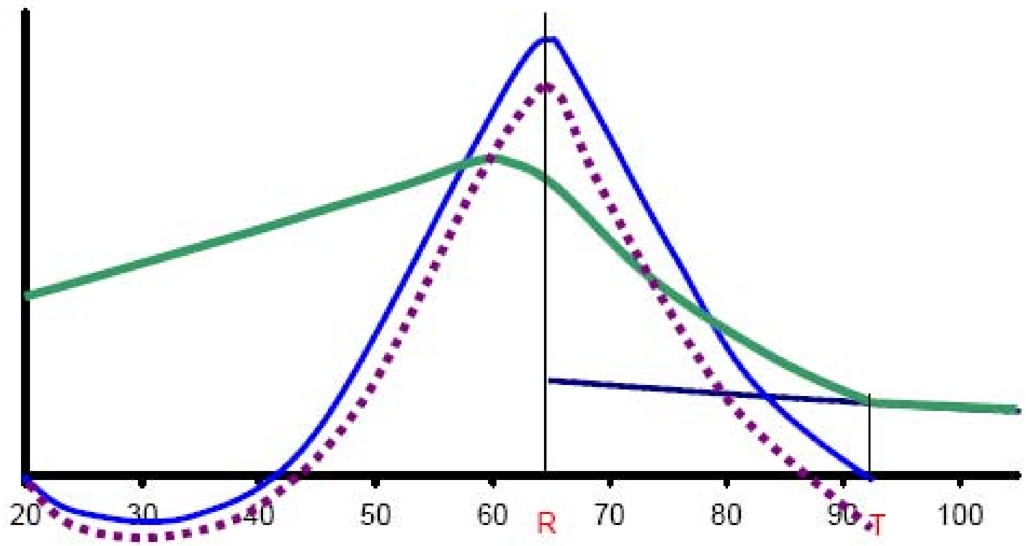


Figure 2



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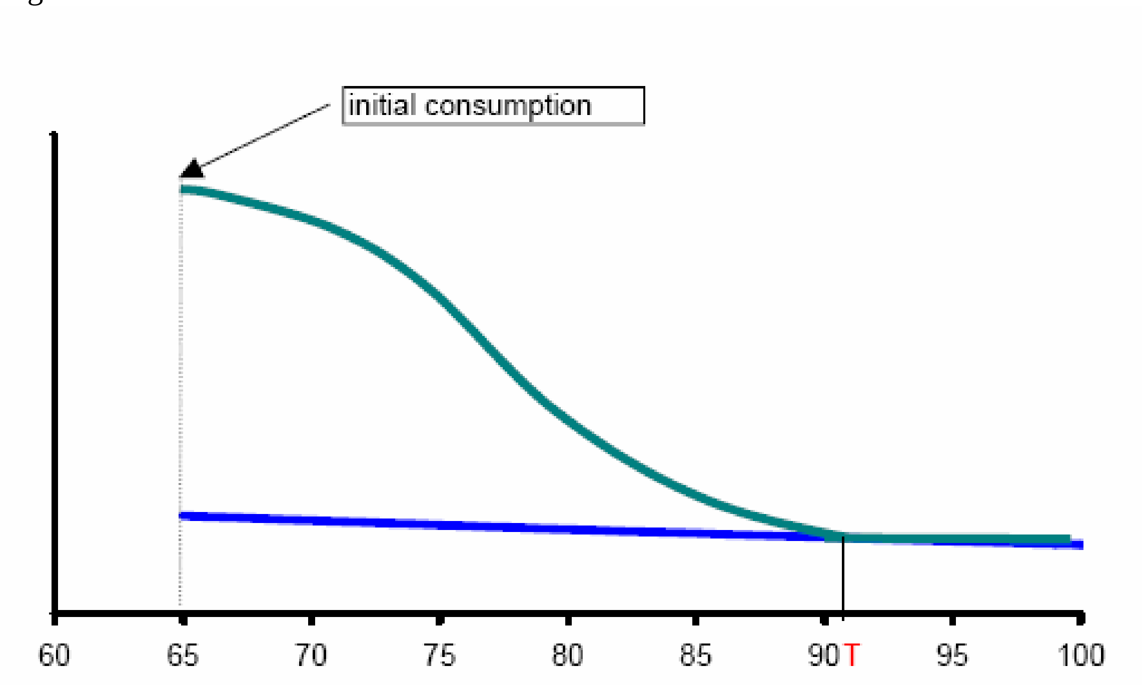

