DISCUSSION PAPER PI-0612

Mortality Heterogeneity and the Distributional Consequences of Mandatory Annuitization

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April 2006

ISSN 1367-580X

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http://www.pensions-institute.org/

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April 6, 2006

ABSTRACT

Using data from the Health and Retirement Study (HRS), we calculate the relationship between socio-economic status and a utility based measure of annuity value. We find considerable variation between groups once we take account of not only socio-economic differences in mortality, but also pre-annuitized wealth and longevity risk pooling in marriage.

Using HRS data on subjective survival probabilities, we then construct a subjective life table for each individual in the HRS. We show that these tables vary appropriately between groups and aggregate closely to group level averages. We calculate the value each household would place on annuitization, based on the husband and wife's subjective life tables, and the household's degree of risk-aversion and proportion of pre-annuitized wealth. A significant minority would perceive themselves as suffering a net loss from mandatory annuitization.

JEL Codes: D91, E21, G11, J14, J26

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1. Introduction

Annuities provide insurance against outliving one's wealth that ought to be valued by risk-averse households facing an uncertain lifespan. However, rates of voluntary annuitization are extremely low, not only in the United States, but also in many other countries.

Although there are many explanations for the reluctance of households to annuitize, increases in the cost of annuitization resulting from adverse selection very likely contribute. One solution to the problem of adverse selection is mandatory annuitization. By forcing high mortality households to annuitize, the cost of annuities is reduced for everyone.

But households that would prefer not to annuitize, even at the more favorable rates made possible by compulsion, would be worse off under mandatory annuitization. The amount that a household gains or loses can be determined by calculating its "annuity equivalent wealth" (AEW). AEW equals the ratio of the amount of unannuitized wealth that would leave a household indifferent between an optimal decumulation of that wealth and the purchase of an actuarially fair annuity, to the cost of that annuity.[1] When AEW exceeds one, the individual is, in expectation, better off annuitizing.

Brown (2000) calculated AEW for twenty categories of individuals – men, women, blacks, whites, and Hispanics, and both blacks and whites with less than a high school education, high school or some college, or at least four years college. He found that the average individual in each category, but not necessarily all individuals in each category, would have an annuity equivalent wealth well in excess of one and would be better off as a result of mandatory annuitization. Importantly, Brown also found almost no variation between groups in annuity equivalent wealth. This was despite the money's worth of an annuity to some categories being very considerably less than the premium paid.[2]

Brown's calculations were for single individuals with no pre-annuitized wealth. Brown and Poterba (2000) showed that longevity risk pooling in marriage would

[1] An annuity is said to be actuarially fair if it offers an individual with a particular mortality risk an expected present value, calculated at some interest rate, equal to the premium paid.

[2] The money's worth of an annuity is defined in the literature as the expected present value, calculated by reference to some mortality table and interest rate, divided by the premium paid.

considerably reduce the value of annuitization to married couples. Dushi and Webb (2004) analysis of Health and Retirement Study data showed that most households entering retirement have extremely high proportions of pre-annuitized wealth, once one included Social Security and defined benefit pension wealth. They showed that under the commonly used assumption of constant relative risk aversion, these households would place little value on annuitizing their unannuitized wealth, although they might still place a high value on the longevity insurance provided by their existing annuitized wealth.

We therefore recalculate annuity equivalent wealth for each of the categories studied by Brown, taking account of both marital status and estimates of each category's average proportion of pre-annuitized wealth obtained from an analysis of HRS households turning 65 from 1994 to 2000. Once we take account of these factors, we find very considerable variation in AEW, although at a three percent discount rate it is still greater than one for all categories, so that the average individual in each category would still benefit from mandatory annuitization.

But as Brown pointed out, group averages may conceal considerable household level heterogeneity in mortality, risk aversion, and proportion of pre-annuitized wealth. The HRS contains individuals' estimates of their probabilities of surviving to specified ages. We apply a Bayesian updating technique developed by Gan, Hurd, and McFadden (2003) to recover each individual's level subjective life table from these responses. We show that these life tables vary appropriately with socio-economic status and that life expectancies derived from them aggregate to those obtained from published life tables. We then calculate AEW for each HRS household turning 65 from 1994 to 2000, based on these life tables and our calculations of each household's degree of risk-aversion and proportion of pre-annuitized wealth. We find considerable variation. Importantly, we also find that 16.5 percent of the overall sample, and even higher percentages of low socio-economic status households, have an annuity equivalent wealth of less than one. Under our assumptions regarding household preferences, these households would perceive themselves as being worse off under mandatory annuitization.

The remainder of the paper is organized as follows. Section two summarizes previous research, section three explains our methodology, section four presents our results, and section five concludes.

2. Previous research

In this section, we review the literature on the money's worth and actuarial unfairness of annuities, the value of annuities to risk-averse households facing an uncertain lifespan, and the distributional consequences of mandatory annuitization.

