

**IMPLICATIONS OF EXPANDED  
ANNUITIZATION FOR  
OLD-AGE WELL-BEING**

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## SUMMARY

This document presents a framework for evaluating the effects of more widespread annuitization of wealth in retirement. We attempt to quantify the implications for old-age consumption of the annuitization of defined contribution (DC) plan balances and individual retirement account (IRA) assets. Following a model developed and estimated by Michael Hurd in his 1989 *Econometrica* article on "Mortality Risk and Bequests," we solve for optimal consumption paths of unmarried retirees. Next, we counterfactually assume that DC/IRA balances are annuitized. We then re-optimize consumption paths and compare the resulting patterns to the baseline. Data for this exercise come from the 1992-2010 Health and Retirement Study (HRS).

Annuitization removes liquid wealth and replaces it with lifelong-guaranteed income. We therefore hypothesize that annuitization can raise consumption in old age and can reduce old-age poverty. Our results are consistent with that hypothesis and are generally plausible and intuitive. We consider both nominal and real annuities and found larger reductions in old-age poverty from real annuities. Annuitization is predicted to also enhance general satisfaction with retirement and boost lifetime utility. While these results hold for the vast majority of sample members, a small number of individuals who wish to leave a bequest became worse off under full annuitization. Even they, though, could benefit from partial annuitization.

The analysis is based on a theoretical model with fairly restrictive assumptions and that is applicable to unmarried people only. Given this narrow focus, we do not intend for our results to be extrapolated to the U.S. population of retirees. That said, the analysis plausibly demonstrates that certain retirees can benefit from increased annuitization. The current trend away from defined benefit (DB) to DC pensions implies a de-annuitization of retirement resources, which risks additional old-age poverty in the future. Increased annuitization of DC and IRA balances appears to have the potential to mitigate those risks.

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## 1. INTRODUCTION

The transition from defined benefit (DB) to defined contribution (DC) pension plans has enabled employers to better manage benefit costs and expanded the portability of benefits to workers who change jobs. However, the transition from DB to DC plans has also introduced challenges for workers/retirees and for policymakers.

DB and DC plans offer different types of protection against poverty in old age. DB pensions pay a lifelong annuity to the retired worker and typically also to his or her surviving widow(er). DC plans that are annuitized offer very similar protection. However, most DC balances are not annuitized. The beneficiary typically draws down the balance to cover living expenses. If he or she lives to an advanced age, the funds may be exhausted.<sup>1</sup> For married couples, this longevity risk falls predominantly on the longest-living spouse, assuming that the balance is bequeathed to the surviving spouse upon the death of the beneficiary. By definition, widows have outlived their spouses and are older, on average, than married individuals. Widows are thus particularly vulnerable to exhausting their DC balance and other savings. In other words, the longevity risks that DC plans impose on workers are most likely to manifest itself in increased widowhood poverty.

Longevity risks apply when DC plan participants live longer than they expected, but the opposite scenario also raises issues. Should they (and their spouse) die sooner than expected, the remaining DC account balance is generally bequeathed and not used for consumption during retirement. In other words, retirees who die at a relatively young age under-consumed. Also, from a public policy perspective, retirement resources leak from the system, i.e., no benefits accrued from a portion of the tax subsidies granted to generate retirement savings.

Annuitization of DC balances may be viewed as a longevity insurance mechanism that captures surpluses arising from early mortality and applies them to deficits associated with late mortality. Separately, it shifts post-retirement investment risks from retirees to the insurance companies that provide annuities. The insurance companies may be better equipped to manage investment and longevity risks and enjoy economies of scale that individual retirees/investors do not.

Despite the apparent benefits of annuitization, most retirees do not currently annuitize their DC plan balance (e.g., Brien and Panis, 2011). The literature offers a number of explanations—high prices due to adverse selection, existing annuitization through Social Security, a desire to meet future medical or other large expenses, a desire to leave a bequest, the risk of outliving the insurance company, et cetera (e.g., Brown 2008). Several recent papers have attempted to design approaches to make annuitization more palatable to retirees (e.g., Beshears et al., 2014). The current document does not address annuity market issues, instead focusing on only the potential benefits of increased annuitization.

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<sup>1</sup> Unexpectedly low rates of return can have similar effects, but this report does not focus on investment risks.

Based on a model in which utility during retirement is derived from consumption and from leaving a bequest, we use data from the Health and Retirement Study (HRS) to simulate the baseline optimal consumption and asset decumulation paths of recent retirees. Those paths depend on DC plan balances, other sources of initial wealth, lifelong-guaranteed income from Social Security and private DB pensions, and other factors. We then counterfactually assume that retirees annuitize the balances of their DC plans and individual retirement accounts (IRAs)—thus lowering their bequeathable wealth and increasing their annuity income—and re-simulate consumption and wealth paths. Finally, we compute old-age poverty, retirement satisfaction, and other aggregate metrics, and compare those outcomes for the baseline and annuitization scenarios to demonstrate the likely effects of increased annuitization.

Even though our analysis is grounded in empirical data, its findings are not readily extrapolated to the entire U.S. population. The economic model applies to unmarried retirees only, so that most of the analysis excludes married couples and delays inclusion of HRS respondents until they become widowed.<sup>2</sup> The analysis sample therefore represents only a subset of retirees and the counterfactual annuitization of DC and IRA balances of married couples is assumed to take place when one spouse becomes deceased, rather than around the time of retirement. Instead, our objective is to illustrate and demonstrate the benefits that retirees may experience from greater annuitization. Also, we abstract from re-marriage, re-entering the workforce, moving in with adult children, and other behaviors that may relate to the economic well-being of retirees.

The remainder of this report is organized as follows. Section 2 summarizes related prior literature. Section 3 discusses our utility model and estimates. Section 4 presents the empirical data. Section 5 discusses results from the simulations, considers an alternative annuitization, and explores sensitivity issues. Section 6 concludes.

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<sup>2</sup> Few authors have attempted to empirically model annuitization by couples. Among the exceptions is Brown and Poterba (2000).

## 2. LITERATURE

### *Theoretical Considerations of Annuitization*

In his seminal paper, Yaari (1965) demonstrated that under a certain set of stylized conditions, an individual seeking to maximize utility in retirement would allocate 100% of his or her assets into annuities. Paraphrasing Davidoff, Brown, and Diamond (2005), a comparison of two securities can provide intuition: Consider a one-year bank certificate of deposit paying a certain interest rate and a security that—like an annuity—pays a higher interest rate at the end of the year conditional on living and nothing if you die before year-end. If you attach no value to wealth after death, then the second alternative is a dominant asset.

The assumptions used in Yaari (1965) were relaxed in subsequent papers, including Bernheim (1987) and Davidoff, Brown, and Diamond (2005). Despite these findings, most retirees do not currently annuitize their DC plan balance. A large portion of the annuities literature following Yaari (1965) have attempted to offer explanations, including high prices due to adverse selection, existing annuitization through Social Security, a desire to meet future medical or other large expenses, a desire to leave a bequest, the risk of outliving the insurance company, et cetera (e.g., Brown 2008). The current paper does not attempt to contribute to the conversation of why individuals are not annuitizing their wealth. Instead, it attempts to add to the discussion on how a policy of promoting annuitization would affect individual retirement outcomes.

### *Conversion of Lump Sums to Annuities*

In order to simulate retirement outcomes under increased annuitization, it is necessary to make certain assumptions about how DC balances would translate to annuity payments. These assumptions are similar to ones that have been made with respect to valuing single-premium life annuities at retirement. Perhaps the most frequently encountered framework for doing so is the Expected Present Discounted Value (EPDV) framework, otherwise known as the “actuarially fair” price of an annuity. This framework is used in the “money’s worth” ratio popularized in Mitchell et al. (1999) and other subsequent papers in the literature. The EPDV valuation framework depends on assumptions regarding the payout amounts available in the private market, mortality rates, and interest rates. A discussion regarding the prevalence of these assumptions in the annuities literature follows.

With respect to interest rate assumptions, the primary distinction lies in the choice of a flat term structure reflecting a steady-state interest rate, versus a time-varying term structure based on publicly-available yield curves. Among papers that have made the assumption of a flat term structure, there are differences with respect to the assumed interest rate. Brown (2003) assumes a 3% real interest rate with a 3 percent inflation rate. Love et al. (2007) assume an interest rate of 2.5% with a 2% inflation rate. Based on the Social Security Administration’s estimate of the steady state interest rate in 2004, Gustman and Steinmeier (2009) use a real interest rate of 3% and a 2.8% inflation rate. On the other hand, papers beginning from Warshawsky (1988) and Mitchell et al. (1999) have calculated the EPDV framework

by testing results against yield curves ranging from Treasury risk-free bonds to corporate bonds at the low end of investment grade.

Mortality assumptions also vary in the annuity valuation literature. The first and most important distinction is the difference between the mortality of the general population and the mortality of annuity purchasers. Because annuity purchasers on average have lower mortality rates (Brown 2008), there will be systematic differences between the two mortality tables. For the purposes of this study, which focuses on individuals who have not annuitized their DC balances, the general population mortality tables may be more appropriate. Another assumption with regards to the selection of mortality tables is the differentiation between period and cohort tables. While the former presents mortality probabilities in a given year in time, the latter constructs mortality probabilities for population cohorts by birth year. The latter is also more appropriate for valuing annuities, given the fact that cohort tables are able to account for improvements in mortality rates over time (Brown et al., 2001). The Social Security Administration (SSA) provides recent sets of mortality period and cohort tables, which were published in 2012. However, these tables do not provide mortality probabilities by demographic group, a potentially important source of variation which is addressed by Brown, Liebman and Pollet (2002) and Brown (2003), who create their own mortality tables based on the National Longitudinal Mortality Study (NLMS). Relatedly, Gong and Webb (2008) found that a significant minority would perceive themselves as suffering a net loss from mandatory annuitization because they expected to die sooner than lifetables suggested.

Annuities can similarly be valued using an expected utility framework, as seen in Mitchell et al. (1999), Brown (2003), and others. Under this framework, uncertainty and risk aversion is incorporated into the calculation; a dollar under risk-free conditions is worth more to an individual than an expected dollar with any level of uncertainty. Given an assumption about the nature of the risk aversion, several authors have computed an "Annuity Equivalent Wealth", a measure of the amount that an individual would have to be compensated if access to annuity markets were closed.