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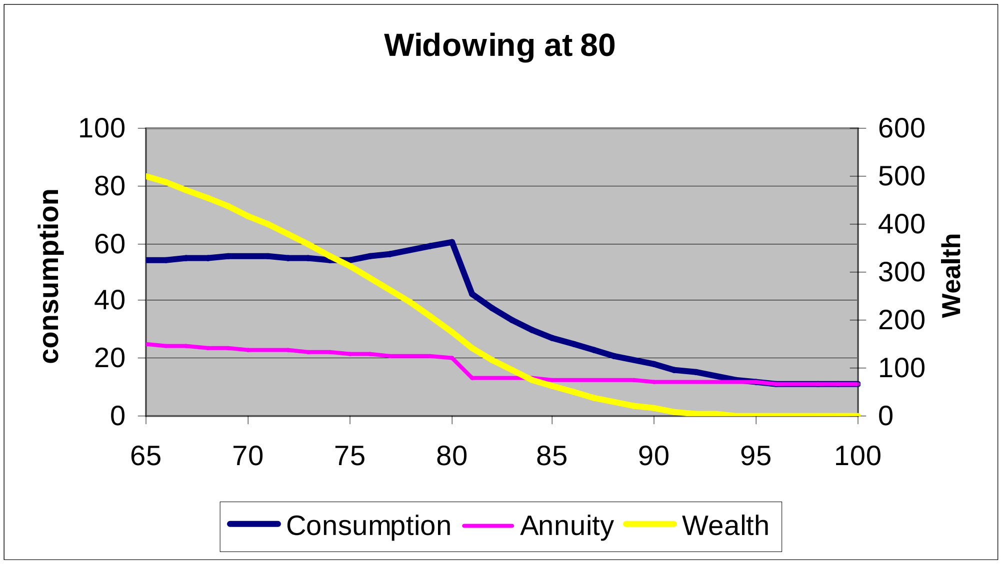


Figure 5

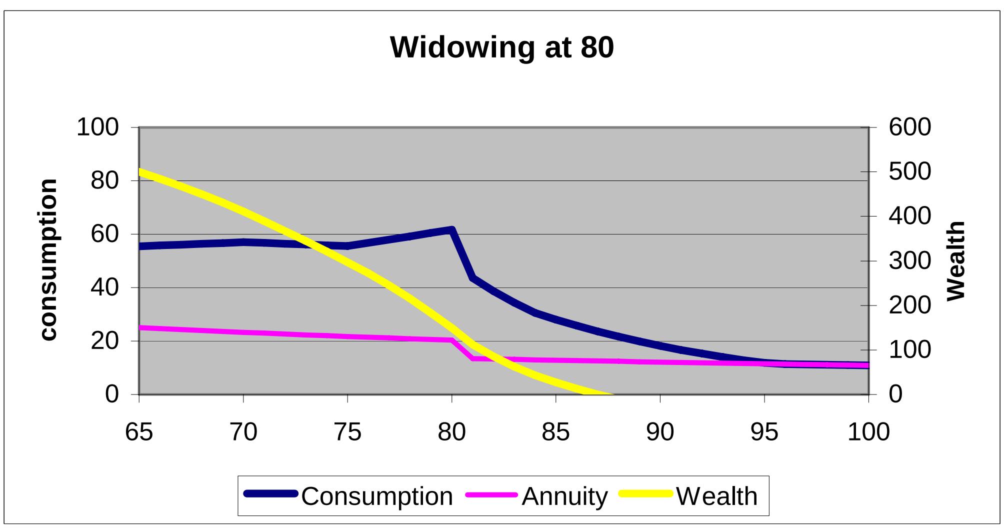
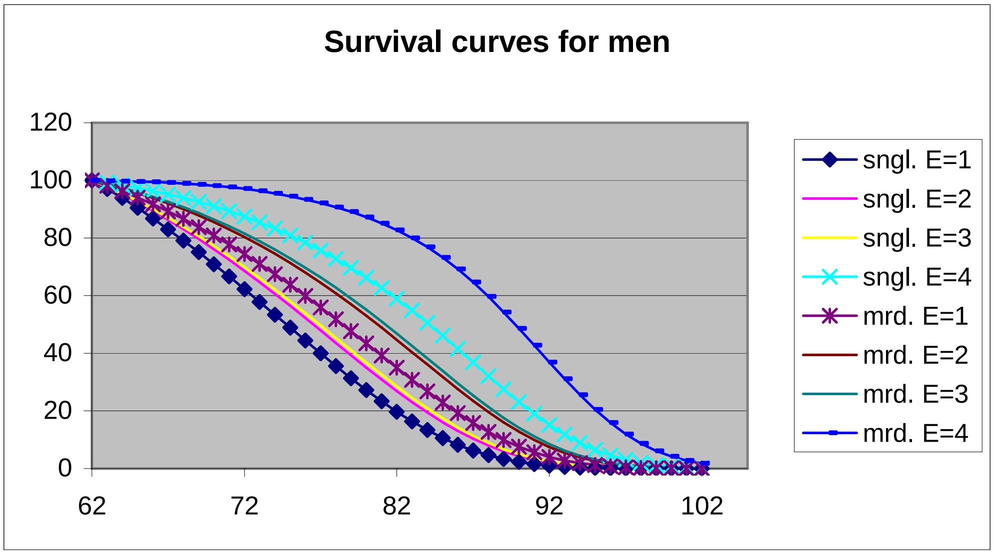