The money's worth of annuities

Using 1983 data, Friedman and Warshawsky (1988) were the first to calculate the money's worth of annuities. Mitchell, Poterba, Warshawsky, and Brown (1999) updated this work, using 1995 data. Mitchell et al calculated that the money's worth of an annuity to men aged 65 with population mortality was 75.6 percent when one discounted the income stream at the corporate bond interest rate, and 81.4 percent when one discounted it at the Treasury strip interest rate. But Dushi and Webb (2006) pointed out that this overstates the cost of annuitizing because households investing directly in the asset classes held by the insurance company will also incur management charges. They calculated that for a married couple aged 65 and 62 respectively, these charges correspond to 2.0 to 10.1 percent in expected present value terms, the wide range reflecting the considerable variation in the level of such charges.

Mitchell et al (1999) also calculated the money's worth of annuities to individuals with annuitant mortality. Annuitants have considerably lower than population average mortality, and they found that the money's worth of an annuity for someone with annuitant mortality was some eight percent higher than that for someone with population average mortality. But this difference in money's worth is a poor measure of the burden of adverse selection to the average potential annuitant. There is a strong and well-documented relationship between wealth and mortality and many high mortality-risk households have little or no annuitizable wealth. We refer the interested reader to Menchik (1993), Attanasio and Hoynes (2000), and Hurd, McFadden, and Merrill (2001). Dushi and Webb (2006) estimate that the difference between the value of an annuity to someone with annuitant mortality and its value to someone with population mortality approximately halves when one weights population mortality by annuitizable wealth.

The value of annuities to risk-averse households facing an uncertain lifespan

Usually, an annuity with an appropriate survivor benefit will have a value in excess of its money's worth to a risk-averse household facing an uncertain lifespan and lacking a strong bequest motive. However, it may be relatively unattractive to a household that is impatient or wishes to retain liquidity to cover, for example, health expenditure shocks.

Most of the literature uses numerical optimization techniques to calculate either the wealth equivalent of an annuity or annuity equivalent wealth. The wealth equivalent of an annuity is defined in the literature as the money's worth at which a household would be indifferent between annuitizing his unannuitized wealth and undertaking an optimal decumulation of that wealth while continuing to hold it in unannuitized form. As mentioned previously, annuity equivalent wealth equals the premium over money's worth at which a household would be indifferent between annuitizing and not annuitizing.

Mitchell et al (1999) calculated the wealth equivalent of an annuity for single individuals. Using 1995 United States data and assuming a real interest rate of 3 percent, an inflation rate of 3.2 percent, a rate of time preference of 1 percent, no bequest motive, no pre-existing annuities, population mortality, and a coefficient of risk aversion equal to one, they calculated that the before tax wealth equivalent of the typical nominal annuity was 0.659 for a single male. At a coefficient of risk-aversion of two, the wealth equivalent fell to 0.619. If half the individual's wealth was held in the form of a pre-existing real annuity, the wealth equivalents increased to 0.730 and 0.695 under the same assumptions. As discussed above, only a very small proportion of single households have half or less of their financial wealth in annuitized form. These results are therefore representative only of the wealthiest households who may also have a stronger than average bequest motive.

Brown and Poterba (2000) extended the analysis by calculating annuity equivalent wealth for married couples considering the purchase of a joint life and survivor annuity. They assumed that couples have a utility function of the following form:

$$U_m(C_t^m, C_t^f) = \frac{(C_t^m + \lambda C_t^f)^{1-\gamma}}{1-\gamma}, U_f(C_t^f, C_t^m) = \frac{(C_t^f + \lambda C_t^m)^{1-\gamma}}{1-\gamma} \qquad (1)$$

where λ measures the jointness of consumption, C_t^m, C_t^f denote the consumption of the husband and wife at time *t*, and γ is the coefficient of risk aversion. When λ equals one, all consumption is joint. When λ equals zero, none of the household's consumption

is joint. Due to longevity risk pooling, married couples value annuitization less highly than do similarly risk-averse single individuals, particularity when much of the household's consumption is joint. Assuming population mortality, no pre-existing annuities, a coefficient of risk aversion of two, a rate of time preference and a real rate of interest both of 3 percent, and a rate of inflation of 3.2 percent, Brown and Poterba calculated annuity equivalent wealth for a 65 year old single man to be 1.576. When λ equals zero, they calculated the annuity equivalent wealth of a joint life and 50 percent survivor annuity to be 1.244 under the same assumptions. Marriage decreases the value of annuitization by 58 percent. When the coefficient of risk aversion equals ten, their comparable figures are 1.703, 1.407 and 42 percent. At higher values of λ annuitization is even less valuable to married couples, particularly if the annuity has an inappropriate survivor benefit.