In actuality, individuals are seldom able to purchase actuarially fair annuities in the annuities market given the implicit tradeoff of longevity risk insurance, the heterogeneous nature of the population, and the administrative costs associated with annuitization. Brown, Mitchell, and Poterba (2002) use data from historical *A.M. Best* publications and data published in *Annuity Shopper* to calculate the money's worth ratio, a ratio of the actuarially fair price of annuities to the empirical market premium. They find that the money's worth ratio lies between 80 and 90 cents per premium dollar for randomly selected individuals in the US population, and between 90 and 100 cents for the average annuitant. The results found in more up-to-date *Annuity Shopper* data used in Poterba et al (2011) and Brien and Panis (2011) roughly corroborate these findings.

### ***Retirement Outcomes of DC vs. DB plans***

While the immediate goal of this study is to simulate the consequences of annuitizing DC and IRA balances, the broader context is an inquiry into retirement outcome differences between DC and DB retirement plans. One of the primary differences between the two plan types is the discretionary nature of the decumulation process of DC plans, as opposed to the annuity-style payouts of DB plans. Some DB plans

also offer the option of a lump sum distribution. Hurd and Panis (2006) find that in such plans, the rate of cash-outs is highest among individuals with low-value plans and low-wealth holdings.

Using the HRS, Panis (2004) demonstrates that retirees with lifelong-guaranteed income (from a DB plan or privately-purchased annuities, but not Social Security) generally experienced higher satisfaction than their counterparts who did not have such income. The disparity in satisfaction increases over the duration of retirement, suggesting that the anxiety over longevity risk becomes more relevant to a retiree during the later years of retirement.

In terms of plan generosity, Poterba et al. (2007) found that private sector DB plans tend to yield lower average retirement wealth accumulation than private DC plans, although they are less likely to generate very low retirement wealth outcomes. The results additionally suggest that although private DC plans also tend to generate higher retirement wealth outcomes than public sector DB plans, the outcomes are relatively volatile with respect to historical equity returns, which may make the DB plan the preferred choice for risk-averse individuals. In a similar vein, Butrica et al. (2009) use a microsimulation model to estimate how freezing DB pension plans and replacing them with DC plans would affect retirement outcomes. They determine that of the individuals who had their DB plans replaced by a DC plan, 26% of the population analyzed (last-wave baby boomers) would have lower incomes at age 67, compared with 11% ending up with higher incomes.

### 3. MODEL AND ESTIMATES

#### Theory

Following Hurd (1989), we assume that retirees maximize their lifetime utility  $\Omega$ :

$$\Omega = \int U(c_t)e^{-\rho t}a_t dt + \int V(w_t)e^{-\rho t}m_t dt,$$

where the first term represents utility from consumption and the second term utility from the knowledge of leaving a bequest. Utility from consumption at time  $t$  is  $U(c_t)$ , discounted by  $e^{-\rho t}$  for time preference  $\rho$ , discounted by the probability of surviving to time  $t$ ,  $a_t$ , and summed over time from the current time ( $t=0$ ) through the highest possible age ( $t=N$ ). Utility from the knowledge of leaving a bequest at time  $t$  is  $V(w_t)$ , discounted by  $e^{-\rho t}$  for time preference  $\rho$ , weighted by the probability of dying at time  $t$ ,  $m_t$ , and summed over time from the current time ( $t=0$ ) through the highest possible age ( $t=N$ ).

Retirees maximize this lifetime utility subject to the budget constraint that wealth cannot become negative:

$$w_t = w_0 e^{rt} + \int_{s=0}^t (A_s - c_s) e^{(t-s)r} ds \geq 0,$$

where  $w_0$  is initial wealth at  $t=0$ ,  $A_s$  is lifelong-guaranteed income at time  $s$ , and  $r$  is the expected real interest rate.

The model applies to only unmarried retirees, not to couples and not to working individuals. The only source of uncertainty is the date of death. The probability of mortality is assumed to be exogenous and varies by only age and sex. The maximum age to which people can live is known and fixed. Lifelong-guaranteed income may stem from Social Security, DB pensions, or privately purchased annuities. Future values of lifelong-guaranteed income flows are equal to their initial values, adjusted for expected inflation. Retirees maximize their remaining lifetime utility  $\Omega$  by optimizing over their consumption path  $\{c_t\}$ . Given that consumption path, their wealth path  $\{w_t\}$  is known.

Utility from consumption is assumed to exhibit constant relative risk aversion. In part to aid in the identification of the bequest motive, we assume that individuals without living children do not have a bequest motive ( $V(w_t) = 0$ ); others enjoy utility from bequests that is linear in wealth at the time of dying. For retirees with children, lifetime utility is therefore:

$$\Omega = \int \frac{c_t^{1-\gamma}}{1-\gamma} e^{-\rho t} a_t dt + \int \alpha w_t e^{-\rho t} m_t dt,$$

where  $\gamma$  and  $\alpha$  represents relative risk aversion and strength of the bequest motive, respectively. For our purposes and throughout this document, it makes no difference whether the person has one or more living children; any non-zero number of children imply a bequest motive. Key behavioral model parameters are time preference ( $\rho$ ), risk aversion ( $\gamma$ ), and bequest motive ( $\alpha$ ).

Hurd (1989) derived the solution to the utility maximization problem. Without a bequest motive, individuals will choose their consumption path such that they fully exhaust their wealth at the end of possible life. With a bequest motive, they may consume less and derive utility from the knowledge of leaving a bequest. Their consumption path will be flatter and it will take longer to exhaust their wealth than without a bequest motive. Depending on the initial conditions, wealth may increase during the early retirement years. Given sufficiently high initial wealth, the bequest motive may inhibit consumption to the point where wealth will never be exhausted. Under that scenario, the budget constraint is never binding and at any time  $t$  the marginal utility from consuming an extra dollar ( $\partial U(c_t)/c_t = c_t^{-\gamma}$ ) is equal to the marginal utility from saving that dollar and eventually bequeathing it:

$$c_t^{-\gamma} a_t = \alpha \int_t^N e^{(r-\rho)(s-t)} m_s ds$$

This relationship readily solves for consumption path  $\{c_t\}$  and thus wealth path  $\{w_t\}$ . If initial wealth is so high that terminal wealth  $w_N$  is positive, the individual is a “high-wealth” individual. However, most individuals, even those with substantial financial resources, will at some time exhaust their wealth if they remain alive to the highest possible age  $N$ . Denote the time at which their wealth reaches zero by  $T$ . After time  $T$ , wealth is zero and consumption is equal to annuity income,  $c_t = A_t$ . Before time  $T$ , the budget constraint is binding and the first order conditions imply:

$$c_t^{-\gamma} a_t = c_{t+h}^{-\gamma} a_{t+h} e^{h(r-\rho)} + \alpha \int_t^{t+h} e^{(s-t)(r-\rho)} m_s ds,$$

where  $h$  denotes any time interval such that wealth is not exhausted at time  $t+h$ . This relationship pins down the intertemporal pattern of consumption. The combination of this intertemporal pattern and the fact that consumption drops to annuity income when wealth is depleted,  $c_T = A_T$ , identifies the entire consumption path. We find  $T$  numerically such that the optimal consumption path implies a wealth path that is exhausted precisely at time  $T$  (which need not be integer-valued).<sup>3</sup> Survey respondents whose consumption path resolves this way are “low-wealth” cases.

Some individuals are neither high-wealth nor low-wealth. Their initial wealth does not support the high-wealth consumption pattern, while their wealth is not exhausted for any  $T < N$ . The consumption path of these “medium-wealth” individuals is found numerically by choosing initial consumption such that the path, dictated by the intertemporal pattern specific above, implies wealth depletion at time  $T$ .

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<sup>3</sup> In practice, we set the highest possible age at 110 years. Suppose a female retiree becomes widowed and enters our model at age 74, so that the optimization period spans 36 years ( $N=36$ ). We numerically find the time at which wealth is exhausted,  $T$ , by looping over integers from 0 to 36, each time finding the optimal consumption path and the resulting wealth path and checking whether wealth at time  $T$  is exhausted. If it was not exhausted at, say,  $T=16$ , but exhausted at  $T=17$ , we numerically search between 16 and 17 to determine  $T$  and the consumption path that exhausts wealth at precisely  $T$ .

In sum, individuals with children may be low-wealth, medium-wealth, or high-wealth. Individual without children will aim to consume their entire wealth and may be low-wealth or medium-wealth only. Their consumption path must satisfy the intertemporal pattern shown above, but without the term that involves  $\alpha$ .

### *Illustrative Consumption Paths*

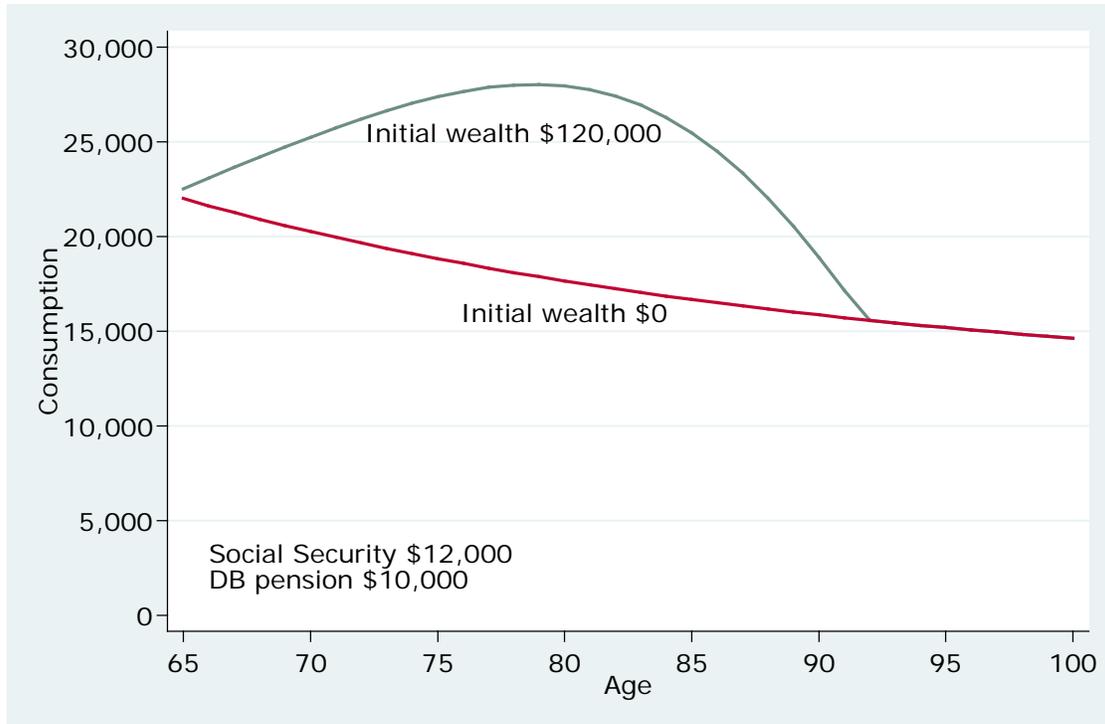
We now illustrate some typical consumption paths. Figure 1 shows a low-wealth case of someone with \$12,000 in annual Social Security benefits and \$10,000 in DB pension benefits. This retiree has children and thus a bequest motive. Throughout, we assume that Social Security income is adjusted for inflation and that pension income is constant in nominal dollars.<sup>4</sup> The top line assumes initial wealth of \$120,000. At first the initial wealth permits the retiree to consume more than her Social Security and pension income. Consumption increases until age 79 and then decreases. This hump-shaped pattern is the result of a trade-off between the interest rate (net of time preference) and mortality risks: so long as the interest rate exceeds time preference by more than the mortality hazard (risk of dying conditional on being alive), consumption increases.<sup>5</sup> Since mortality rates increase with age, eventually  $r - \rho < m_t/a_t$ , and thus eventually consumption will decline. Wealth is exhausted by age 92, after which consumption equals inflation-adjusted income.