Figure 6



sngl. = single
mrd = married/partnered
E=1 : less than high school
E=2 : high school or GED
E=3 : some college
E=4 : college or more

Figure 7:

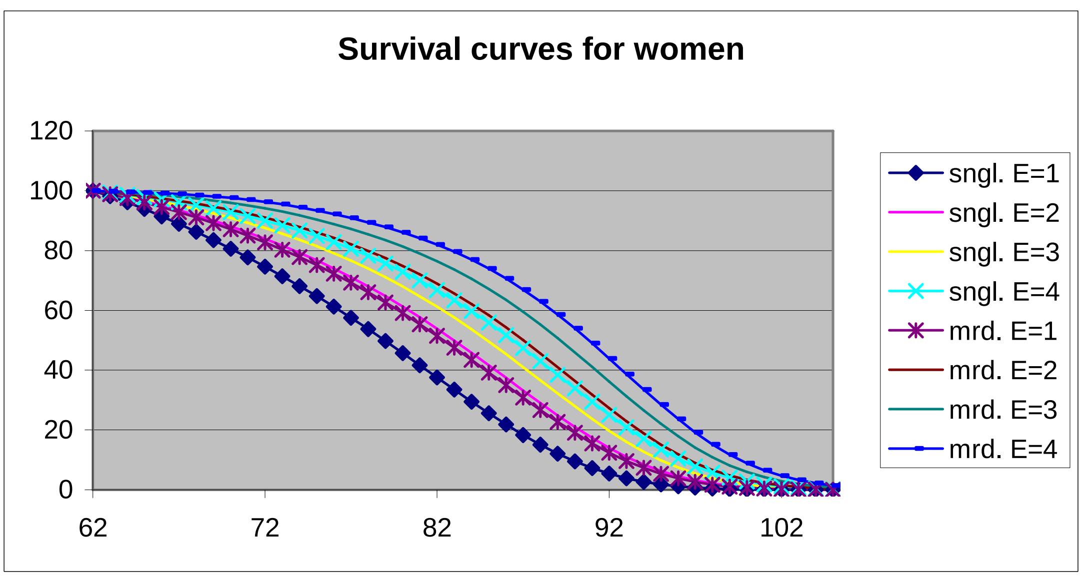


Figure 8