Dushi and Webb (2004) examined the balance sheets of HRS households in which the older spouse turned 65 during the period 1994-2000. They calculated total wealth, inclusive of the present value of Social Security and employer pensions, sorted the households by total wealth, and then calculated the mean proportion of pre-annuitized to total wealth for households in each wealth decile. Our Table 1 reproduces Table 1 (a) in Dushi and Webb and reports the composition of wealth of married couples in each total wealth decile. In all but the top wealth decile, pre-annuitized wealth is greatly in excess of one half of total financial wealth. Dushi and Webb show that under plausible preference assumptions, these high proportions of pre-annuitized wealth are a sufficient explanation for the failure of the average currently retired household to voluntarily annuitize. Households undoubtedly place a high value on annuitizing some of their wealth. At prevailing annuity rates most households' demand will be satisfied by Social Security and defined benefit (DB) pensions. Of course, legal and regulatory barriers such as those discussed by Brown and Warshawsky (2001) may also deter voluntary annuitization.[3]

Although currently retired households are highly annuitized, subsequent birth cohorts are projected to have much smaller proportions of pre-annuitized wealth as 401(k) and other defined contribution (DC) pensions which almost never mandate

[3] A bequest motive would also affect the value of annuitization, although a lot would depend on precisely how it entered into the utility function.

Table 1
Composition of HRS Households' Balance Sheets at Age 65 – Couples

Total Wealth Deciles		1	2	3	4	5	6	7	8	9	10
Lower Bound of Total Wealth		-9,223	262,881	362,390	455,058	536,719	631,824	747,606	875,827	1,060,204	1,482,087
					Means by Deciles						
Net Non-Retirement Financial Wealth		2,547	17,870	33,327	61,868	77,461	103,869	178,362	275,926	365,292	852,772
Business Assets		973	2,458	7,297	14,290	11,821	13,118	23,413	25,108	50,399	204,085
Financial Assets		-243	7,708	17,056	25,487	37,811	49,922	80,747	147,812	184,499	416,386
IRAs		1,817	7,704	8,974	22,091	27,829	40,829	74,472	103,006	130,394	232,301
Property		27,981	49,910	72,096	92,295	104,334	140,692	154,831	185,561	215,589	568,069
Primary Residence Net of Mortgage		25,983	46,386	63,678	77,399	87,335	115,327	109,670	142,139	157,521	244,241
Net Other Property		1,998	3,524	8,418	14,896	16,999	25,365	45,161	43,422	58,068	323,828
Retirement Wealth		153,364	244,224	309,309	337,310	402,198	443,513	470,932	497,493	643,843	819,387
Social Security		142,111	209,310	227,351	251,752	260,138	272,463	261,455	270,474	296,868	301,920
DB Pensions		10,203	28,943	75,548	77,523	129,641	160,455	187,735	205,334	303,128	394,919
DC Pensions		1,050	5,971	6,410	14,895	12,419	10,595	21,742	21,685	43,847	122,548
Total Wealth		183,892	312,004	414,732	491,473	583,993	6 88,074	804,125	958,980	1,224,724	2,240,227
Annuitized Wealth as % of Financial and Retirement Wealth	All	94	91	90	85	83	81	72	65	63	49
	With DB	91	91	92	89	85	83	74	68	66	56
	Without DB	95	91	82	78	73	71	60	52	49	37
As % of Total Wealth		80	76	73	67	67	63	56	50	49	32
% of Homeowners		68	94	94	96	97	99	98	98	97	99
% with Living Children		98	96	96	100	97	99	98	100	98	96
N of obs	Total	180	158	158	144	140	139	128	126	131	114
	With DB	44	78	118	96	120	117	103	101	107	74
	Without DB	136	80	40	48	20	22	25	25	24	40

Notes: Data from Health and Retirement Study, waves 2 to 5. Sample: married couples who turned 65 in any of the waves 2 to 5. Sample size - 1431 observations, from which 13 observations falling in the 100th wealth percentile were dropped resulting in a sample of 1418. We excluded the 100th percentile from the 10th decile and the wealth upper cut-off point is $4,332,141. The present values of Social Security and employer Defined Benefit pensions were calculated using a real rate of interest of 3% and an inflation rate of 2.5%. Annuitized wealth equals the sum of SS and DB pensions. Figures are in 2000 dollars and weighted using household weights. Variation between deciles in number of observations is due to weighting.

annuitization, displace DB plans. The increase in the Social Security Normal Retirement Age will reduce the real value of Social Security wealth. Poterba, Venti, and Wise (2002) project that, as a result, the mean 401(k) plan balance of the cohort retiring in 2025 will exceed its mean Social Security wealth, even after allowing for the impact of increased longevity on the latter. The reforms proposed by the President's Commission (2001) would further reduce the compulsorily annuitized proportion of household wealth if enacted without a provision for mandatory annuitization. Munnell (2003) highlighted the impact of projected increases in Medicare Part B premiums and in the proportion of retirees who will pay income tax on Social Security. She calculates that average Social Security income replacement rates could drop from the current 41.2 percent to 26.9 percent by 2030. The above trends may increase the value households place on annuitization and increase the potential costs of adverse selection.