The bottom line in Figure 1 represents the same scenario, but without any initial wealth. In our stylized model, the fact that this retiree allowed her wealth to be depleted implies that her bequest motive is too weak to save out of Social Security and pension income. Consumption is therefore equal to income once wealth is exhausted. It decreases over time because inflation erodes the person's pension income.

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<sup>4</sup> All figures and tables in this document express monetary values in 2010 dollars. Following Hurd (1989) and Hurd and Panis (2004) we adopt an expected interest rate of 3% and expected inflation of 3.8%.

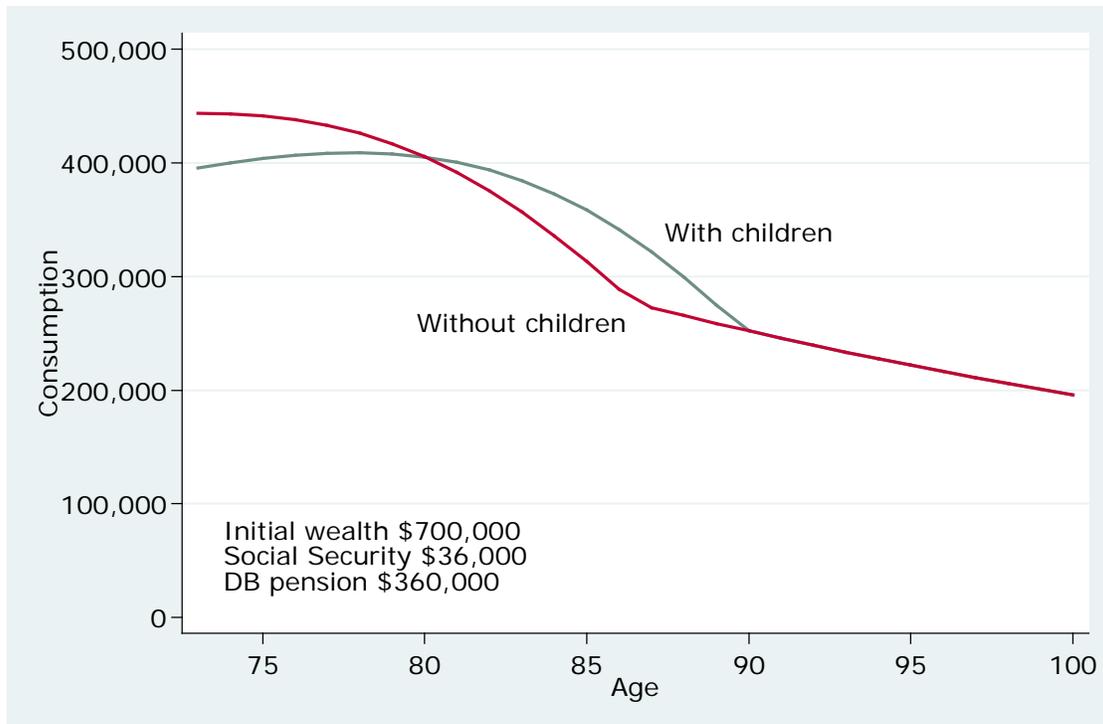
<sup>5</sup> If the rate of time preference is greater than the interest rate, as is often assumed, consumption will monotonically decrease with age. Most simulations in this report are based on a near-zero time preference from non-linear two-stage least squares estimates of Hurd (1989)—see Table 1 below. While that magnitude may seem implausible, only the difference between interest rate and time preference is identified in the model. Key for the hump-shaped consumption pattern in Figure 1 is that the rate of time preference is estimated to be smaller than the interest rate, and that their difference exceeds the conditional mortality risk at some ages.



**Figure 1. Illustrative Consumption Paths for Low-Wealth Individuals with and without Initial Wealth**

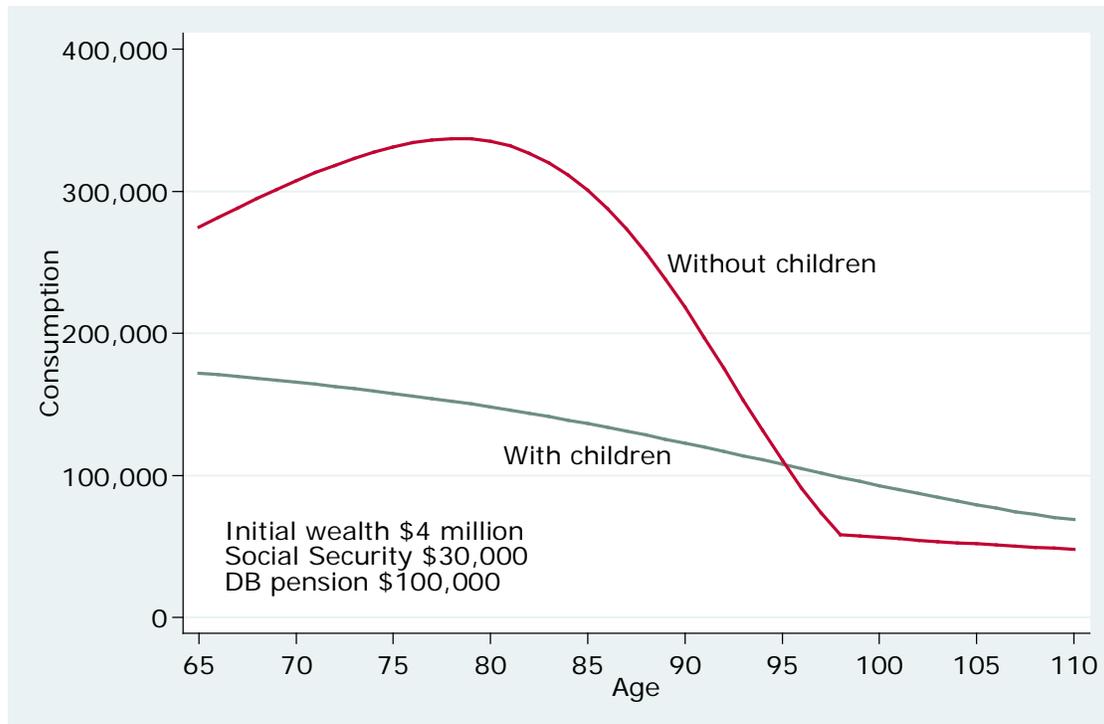
Figure 1 and similar figures below depict consumption streams through age 100 to illustrate the level of consumption for someone who lives through that age. For clarity, there is no assumption that people live through age 100, or 110, or any other age; instead, sample members are assumed to be subject to prevailing mortality rates.

Figure 2 also shows two low-wealth scenarios, differing by whether the retiree had living children and thus a bequest motive. As discussed at Table 1 below, the bequest motive in our model is estimated to be weak. In order to visually show the effects of a bequest motive, we therefore select an individual with substantial wealth and income. (The scenarios are “low-wealth” only in the technical sense that wealth will be exhausted prior to age 110.) This individual has initial wealth of \$700,000, Social Security (or other inflation-protected) income of \$36,000, and DB pension income of \$360,000. The consumption path with children starts lower and is flatter than that without children, signaling a desire to leave a bequest. By age 90, his wealth is depleted and consumption at higher ages becomes equal to income from Social Security and DB pensions. Without children, wealth depletes about three years earlier. It may seem counter-intuitive that a person with children would ever consume more than the same person without children, but the consumption trajectories necessarily cross as the person with children attempts to postpone the moment at which savings are exhausted.



**Figure 2. Illustrative Consumption Path for Low-Wealth Individuals with and without Children**

The curve labeled “With children” in Figure 3 shows the consumption path of a high-wealth retired widow with children. Her initial wealth is \$4 million, her Social Security benefits \$30,000, and her DB pension benefits \$100,000 per year. This person is “high-wealth” because her wealth will never become depleted. The consumption profile is dictated by the trade-off between utility from consumption and from leaving a bequest. So long as initial wealth is sufficiently high, the consumption path is not affected by initial wealth. For example, if initial wealth were higher than \$4 million, the consumption path would not change; any additional wealth would be bequeathed. However, if this person did not have a bequest motive, she would attempt to spend down her wealth. Consumption would initially be substantially higher than with children. Wealth would be exhausted by age 98 and consumption after that age would be equal to Social Security and DB pension income. Since wealth becomes depleted at some time, this person is now considered a “low-wealth” case, even though initial wealth and income are the same as for the high-wealth case with children. The distinction between low-wealth and high-wealth is thus based on the algorithm that solves for optimal consumption path, not on any threshold values of wealth or income.



**Figure 3. Illustrative Consumption Path for High-Wealth Individual with Children and Low-Wealth Individual without Children**

### *Model Estimates*

The model discussed above was developed by Hurd (1989) and also used by Hurd and Panis (2004). Instead of estimating the model parameters, we adopt prior estimates. Hurd (1989) produced non-linear least squares (NLLS) and non-linear two-stage least squares (NL2SLS) estimates based on the 1969-1979 Retirement History Survey (RHS); Hurd and Panis (2004) applied NL2SLS to the 1992-2000 Health and Retirement Study (HRS).

Table 1 presents prior model parameter estimates. The risk aversion and time preference parameters estimated by Hurd (1989) are strongly significant, but the bequest motive parameter is not. Hurd (1989) argued that the bequest motive estimate implies that the desire to leave bequests is also economically weak. Indeed, simulations of optimal consumption paths with and without children show only small adjustments to children, except for wealthy individuals (such as those depicted in Figure 2 and Figure 3). For our main analysis, we adopted the NL2SLS estimates of Hurd (1989), and separately explore the sensitivity of our results to the model parameter estimates.