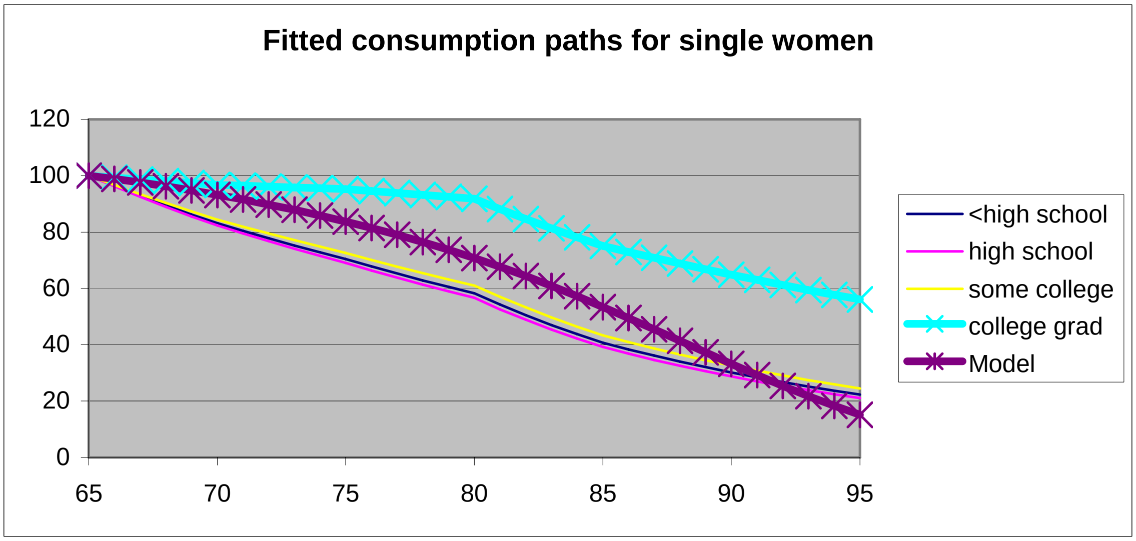


Figure 9

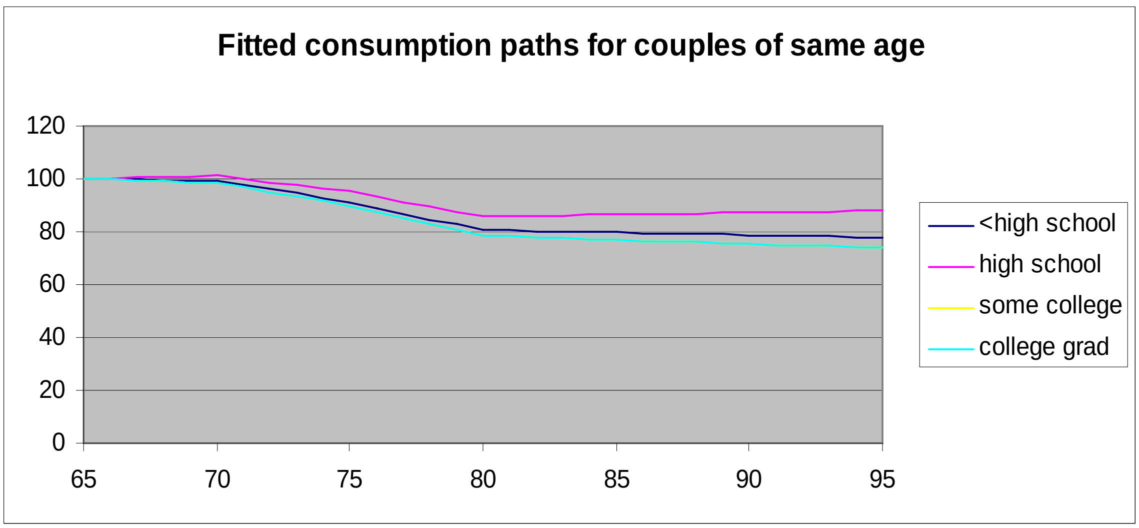
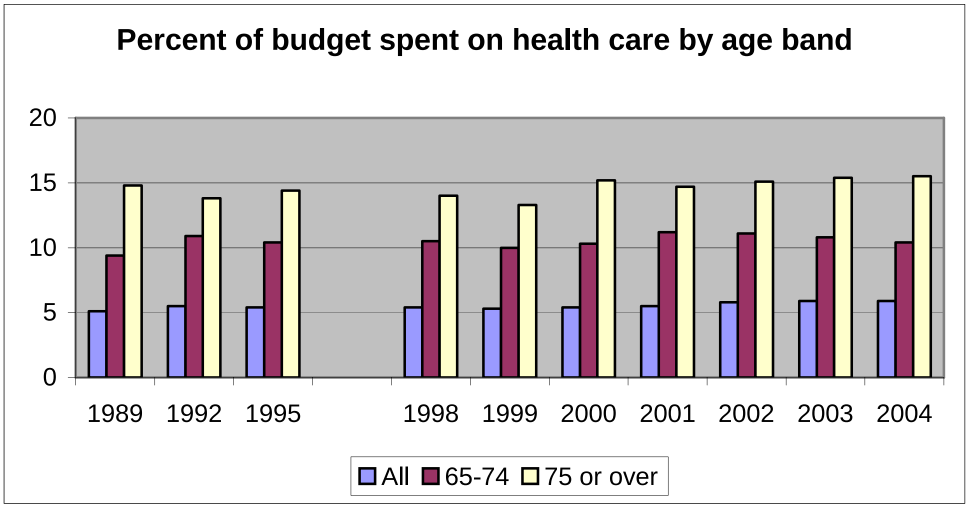


Figure 10



Source: Consumer Expenditure Survey, various tables found at http://www.bls.gov/cex/home.htm#tables