There is also a literature, including work by Milevsky (1998, 2000) that examines the question of whether households might wish to postpone the purchase of a fixed annuity in order to obtain the benefit of the equity premium. But it is possible to purchase variable immediate annuities that offer the advantages of both annuitization and investment in equities, although they form only a small proportion of total annuity sales, despite a considerable body of literature demonstrating their attractiveness. We do not address the question of whether a program of mandatory annuitization should offer a variable annuity option, and instead assume that there is a single risk-free asset in which households may invest, and which the annuity provider uses to price the annuity. We refer the interested reader to Blake, Cairns, and Dowd (2003) for an analysis of optimal household portfolio allocations when variable annuities are available.

The distributional consequences of mandatory annuitization

There is a considerable literature that evaluates the distributional effects of the United States Social Security system in money's worth terms, for example, Gustman and Steinmeier (2001), Liebman (2002), and Coronado, Fullerton, and Glass (2000). The literature finds that because households with high lifetime income have, on average, lower mortality, mandatory annuitization reduces, but does not eliminate, the overall progressivity of the system.

Brown (2003) is the only previous paper that calculates the distributional consequences of mandatory annuitization in expected utility terms. He first calculated the money's worth of various types of annuities – real, nominal and 20 year period certain – to various categories of individual, and then calculates the annuity equivalent wealth of the various types to each category. His methodology is described in detail in his paper. To summarize, he made use of data from the National Longitudinal Mortality Study (NLMS, a nationally representative sample of over 600,000 individuals of all ages that was merged with National Death Index data for a period of nine years during the 1980s. He sorted the NLMS data by gender and ethnicity (black, white or Hispanic), and further sorts blacks and whites into three educational categories; less than high school, high school or some college, and at least four years' college. He then calculated an age specific non-parametric mortality rate for each category, there being up to nine observations for each individual. Using non-linear least squares, he estimated a survival function based on mortality rates for ages 25 to 84 and used the survival function to estimate mortality rates up to age 100.[4] He then calculated mortality rates for each category and age, relative to the all category average for that particular age. Assuming that relative mortality rates remain constant over time, he then combined this data with the 1978 birth cohort life table published by the Social Security Administration to calculate 1978 birth cohort life tables for each category of individual.

He then used these life tables to calculate the money's worth of an actuarially fair annuity to each category, assuming that the annuity is priced on uniform terms, using a combined male and female life table, and that the annuity is purchased at age 67. As one might expect, the money's worth of an annuity was higher for women than for men, for whites than for blacks, and for the better educated than the less well educated. The largest differences were between men and women, but the racial and educational differences were also substantial. His calculations show that, in dollar terms, mandatory annuitization involves a substantial degree of redistribution from men to women and from traditionally disadvantaged groups towards the more advantaged.

Brown then calculated AEW for each class, using numerical optimization techniques. A completely different picture emerged. When evaluated in expected utility terms, the redistributive effect of mandatory annuitization is small to insignificant,

[4] Except at advanced ages, mortality rates are exponentially increasing, an empirical fact first reported by Benjamin Gompertz, a British actuary, in 1825.

particularly at higher degrees of risk aversion. He has kindly consented to us reproducing his calculations of annuity equivalent wealth (Table 3 in his paper), and they appear as our Table 2.

All categories have AEWs well in excess of one. At a coefficient of risk aversion of five, women's AEWs are about four percent more than those of men, but black men valued annuitization only 0.4 percent less than white men, and black women have precisely the same valuation as white women. Education related differences in AEW are similarly small. The intuition behind these results is that both high and low mortality

Table 2 Annuity Equivalent Wealth Under Uniform Pricing - Single households No Pre-Annuitized wealth Actuarially Fair Annuities

	CRRA = 1	CRRA = 2	CRRA = 3	CRRA = 4	CRRA = 5
MEN					
All	1.350	1.449	1.497	1.527	1.546
All whites	1.352	1.450	1.498	1.528	1.546
All Blacks	1.328	1.437	1.488	1.522	1.542
All Hispanics	1.362	1.449	1.495	1.523	1.543
Whites: College +	1.361	1.452	1.498	1.527	1.546
Whites: HS +	1.351	1.451	1.499	1.529	1.548
Whites: < HS	1.325	1.434	1.486	1.520	1.540
Blacks: College +	1.343	1.443	1.492	1.523	1.542
Blacks: HS+	1.328	1.437	1.488	1.523	1.543
Blacks: < HS	1.296	1.415	1.472	1.511	1.534
WOMEN					
All	1.465	1.531	1.560	1.577	1.588
All Whites	1.465	1.531	1.560	1.577	1.588
All Blacks	1.459	1.529	1.560	1.577	1.588
All Hispanics	1.487	1.545	1.570	1.585	1.597
Whites: College +	1.466	1.530	1.559	1.576	1.588
Whites: HS +	1.465	1.531	1.561	1.577	1.588
Whites: < HS	1.463	1.531	1.562	1.578	1.589
Blacks: College +	1.462	1.530	1.560	1.577	1.588
Blacks: HS+	1.459	1.529	1.561	1.577	1.588
Blacks: < HS	1.453	1.526	1.560	1.577	1.587