**Table 1. Parameter Estimates**

	Hurd (1989)		Hurd and Panis (2004)
	NLLS	NL2SLS	NL2SLS*
Risk aversion $\gamma$	0.729 (0.091)	1.12 (0.074)	1.4614
Time preference $\rho$	0.0501 (0.004)	-0.011 (0.002)	-0.006298
Bequest motive $\alpha$	$5.0 \times 10^{-7}$ ( $1 \times 10^{-4}$ )	$6.0 \times 10^{-7}$ ( $32 \times 10^{-7}$ )	$1.7253 \times 10^{-7}$

Standard errors in parentheses.

\* Hurd and Panis (2004) did not estimate standard errors.

As indicated above, the model does not support independent estimates of the interest rate and the time rate of preference; only their difference is identified. The estimates in Table 1 assumed an interest rate of 3% and two out of three optimization algorithms found a slightly negative time preference. Our belief is that the time rate of preference is generally positive, which would be consistent with a higher interest rate. In the context of this model, the interest rate is an expected rate of return; it is possible that survey respondents expected a much higher rate of return than 3%.

## 4. DATA

We simulate optimal consumption paths for respondents in the 1992-2010 HRS.<sup>6</sup> The HRS is a biennial survey of Americans over the age of 50, and their spouses. It collects extensive information about financial resources, health, and other topics.

Given the focus of the theoretical model on unmarried retired individuals, we identify HRS respondents when they (1) are unmarried, (2) report being completely retired, (3) receive Old-Age, Survivors, or Disability Insurance (OASDI) benefits, and (4) are at least 60 years old. We include them in the analysis sample as of the first HRS wave in which they meet the above criteria. However, (5) if in a future wave they report receiving benefits from a DB pension or a privately purchased annuity, we include them as of the first wave in which they receive such benefits. Finally, given our focus on the effects of annuitizing a DC plan or IRA balance, (6) we restrict the sample to individuals with a DC plan or IRA.

While the HRS is a longitudinal survey, our analysis sample includes only a single wave for each respondent. That wave provides the initial conditions from which future consumption paths are simulated. The sample includes individuals with a range of ages. For example, if someone becomes widowed at age 78, he or she is included as of the first HRS wave after becoming widowed and the simulations of optimal consumption paths run from that age to age 110. This has implications for the interpretation of our results, as discussed in the next section.

The total sample consists of 1,912 individuals; 1,358 women (71%) and 554 men (29%). The skewed sex ratio mostly reflects the fact that wives tend to live longer than husbands; the sample included 1,006 widows and only 333 widowers. Most (88%) had one or more living children and are thus assumed to derive utility from leaving bequests.

Table 2 shows the age distribution of respondents in our analysis sample. Approximately one-half of respondents enter the sample between age 65 and 74; some enter at a younger age, and as much as 6% did not become eligible until age 85 or older.

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<sup>6</sup> We thank Alan Gustman, Thomas Steinmeier, and Nahid Tabatabai (2014) for making cleaned pension variables available and Sandy Chien, Nancy Campbell, Orla Hayden, Michael Hurd, Regan Main, Josh Mallett, Craig Martin, Erik Meijer, Michael Moldoff, Susann Rohwedder, and Patricia St.Clair (2014) for preparing the RAND HRS file.

**Table 2. Age Distribution of the Analysis Sample**

Age	Freq.	Percent
60-64	354	18.5%
65-69	469	24.5%
70-74	497	26.0%
75-79	268	14.0%
80-84	213	11.1%
85+	111	5.8%
Total	1,912	100.0%

Source: HRS analysis sample.

Table 3 presents summary statistics of initial wealth and income from Social Security and DB pensions, converted into 2010 dollars. By design, all sample members own a DC plan or IRA and all are receiving Social Security benefits. The median DC/IRA balance is \$46,873 and the median value of other wealth is \$249,073.<sup>7</sup> These figures imply that our sample is relatively wealthy. For example, the median wealth (DC/IRA balances plus other wealth) is roughly seven times as high as the median wealth of individuals without a DC plan or IRA balance who meet all other criteria for inclusion.

**Table 3. Summary Statistics of Initial Wealth and Income**

	Min	Median	Mean	Std. dev.	Max
DC/IRA balances	24	46,873	116,135	243,872	4,950,661
Other wealth	0	249,073	474,785	965,200	23,257,143
OASDI benefits	12	13,660	13,556	5,694	48,000
DB pensions, annuities	0	5,091	16,377	132,430	5,401,560

Source: HRS analysis sample. All figures converted to 2010 dollars.

Most respondents in the analysis sample (69%) are receiving benefits from a DB pension or private annuity. The median benefit is \$5,091 per year over the entire sample and \$10,947 for those with a DB plan or private annuity (not shown).

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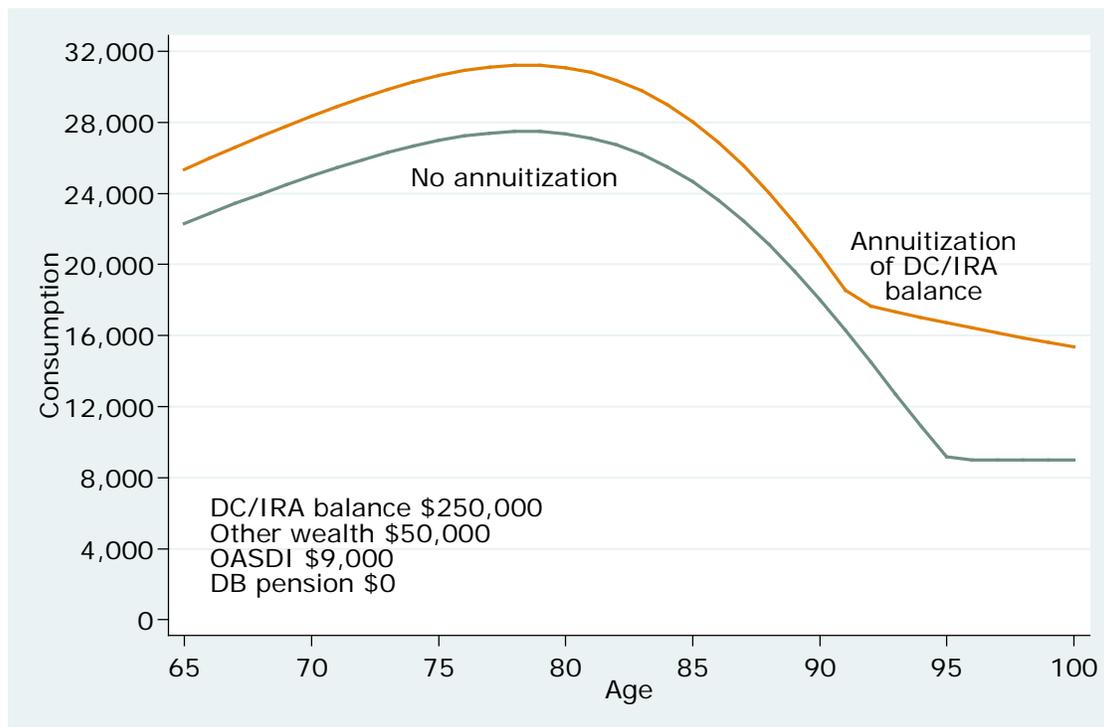
<sup>7</sup> Other wealth includes the value of financial assets, real estate, businesses, and vehicles, net of mortgages and other debt.

## 5. ANALYSIS AND DISCUSSION

This section discusses the results of simulating optimal consumption paths based on actual (“baseline”) wealth and income and on an alternative scenario in which all DC and IRA balances are annuitized when the respondent enters the analysis sample. The annuitization is conducted with actuarially fair, sex-specific annuity prices, and the annuity is assumed to be constant in nominal dollars, unless specified otherwise.

### *Conversion of DC/IRA Balances into Nominal Annuities*

In the baseline scenario, DC/IRA balances are combined with other forms of wealth and treated interchangeably.<sup>8</sup> Figure 4 illustrates typical consumption paths under the baseline and annuitization scenarios. This retiree is female, is 65 years old, and has children. She starts with a DC/IRA balance of \$250,000, other wealth of \$50,000, Social Security benefits of \$9,000 per year, and no DB pension. Without annuitization, her consumption rises until age 78 and then drops off; after her wealth is exhausted at age 95, her consumption equals her Social Security benefits. See the curve labeled “No annuitization” in Figure 4.

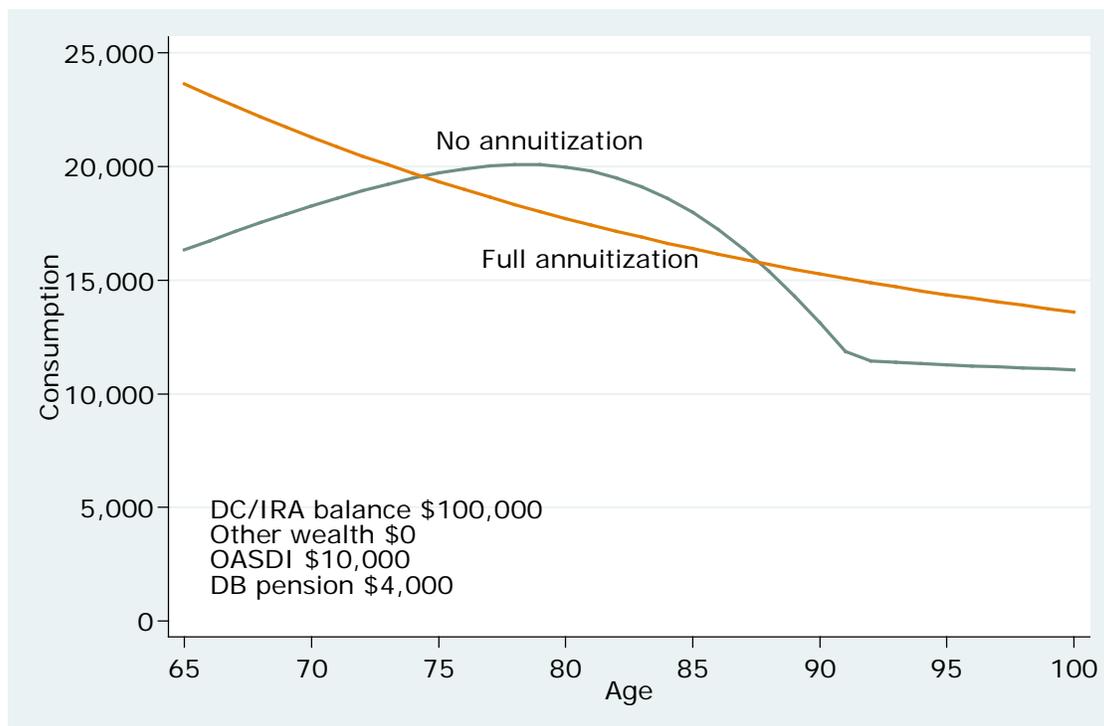


**Figure 4. Illustrative Consumption Paths with and without Annuitization of DC/IRA Balances**

<sup>8</sup> We ignore taxation of DC/IRA withdrawals. This simplification may not be realistic for retirees with substantial financial resources, but the practical implications for retirees at risk for old-age poverty are likely minor. The practical implications are even smaller when comparing consumption with and without annuitization, since we also ignore taxation of annuity income generated by converted DC/IRA balances.