Source: Brown (2003) Table 1 page 32. Calculations as descrbed in text

groups wish to restrict their consumption by approximately equal amounts to self-insure against destitution in advanced old age, even though the risk of attaining advanced old age is much less for people in the high mortality groups.

Brown (2003) calculations of AEW can be compared with Mitchell, Poterba, Warshawsky, and Brown (1999) calculations of the money's worth of annuities. When there is no pre-annuitized wealth, annuitization is advantageous when the reciprocal of annuity equivalent wealth is less than the money's worth of annuities. As previously mentioned, the above authors calculated that the money's worth of an annuity to a 65 year old male was 75.6 percent, more when the more conservative Treasury strip interest rate was used. Comparing the money's worth of an annuity, calculated using even the corporate bond interest rate, with the reciprocals of AEW, would lead one to predict substantial rates of voluntary annuitization whereas, of course, Poterba (1997) and many other authors have highlighted the rarity of its occurrence.

The Brown results are for single individuals and assume no pre-annuitized wealth. As previously mentioned, Brown and Poterba (2000) show that married couples will place a lower valuation on annuitization than single individuals, for any given level of risk-aversion while Dushi and Webb (2004) show that incorporating actual levels of pre-annuitized wealth further reduces of the value of annuitization.

Thus, it is clear that Brown (2003) calculations represent an upper bound to the value of annuitization. However, it is difficult to tell ex-ante whether, if we were to incorporate the above factors, we would still obtain his key findings; namely that average AEW varies little from one household type to another, and that in expected utility terms, the average household in each category would be better off under mandatory annuitization than it would be were it to undertake an optimal decumulation of its unannuitized wealth.

Furthermore, Brown's calculations are for the average individual in each household type. As he points out, the types are not monolithic, and averages may conceal considerable household level heterogeneity. It is possible that although the average household of each type may be better off under annuitization, substantial minorities may not be.

3. Methodology

Calculating group average annuity equivalent wealth

When calculating category average annuity equivalent wealth, we follow Brown (2003) by focusing on the 1978 birth cohort. If Social Security Individual Accounts are introduced, this will be one of the first cohorts to have contributed to such accounts for most of their working lives, and if they have an employer provided pension, they will also very likely have contributed to a DC plan.

We follow Brown by combining his tables of relative mortality rates with Social Security Administration life tables for the 1978 birth cohort to construct 1978 birth cohort male and female mortality tables for all Hispanics, whites, and blacks, and for whites and blacks with less than a high school education, a high school education or some college, and at least four years' college.[5][6] We again follow Brown by constructing tables for all whites and all blacks by calculating a weighted average of the mortality rates of the three education categories using weights obtained from an analysis of 30-34 year olds in the March 1999 Current Population Survey. Our all male and all female mortality tables are simply the Social Security Administration mortality tables for the 1978 birth cohort.

We use numerical optimization techniques to calculate annuity equivalent wealth for each category of married couple, assuming no pre-annuitized wealth. We then calculate annuity equivalent wealth for each category of married couples and single women, and for all single men, taking account of pre-annuitized wealth, there being insufficient single men in the sample to permit an analysis by category.[7]

Dushi and Webb (2004) show that the mean proportion of pre-annuitized to total financial wealth varies with wealth decile and marital status. Given the strong relationship between wealth and socio-economic status, it would be surprising if the proportion of pre-annuitized wealth did not also vary with ethnicity and education. We

[5] The tables are published in Brown, Liebman, and Pollet (2002).

[6] One of Brown's assumptions is that the ratio of group to population mortality is constant over time. As Brown, Liebman, and Pollet (2002) points out, this assumption is not innocuous. For example, over the last century there has been an enormous increase in high school and college graduation rates, particularly among ethnic minorities. Each educational group has become less select over time, and this may have affected their relative and absolute mortality risks.

[7] We assume that, after controlling for education and ethnicity, marital status has no effect on relative mortality risk and that the risk of death does not increase following bereavement. For an analysis and review of the literature, see Korenman, Goldman, and Fu (1995).

would ideally wish to forecast the balance sheets and proportions of pre-annuitized wealth of the 1978 birth cohort at retirement in 2045. This task is well beyond the scope of this paper. Poterba, Venti, and Wise (2002) project 401(k) and Social Security wealth for households retiring in 2025 and 2035, but do not similarly project DB pension wealth, non-pension financial wealth, or the value of Social Security Individual Accounts, and do not extend their analysis to 2045. We therefore adopt an alternative approach, and use the mean proportion of each category's pre-annuitized to total financial wealth obtained from an analysis of the Dushi and Webb (2004) data for HRS households turning 65 between 1994 and 2000 (65 is the Social Security Normal Retirement Age for this cohort).

The HRS oversamples black households, so the sample sizes for both blacks and whites are generally adequate, the principal exception being college-educated blacks.[8] We refer the reader to Dushi and Webb (2004) for a description of the methodology used to calculate the expected present value of pension wealth, but in brief, they use self-reported data on actual or anticipated pension income, a three percent real interest rate, a 2.5 percent inflation rate, and population average mortality for the appropriate birth cohort.

The 1978 birth cohort retiring in 2045 will almost certainly have smaller proportions of pre-annuitized wealth than the HRS households by reason of the fact that they will be more likely to have participated in a DC pension plan (DB plans still predominated among the HRS cohort). They may have considerably smaller proportions if Social Security Individual Accounts are introduced. Our calculations therefore represent a lower-bound estimate of the value the 1978 birth cohort would place on mandatory annuitization.[9]

[8] This is a birth cohort that would have most likely attended college between 1947 and 1957. We find that college educated whites have 10.9 percent less of their financial wealth in pre-annuitized wealth than whites with a high school education. In contrast, college educated blacks have 5.1 percent more than blacks with a high school education. We suspect that we are overstating the pre-annuitized proportion of the wealth of black college educated households, but our estimates of black college-educated households' annuity equivalent wealth would not be substantially increased were we to assume that their proportions of pre-annuitized wealth equaled those of similarly educated white households.

[9] Under any plausible utility function the value of mandatory annuitization decreases with each additional dollar annuitized. Our calculations assume that all unannuitized wealth is annuitized. Some proposals envisage that households would be required to annuitize only part of their Social Security Individual Account – for example of an amount sufficient to lift their income above the poverty threshold - in which case the value of annuitization would be slightly higher.

Brown's calculations assumed that the annuities being offered were actuarially fair, or alternatively, actuarially fair minus an eight percent expense load. However, if wealthy and, on average, long lived households have larger account balances, then the annuity provider must charge a higher than actuarially fair premium. We consider how large this effect might be, focusing on Social Security Individual Accounts, making use of analyses kindly provided by Cori Uccello using Urban Institute's DYNASIM microsimulation program. Uccello, Favreault, Smith, and Thompson (2003) used the program to calculate the money's worth of Social Security Individual Accounts for people in the 1978 birth cohort. It models individual level mortality risk and can be used to calculate equilibriums level of actuarial unfairness resulting from mandatory annuitization of Social Security Individual Accounts under a number of policy options.

At our request, Cori Uccello used DYNASIM to provide us with an estimate of the premium loading that would have to be applied to enable an annuity provider with zero administrative costs to break even under a system of mandatory annuitization of Social Security Individual Accounts. Her estimate of only about one percent reflects not only the very modest variation across socio-economic classes in projected Individual Account balances, but also the fact that women, who have lower mortality than men, have lower average lifetime earnings and lower projected Individual Account balances.[10]

For simplicity, and in view of the very small magnitude of Uccello's estimate, we follow Brown by assuming that the annuity is priced at an actuarially fair rate with zero administrative costs, using uniform pricing and a three percent real rate of interest. It is important to note that the annuity provider cannot simply use the average of the male and female mortality rates to price the annuity. Men have higher mortality rates than women, so women predominate at older ages, and at older ages, uniform mortality rates will be closer to female than to male rates.

[10] Uccello calculated residual actuarial unfairness for the 1940-1980 birth cohorts, weighted in favor of younger households by reason of the fact that they would accumulate individual account wealth over a greater number of years. The DYNASIM model's assumptions regarding socio-economic differences in mortality rates based upon 1980-1982 data from the National Longitudinal Mortality Study – the same dataset that Brown used in his research – see Favreault and Smith (2004) for a description of the DYNASIM methodology. Mandatory annuitization of 401(k) balances would likely result in much greater levels of actuarial unfairness, at least from the viewpoint of someone with population average mortality, because of the much stronger relationship between income and account balances in such plans resulting from the capping of the Social Security tax, and the fact that high earners are disproportionately likely to be eligible for, participate in, and contribute maximum amounts to 401(k) plans.

Calculating household level annuity equivalent wealth

The above analyses have focused on the average household within each group. But annuity equivalent wealth will vary within each group, due to within-group variations in mortality risk, risk aversion and proportion of pre-annuitized wealth. To obtain estimates of these variations, we calculate annuity equivalent wealth for each HRS household in which the husband turned 65 between 1994 and 2000, taking account of the household's composition, proportion of pre-annuitized wealth, coefficient of risk-aversion, and its members' subjective assessments of their annual survival probabilities. In the following paragraphs, we introduce the HRS data on subjective mortality beliefs and explain how we recover each individual's subjective life table and estimates of each household's coefficient of risk-aversion.