At actuarially fair prices, sex-specific mortality rates, and a nominal interest rate of 6.8% (real interest plus inflation) the retiree can convert her DC/IRA balance of \$250,000 into a nominal annuity of about \$24,100, giving her a total income of \$33,100 at age 65 (and less in future years because of inflation). The model predicts that she will initially save some of that income. Even so, the annuitization sustains a consumption that is higher at all ages than without annuitization. Her wealth is exhausted at age 92, after which her consumption equals the sum of Social Security benefits and the inflation-adjusted annuity. Bequeathable wealth is lower and depletes sooner with annuitization than without, but her subsequent income from Social Security plus annuitized DC/IRA balances is substantially higher than consumption without annuitization. Whether her higher consumption translates into higher utility depends on the strength of her bequest motive.

Figure 5 shows another illustration of consumption paths without and with annuitization. This retiree is again female, is 65 years old, and has children. She has a DC/IRA balance of \$100,000, has no other wealth, annually receives \$10,000 from Social Security, and has a nominal \$4,000 annual DB pension. Without annuitization, her consumption rises through age 78 and subsequently falls until her wealth is depleted at age 92. With annuitization of her DC/IRA balance (i.e., of her entire wealth holdings), wealth is immediately exhausted and consumption is always equal to her combined income from Social Security, DB pension, and annuitized DC plan or IRA. That income supports consumption that is at first higher, then lower, and after age 88 higher again than under the baseline scenario.

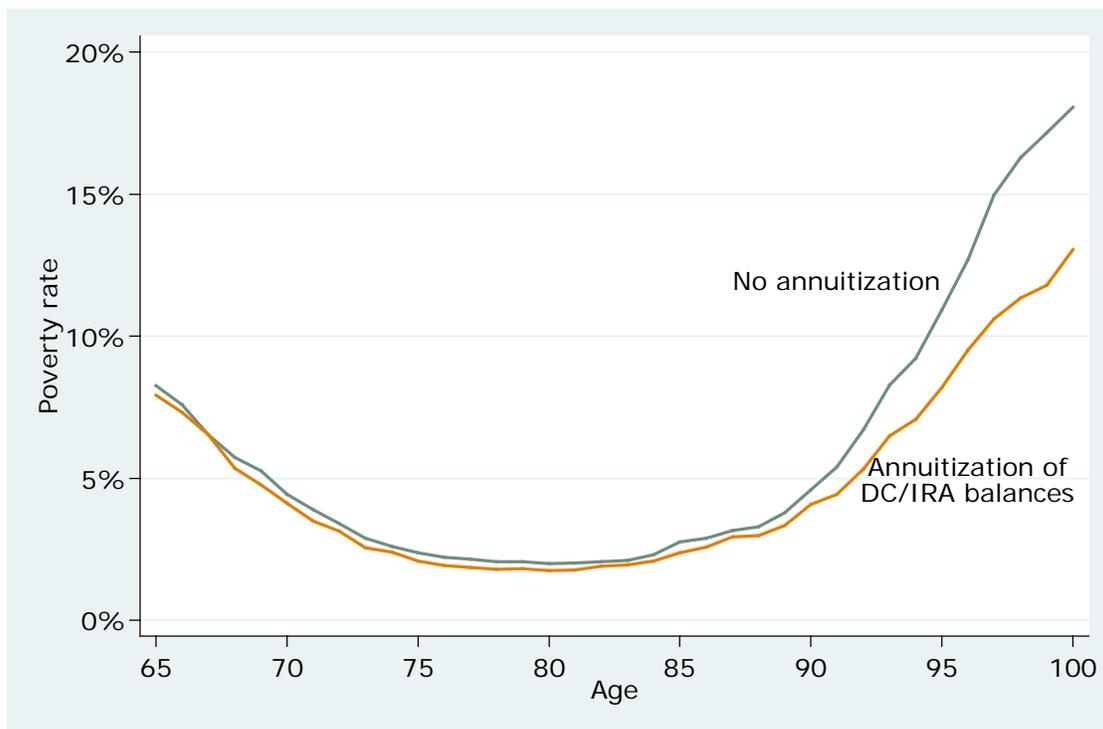


**Figure 5. Illustrative Consumption Paths with and without Full Annuitization**

### ***Implications of Annuitization for Old-Age Poverty***

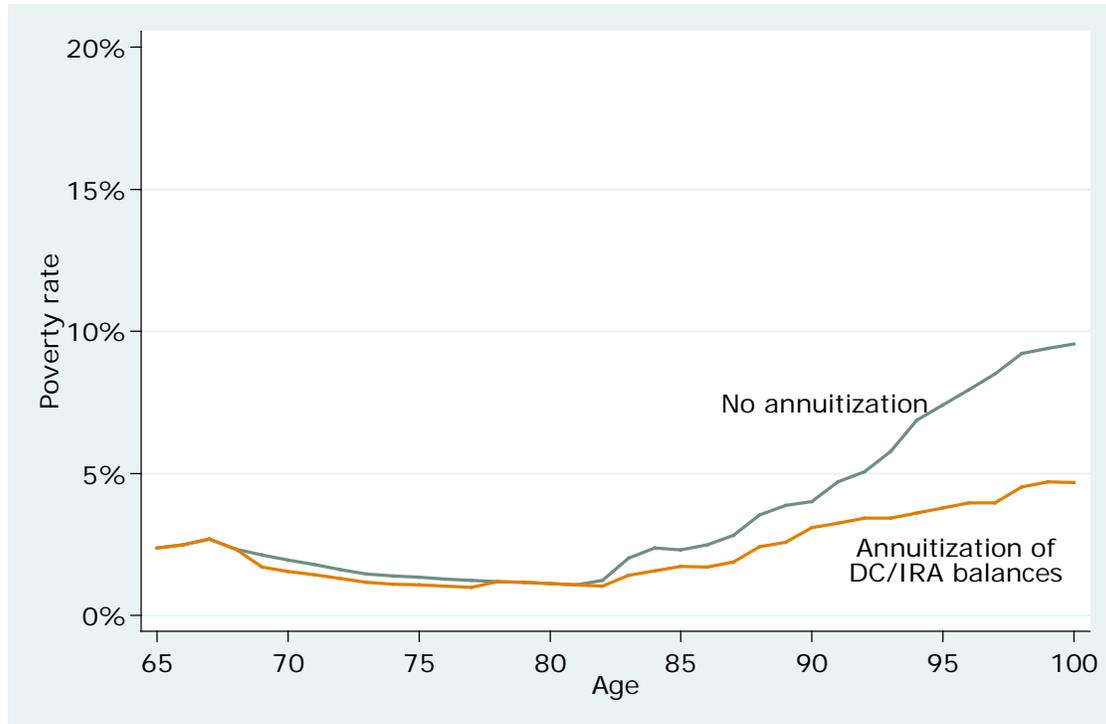
In our context the purpose of purchasing an annuity is to be assured of higher income in old age. We now turn to the implications for old-age poverty. According to the Census Bureau, the poverty threshold for a single individual age 65 or older was \$10,458 in 2010.<sup>9</sup>

Consider for example the retiree depicted in Figure 4. Her baseline consumption exceeds the poverty threshold until age 94, after which she is projected to live in poverty. In contrast, her consumption after annuitization is always above the poverty line. We determine poverty status for all sample members and all ages, and summarize by age. Figure 6 shows the resulting age-specific poverty rates among women in our analysis sample. Until approximately age 90, poverty rates with and without annuitization are very close. However, they diverge after age 90, when bequeathable wealth is increasingly depleted and annuity income may lift retirees above the poverty line. As expected, poverty rates among the oldest-old are projected to be lower when DC/IRA balances are annuitized. Figure 7 confirms this pattern for males in the sample. (Men's poverty rates tend to be lower than women's because of greater retirement resources. For example, upon entry into the sample, their average DC/IRA balance was 54% higher than for women, other wealth was 14% higher, Social Security benefits were 11% higher, and DB pension income was 16% higher than for women.)



**Figure 6. Projected Poverty Rates among Women in the Analysis Sample, by Age**

<sup>9</sup> <http://www.census.gov/hhes/www/poverty/data/threshld/index.html>.

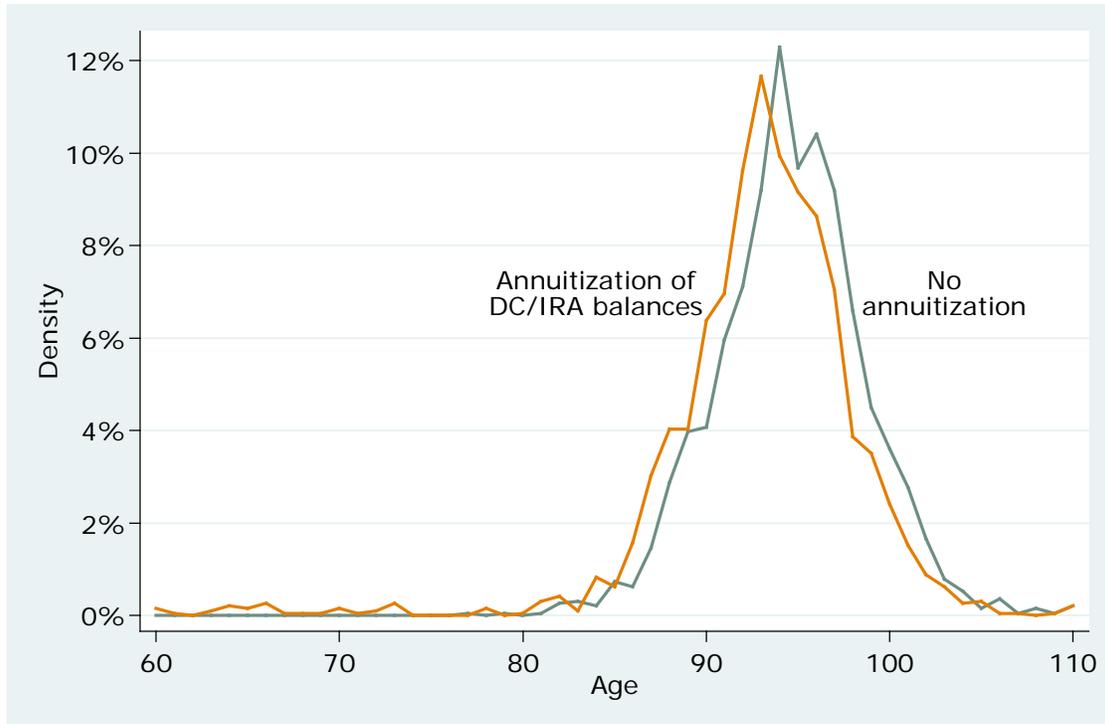


**Figure 7. Projected Poverty Rates among Men in the Analysis Sample, by Age**

As expected, Figure 6 and Figure 7 show that poverty rates rise after about age 80. However, they also show elevated poverty levels among younger retirees. This is in part a consequence of the unusual sample selection, which excludes married couples. Among sample members who entered before age 70, 39% were separated or divorced, compared with 9% among those who were at least age 70 at the time of sample entry. Separated and divorced individuals tend to have lower retirement resources than widowed or never married individuals. We will return to this issue below with an additional explanation.