HRS data on subjective mortality beliefs

Participants in the HRS and the Asset and Health Dynamics Among the Oldest Old (AHEAD) panel of somewhat older individuals born between 1890 and 1923 are asked to estimate their chances to surviving to ages ten to twenty five years hence. Hurd and McGarry (1995, 2002) analyzed the HRS data and found that these subjective survival probabilities contained important information. The responses aggregated quite closely to the predictions of life tables and varied appropriately with known risk factors and determinants of mortality. In panel, individuals modify their subjective survival probabilities in response to new information. The subjective survival probabilities also predict actual survival.

Hurd and McGarry (1995) analyzed data from wave two of the HRS and found that, after the inclusion of a variety of controls, nonwhite individuals reported significantly higher subjective survival probabilities. We find that both before and after controlling for age, education, gender, and cognitive ability, black individuals report significantly higher survival probabilities.[11] We consider the implications of this finding when discussing our results.

[11] We experimented with a control for cognitive ability, which in the HRS data is correlated with educational attainment, because Perry (2005) found that individuals with low cognitive scores were more likely to report a 100 percent survival probability, possibly indicating that they had misunderstood the question.

Constructing subjective life tables for each individual in the HRS

In each wave, individuals were asked to assess their probabilities of surviving to ages 75 and 85, the wave one question being evaluated on a scale of one to ten, and subsequent waves' questions being evaluated on a scale of one to 100. We restricted our analysis to the age 75 responses.[12]

Since we have wealth data at the wave the household attains age 65, we decided to calculate AEW at that age. We use the survival probability estimates given at the last wave before the husband turned 65.[13] Our sample therefore consists of the 1,689 husbands who were aged 63 to 65 years old at waves one to four of the HRS and their wives of any age. We do not use waves five to seven, as only the first four waves can be matched to Dushi and Webb (2004) data on proportions of pre-annuitized wealth. We discard 79 households for whom we lack data on education or ethnicity, leaving 1,610.

Neither the subjective survival probability nor the risk aversion questions were asked of proxy respondents, and responses are missing for some other individuals. We have subjective survival probability responses for both spouses in 1,255 of the above households, and responses to questions regarding risk-aversion, discussed later, for 1,152 of the 1,255. We find that the non-respondents to the survival questions had higher mortality than the remainder of the sample. Wave one of the HRS contains a total of 12,652 individuals, and subjective survival probabilities are missing for 944, or about seven percent of the total. At wave six the vital status of 8.45 percent of the 944 was unknown and 17.5 percent were known to be deceased, compared with 5.87 and 12.13 percent for those who provided data. Under the alternative assumptions that all of those who dropped out of the sample were either alive or dead at wave six, non-respondents have a mortality rate about 44 percent higher than respondents.

We therefore imputed missing responses using hot-deck imputation, with gender, education, ethnicity, and self-reported health status as covariates.[14] Hurd and McGarry (1995) showed that self-reported health status is a highly significant predictor of self-

[12] We conjectured that individuals' knowledge about their relative mortality risk may decrease as the mortality time horizon lengthens. It is possible that the age 85 responses may contain additional information, but we defer to future research the recovery of subjective mortality tables from survival estimates to multiple ages.

[13] We decided against using the following wave's estimates as they would include mortality information received after the assumed date of annuitization.

[14] Hot-deck imputation is widely used in the HRS and similar datasets and involves filling in missing data by randomly drawing responses from the subset of individuals with the same characteristics.

assessed survival probabilities, even after controlling for many other variables that are likely correlated with health status. We also imputed the missing risk aversion data, although the relationship between risk aversion and socio-economic status is less clear.

Continuing with our analysis of sample attrition, we eliminated 65 households with wives aged less than 51, as these are unlikely candidates for immediate annuitization, leaving 1,545, and eliminated two households with a spouse over 75, leaving 1,543. We matched 1,229 of these households to Dushi and Webb data on proportions of pre-annuitized wealth.[15]

We now explain how we recovered subjective annual survival probabilities from individuals' estimates of their survival probabilities. The difficulty faced by researchers in undertaking this task is that the data suffers from serious focal response problems; some individuals give responses of 0.0 and 1.0. These focal responses cannot be used directly as the measure of true subjective probabilities, because the distribution of true probabilities should be continuous and the true probabilities cannot be literally either zero or one.

Gan, Hurd, and McFadden (2003, henceforth GHM) propose a Bayesian updating method for recovering subjective annual survival probabilities from the AHEAD panel of somewhat older individuals born before 1924. More specifically, they assumed that an individual's true belief regarding his or her survival probability is unknown to the econometrician. However, the econometrician does know the distribution of those beliefs - the Bayesian "prior." The individual reports a survival probability based on his true beliefs. The difference between his true and his reported beliefs represents measurement error.