### ***Age at Which Savings Are Depleted***

Next we consider the age at which bequeathable wealth is exhausted (Figure 8). Without annuitization, initial bequeathable wealth is higher than with annuitization and wealth exhaustion occurs later. On average, wealth is depleted 1.6 years sooner when DC/IRA balances are annuitized.



**Figure 8. Age at Which Wealth Is Projected to Be Exhausted under Baseline and Annuitization Scenarios**

It is, of course, not surprising that wealth is exhausted sooner under annuitization, since some of it was used to purchase an annuity. In exchange, income at advanced ages is higher than without annuitization.

### ***Retirement Satisfaction***

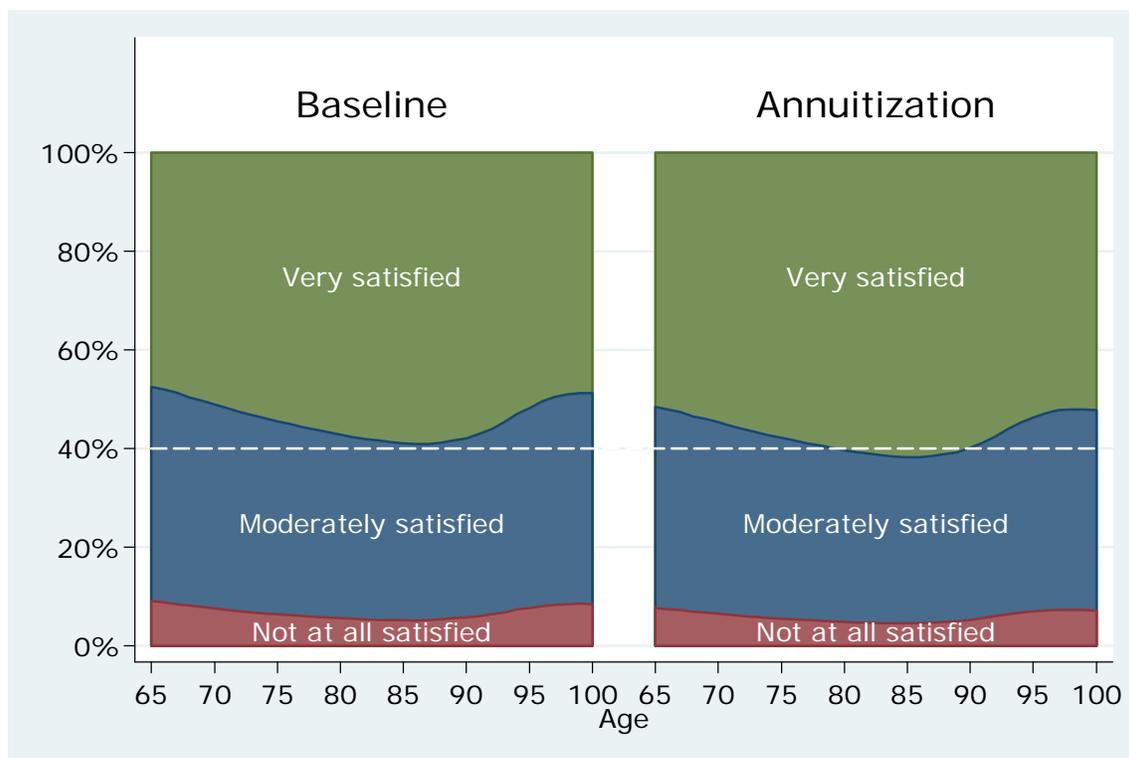
The third outcome measure that we consider is retirement satisfaction. The HRS poses a direct question to retired respondents: “All in all, would you say that your retirement has turned out to be very satisfying, moderately satisfying, or not at all satisfying?” Panis (2004) found that the greater the share of one’s retirement resources from lifelong-guaranteed income (such as pensions and annuities, but not Social Security), the more satisfied a respondent tended to be. He also found that retirees without lifelong-guaranteed income became less satisfied over time, possibly because they saw their savings dwindle. In contrast, those with a pension or annuity maintained their satisfaction over the duration of their retirement.

Based on the 1992-2010 HRS, we estimated a model to explain retirement satisfaction, applied the coefficient estimates to project satisfaction in our simulated population, and compared projected satisfaction levels with and without annuitization.

The Appendix shows the results of estimation. The model is an ordered probit, estimated on completely retired HRS respondents who are not married. Overall, 9% responded being not at all satisfied, 41% moderately satisfied, and 50% very satisfied. Retirement satisfaction generally increases with both income (from Social Security, DB pensions, and annuities) and wealth (including DC/IRA balances, if

any). Annuitization increases one's income flow but decreases wealth and, a priori, the net effect is ambiguous. However, annuitization also boosts the share of retirement resources in the form of annuities, which itself tends to enhance satisfaction. Finally, annuitization may help satisfaction over time: while respondents without income from pensions or annuities generally reported a decline in satisfaction over time, those with pension or annuity income experienced improving satisfaction with retirement duration.

Figure 9 depicts the predicted distribution of retirement satisfaction in the analysis sample, by age from age 65 to 100. The left and right panels refer to predicted satisfaction under the baseline and annuitization scenarios, respectively. The panels differ in that satisfaction under annuitization tends to be somewhat greater. Consider the fraction predicted to be very satisfied relative to the dashed line: unlike under the baseline scenario, more than 60% of respondents are predicted to be very satisfied under annuitization when they are octogenarians.



**Figure 9. Predicted Distributions of Retirement Satisfaction, by Age**

Overall, annuitization is predicted to enhance retirement satisfaction for 95% and reduce it for 5% of respondent-years. The changes are generally modest, as is evident from the similarity of the panels in Figure 9.

### ***Lifetime Utility***

The fourth and final outcome measure under consideration is lifetime utility as defined on page 6. The simulations maximize lifetime utility; at issue is whether respondents are better off in terms of lifetime utility with or without annuitization.

Table 4 compares lifetime utility for individual respondents under the Baseline and Annuitization scenarios. Overall, 6 out of 1,912 respondents (0.4%) attained a higher lifetime utility without annuitization, whereas 99.6% of respondents were better off with annuitization.<sup>10</sup> All respondents without children and thus without a bequest motive were better off annuitizing, which is consistent with Yaari (1965) and other authors. However, annuitization can be suboptimal for individuals who value wealth holdings, be it to leave a bequest, to have a cushion against unexpected expenses, or other reasons. In our findings, annuitization was almost always better, even for people with children.

**Table 4. Comparison of Lifetime Utility under the Baseline and Annuitization Scenarios, by Bequest Motive**

	Respondents without children	Respondents with children	Total
Better off under Baseline	0	6	6
Better off with Annuitization	221	1,685	1,906
Total	221	1,691	1,912

Under a scenario in which all respondents annuitized 50% of their DC/IRA balances (instead of 100%), only one respondent was worse off.

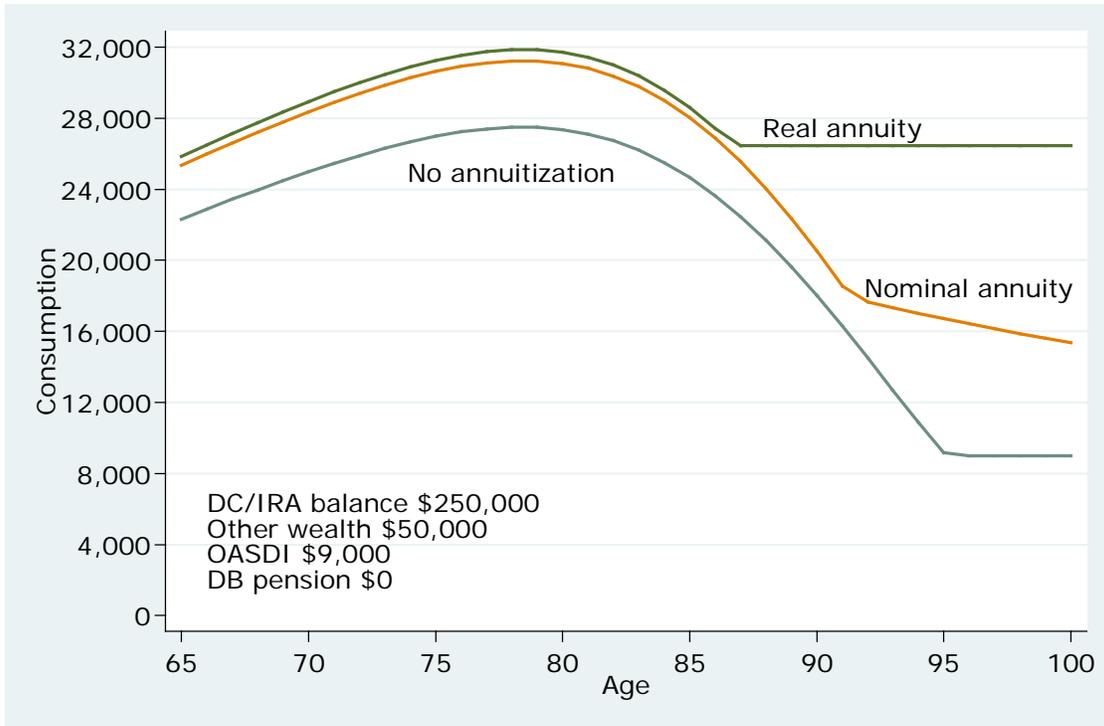
### *Real versus Nominal Annuities*

The discussion has so far centered on nominal annuities, i.e., annuities that are fixed in nominal terms and are eroded by inflation over time. We now turn to real annuities that are annually adjusted for inflation.

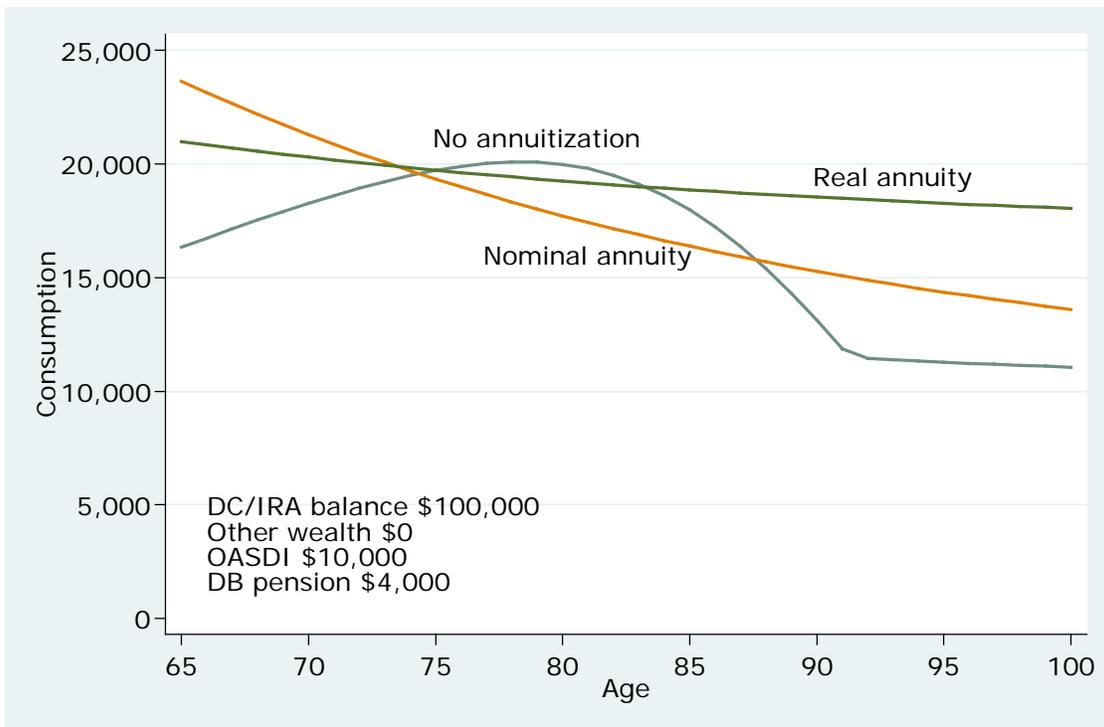
Consider the hypothetical person whose optimal consumption profiles are depicted in Figure 4. She could convert her \$250,000 DC/IRA balance into a nominal annuity of about \$24,100. This annuity was priced actuarially fairly with a nominal interest rate of 6.8%. Alternatively, at a real interest rate of 3% she could purchase a real annuity of about \$17,500. Figure 10 shows optimal consumption paths under these scenarios. Her bequeathable wealth would be exhausted even earlier than under nominal annuitization (age 87 versus 92), but her income is higher at all ages. After her wealth is exhausted, her consumption is equal to the sum of her Social security benefits (\$9,000) and real annuity (about \$17,500).

While a real annuity supports higher consumption at all ages than a nominal annuity in Figure 10, this is not always the case. Consider the hypothetical person of Figure 5 with a DC/IRA balance of \$100,000, no other wealth, Social Security benefits of \$10,000, and a nominal pension of \$4,000. With her DC/IRA balance she can purchase a nominal annuity of about \$9,600 or a real annuity of about \$7,000. Figure 11 illustrates her optimal consumption paths. At some ages, her consumption is highest without annuitization, at others nominal or real annuitization result in higher consumption. Her lifetime utility is highest under real annuitization (not shown in graph).

<sup>10</sup> Five of the six individuals who became worse off by annuitizing had no wealth other than their DC/IRA balances; one had exceptionally high DB pension income.



**Figure 10. Illustrative Optimal Consumption Paths with Real, with Nominal, and without Annuitization of DC/IRA Balances**



**Figure 11. Illustrative Optimal Consumption Paths with Real, with Nominal, and without Annuitization of DC/IRA Balances**

We projected age-specific poverty rates under real annuitization, similar to those shown in Figure 6 and Figure 7. Conversion of DC/IRA balances into real annuities appears to reduce old-age poverty even more than conversion into nominal annuities. The reduction is roughly twice as large for women and roughly 25% greater for men.

Theoretically, real annuities are not always better than nominal annuities. Increasing mortality risks imply that optimal consumption will eventually decrease with age, and real annuities force a flatter consumption pattern than nominal annuities in an inflationary environment. However, real annuities generated uniformly higher lifetime utility than nominal annuities in our application.

### ***An Imperfect Attempt to Include Married and Younger Retirees***

As discussed earlier, the analysis sample excludes married individuals. Only when a married person becomes widowed is he or she included in the analysis sample. As a result, the sample is not representative of the U.S. population of retirees.

This section expands the analysis sample to married individuals, increasing the sample size from 1,912 to 6,904 and lifting the sex ratio from 29% to 49% males. Unfortunately, the utility maximization model is not readily adapted to couples' preferences. We therefore—imperfectly—maintain utility maximization at the individual level and also split couples' retirement resources equally. Specifically, we allocate each spouse 50% of their combined DC/IRA balances, after-tax wealth, Social Security benefits, and pension/annuity income.

The exercise essentially converts married couples into egocentric individuals with only half the financial resources that they enjoy together. Perhaps not surprisingly, the results reflect a low standard of living. Projected age- and sex-specific poverty rates are similar in shape to those shown in Figure 6 and Figure 7, but about twice as high for women and four times as high for men. Key for our purposes, though, is that annuitization is projected to substantially reduce poverty, especially among men.

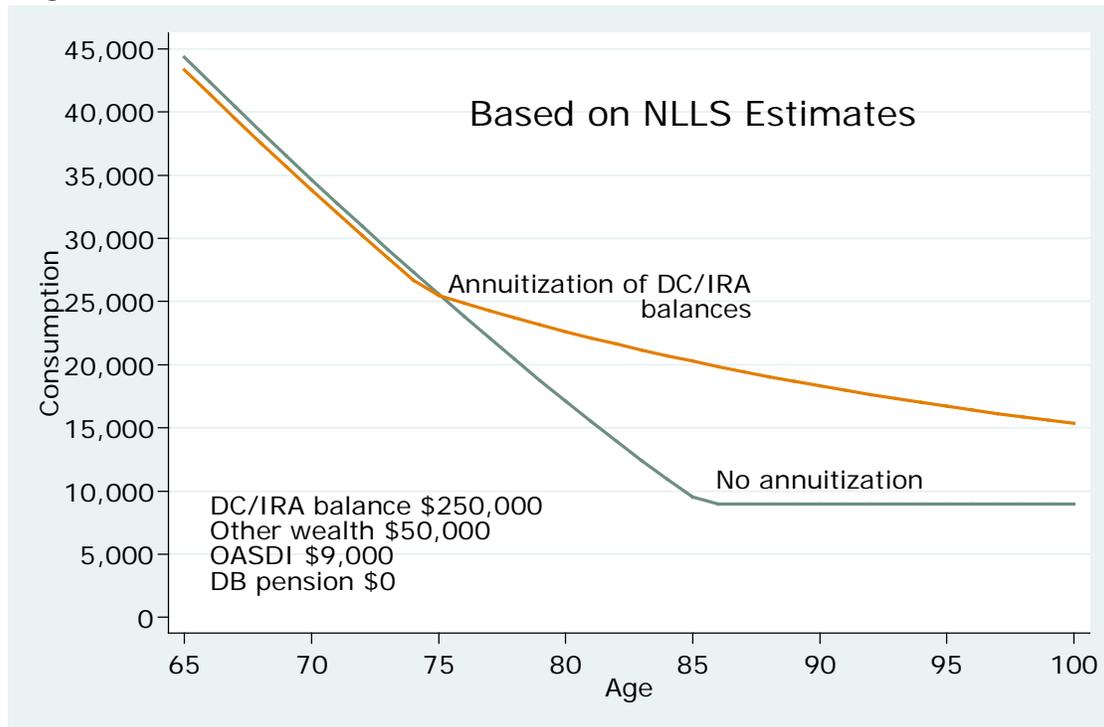
Projected poverty rates exhibit a U-shaped pattern with higher rates at relatively young and oldest-old ages. We found the same for the unmarried population in Figure 6 and Figure 7 and explained that elevated poverty among relatively young ages that was the result of disproportionately many separated and divorced respondents among the early entrants into the analysis sample. That is no longer the case in the expanded sample, but it remains the case that younger entrants have lower average Social Security benefits than later entrants, which may play a pivotal role to lift people out of poverty. The next section sheds additional light on this issue.

### ***Sensitivity to Model Estimates***

All simulations above were carried out using NL2SLS estimates of Hurd (1989)—see the second column of Table 1. To shed light on the sensitivity of the model and its implications to parameter estimates, we repeated the analysis based on NLLS estimates in the first column of Table 1.

Consider first a simulation of optimal consumption paths with and without annuitization for the hypothetical person of Figure 4. She is 65 years old, has a DC/IRA balance of \$250,000, other wealth of \$50,000, receives \$9,000 annually in

Social Security benefits, and does not have pension income. Figure 12 shows her optimal consumption paths with and without annuitization. They differ markedly from the hump-shaped patterns in Figure 4. Instead of increasing consumption during early retirement, the pattern is downward from the start. The change in shape is mostly caused by the rate of time preference, which was near-zero in NL2SLS estimates and about 5% in NLLS estimates. This rate of time preference exceeds the interest rate, so that mortality risks dictate a downward sloping consumption path at all ages.



**Figure 12. Illustrative Consumption Paths with and without Annuitization of DC/IRA Balances (Based on NLLS Estimates)**

While consumption profiles differ from those generated by NL2SLS estimates, the implications of annuitization for old-age poverty appear to be more robust to parameter estimates. Figure 13 shows projected age-specific poverty rates among women. As before, poverty is projected to increase with age and reduce substantially in case of annuitization. The magnitude of the reduction appears to be greater than that based on NL2SLS estimates; see Figure 6. Figure 14 shows projected age-specific poverty rates for men based on NLLS estimates, and similar comments apply to men as to women.

The projected age-specific poverty rates based on NL2SLS estimates (Figure 6 and Figure 7) are U-shaped, implying that poverty rates among relatively young retirees are higher than among octogenarians. In contrast, NLLS estimates project roughly constant poverty rates or even slightly increasing until age 80 (Figure 13, Figure 14). Earlier we pointed at lower financial resources among respondents who entered our analysis sample earlier as part of the explanation. Another part of the explanation appears to lie in hump-shaped consumption patterns that are optimal under NL2SLS estimates but not under NLLS estimates. Under downward-sloping consumption patterns, fewer retirees fall below the poverty line at relatively young ages.

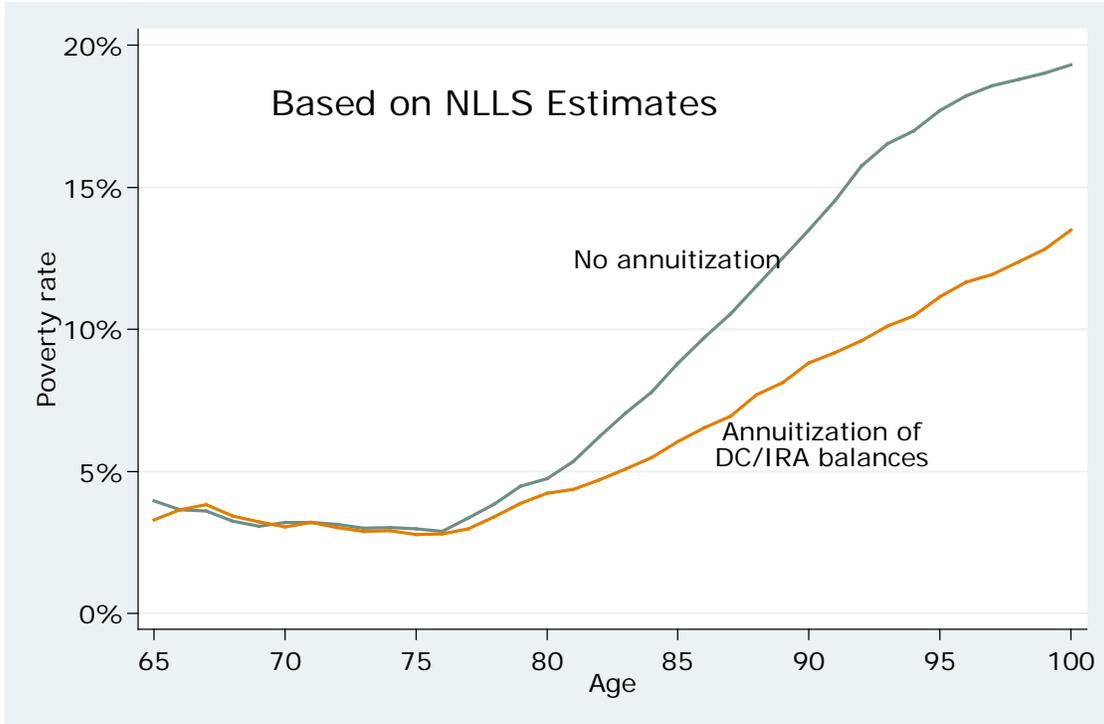


Figure 13. Projected Poverty Rates among Women in the Analysis Sample, by Age (Based on NLLS Estimates)

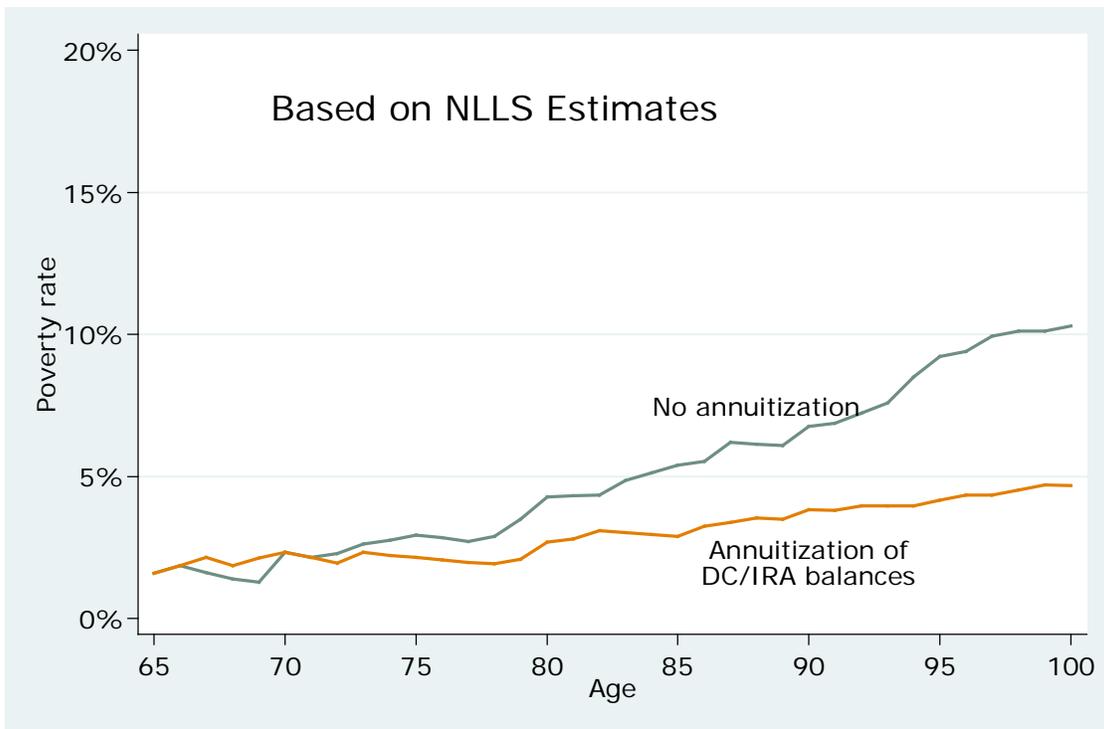


Figure 14. Projected Poverty Rates among Men in the Analysis Sample, by Age (Based on NLLS Estimates)

## 6. CONCLUSION

This report develops a framework for evaluating the effects of more widespread annuitization of DC or IRA balances. The results are generally plausible and in the expected direction, namely that more annuitization is likely to reduce old-age poverty and increase retirement satisfaction. Put differently, old-age poverty may be expected to rise and retirement satisfaction to deteriorate because of large-scale de-annuitization implied by the trend from traditional DB pensions to DC plans in the United States. Wider adoption of annuitization may offer a way to counter those adverse consequences while preserving employers' ability to manage pension benefit costs.

Employers that sponsor a traditional DB plan bear investment and longevity risks. In part because of a desire to better control pension benefit costs, many employers are foregoing DB plans in favor of DC plans, in which workers shoulder the investment and longevity risks. Annuitization shifts those risks onward to insurance companies. Indeed, insurance companies may be better equipped to manage risks than both employers and workers. Of course even within DB plans, investment and longevity risks may be transferred to an insurance company. Insurance companies can offer longevity re-insurance (absorbing longevity risks but not investment risks), "buy in" to the plan (pay monthly annuities to the plan, which continues to pay benefits to participants) or partially "buy out" the plan (take over certain liabilities).<sup>11</sup>

Our analysis is mostly concerned with unmarried individuals who are completely retired. It omits married couples and delays inclusion into the analysis sample until one spouse becomes deceased. As a result, the analysis sample is not representative of the U.S. population of retirees. Also, the financial resources of HRS respondents may not reflect those of future retirees. For example, 69% of our sample members have some income from a DB pension. Future retirees will likely have less of their retirement resources in the form of lifelong-guaranteed income, suggesting even greater benefits from annuitization than we demonstrated for current retirees.

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<sup>11</sup> E.g., McDonald and Gaul (2015).

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## APPENDIX: RETIREMENT SATISFACTION

This appendix provides details of the model of retirement satisfaction that is used in the main text (page 19 and further) to simulate retirement satisfaction of analysis sample members under the Baseline and Annuitization scenarios.

Table 5 shows the results of estimation. The model is an ordered probit, estimated on completely retired HRS respondents who are not married, receive Social Security benefits, and are at least 60 years old. The table shows ordered probit coefficients, standard errors in parentheses, and asterisks to denote statistical significance from zero: \*\*\* for 1% significance level, \*\* for 5%, and \* for 10%. The outcome is an ordered categorical variable that is equal to 0 (not at all satisfied), 1 (moderately satisfied), or 2 (very satisfied). Overall, 9% responded being not at all satisfied, 41% moderately satisfied, and 50% very satisfied.

**Table 5. Ordered Probit Estimates of Retirement Satisfaction among Unmarried HRS Respondents (Coefficient estimates and standard errors)**

	Ordered probit
Share of retirement resources from pensions, annuities	0.5017 *** (0.0758)
Share of retirement resources from Social Security	0.0018 (0.0020)
Log(income)	0.1516 *** (0.0189)
Log(wealth)	0.0496 *** (0.0025)
Separated/Divorced	-0.0873 *** (0.0235)
Never married	0.1046 *** (0.0352)
Male	-0.0314 (0.0208)
Age	0.0165 *** (0.0013)
Log(years since retiring)	-0.0262 ** (0.0133)
Pension*Log(years since retiring)	0.0678 *** (0.0100)
Missing retirement duration	-0.1178 *** (0.0417)
Threshold 1	1.8299 (0.1932)
Threshold 2	3.2809 (0.1940)
Number of observations	16,910

Source: 1992-2010 HRS.

Note: Standard errors in parentheses.

Significance: \*\*\*=1%, \*\*=5%, \*=10%.

The results are generally intuitive. The greater one's share of retirement resources in the form of lifelong-guaranteed income from pensions or annuities, the greater one's satisfaction in retirement. That share is defined as the present value of income from pensions and annuities divided by total retirement resources, in turn defined as bequeathable wealth (including DC/IRA balances, if any) plus the present value of pensions, annuities, and Social Security benefits. The share from Social Security did not have such an effect, presumably because reliance on Social Security signals limited financial resources. The logarithms of income (from Social Security, pensions, and annuities) and bequeathable wealth (including DC/IRA balances) are positively related to satisfaction. Relative to widow(er)s, separated or divorced respondents were less satisfied, whereas never married respondents tended to be more satisfied. All else equal, men and women expressed about equal satisfaction. Satisfaction increases with age. It decreases with duration since retirement, but the interaction of duration with an indicator of receipt of any DB pension benefits or annuities shows that retirement satisfaction in fact increases over time for those with pension or annuity income.

The model we estimated is similar to that in Panis (2004), but adjusted to support our current simulation purposes: only covariates that are available in the simulations can enter the model. For example, we do not control for health status, even though it is highly predictive of retirement satisfaction, because future health status is not available in the simulations. We do control for marital status and assume that unmarried retirees will not marry or re-marry.

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