GHM use the self-reported survival probabilities to update the prior distribution and to obtain the posterior distribution. GHM then apply the posterior distribution of survival probabilities to observed mortality among the panel to estimate parameter values that best characterize each individual's belief as to his annual survival probabilities.

For each individual in the AHEAD data set, GHM estimate an "optimism" index. Compared to the life table survival probability, an individual may overestimate or

[15] Dushi and Webb measured wealth immediately after the older spouse turned 65 to capture any changes in wealth allocations that might occur on or around retirement. A total of 316 of the 1,543 households could not be matched to the Dushi and Webb data because the household dissolved, was lost to the survey between the two waves, had an older wife who attained age 65 before wave two, or in 13 cases, was in the top percentile of the wealth distribution.

underestimate his/her survival probability. The estimated "optimism" indices show significant individual heterogeneity and can be applied to derive individuals' subjective annual survival probabilities, their "subjective life tables," without focal biases.

GHM consider four different optimism indices. Individuals may think of themselves as aging more or less rapidly than the average person of their age and gender, "age scaling," or may think of themselves as facing an annual mortality risk that bears a fixed relationship to the average for persons of their age and gender, "hazard scaling." The index can also be constrained so that the average belief coincides with the predictions of life tables, or allowed to be unconstrained.

We apply the GHM methodology to the HRS data. We use the "unconstrained hazard-scaling" index because GHM found it had the best predictive power of actual survival experience among all four indices. In particular, let the current age of individual i be a. An individual's subjective survival probability to age $a+t$ is given by:

$$s_{ia}(t) = \exp\left(-\int_0^t \lambda_{ia}(a+t)dt\right),$$

where $\lambda_{ia}(a+t)$ is the hazard function at age $a+t$. Further, let the individual's life table hazard be $\lambda_{i0}(a+t)$. The "unconstrained hazard-scaling" model assumes that: $\lambda_{ia}(a+t)=\psi_i\lambda_{i0}(a+t)$ where ψ_i is the individual's optimism index. If $\psi_i>1$, this individual is said to be "pessimistic." If $\psi_i<1$, then this person is "optimistic."

Calculating households' degrees of risk-aversion

Individuals in the 1992 wave of the HRS were asked how they would choose between their present income for life and a 50:50 lottery in which their lifetime income would either increase or decrease by specified percentages. Under the assumption of constant relative risk-aversion, one can use the responses to determine whether an individual's coefficient of risk-aversion is less the one, in the ranges 1-2 or 2-3.76, or is greater than 3.76. We follow Brown (2003) by assuming, dependent on the range in which the individual's coefficient of risk-aversion lies, that his coefficient is 0.7, 1.5, 2.9 or 5.0. We assign each household a coefficient of risk-aversion equal to the average of the husband's and the wife's coefficients.

4. Results

In the following sections, we first report calculations for the average household of each type. We start by reporting calculations for married couples with no pre-annuitized wealth, then married couples with pre-annuitized wealth, and finally, single individuals with pre-annuitized wealth. We then report our calculations of the entire distribution of annuity equivalent wealth.

Utility-based calculations - average household in each category

We report AEWs for the 1978 birth cohort, and for consistency with Brown, assume a retirement age of 67.[16] We follow Brown by reporting results for all households, all whites, blacks, and Hispanics, and whites and blacks with less than a high school education, high school or some college, and at least four years' college. We report results only for married couples that are of the same ethnicity and have the same level of education. Our analysis of HRS couples turning 65 between 1994 and 2000 shows that 60.4 percent report the same ethnicity and education. We assume the constant relative risk aversion utility function specified in equation (1), and again follow Brown by considering coefficients of risk aversion of one, two, three, four, and five. We assume that the real interest rate equals three percent and that households are required to purchase a real joint life and 2/3 survivor annuity that is priced using a uniform life table. This survivor benefit corresponds to that payable under Social Security when the widow's benefit is payable by reason of her husband's contributions.

Warner and Pleeter (2001) argue that many households might have quite high discount rates. We consider how the rate of time preference might affect AEW by also reporting results calculated at rates of time preference of five and ten percent. These results might be applicable not only to households that are impatient, but also to those that might prefer a decreasing consumption path during retirement, because, for example, they fear that declines in health may limit their activities at older ages.

The top panel of Table 3 reports our calculations of AEW for married couples in each of the above categories, assuming a three percent interest rate and no pre-annuitized

[16] Governments might require individuals to annuitize their pension wealth at some older age. For example, until April 2006, the United Kingdom used to require annuitization of personal pensions by age 75 at the latest.

Table 3 - Annuity Equivalent Wealth Under Uniform Pricing - Married Couples - No Pre-Annuitized Wealth and Actuarially Fair Pricing

	CRRA = 1	CRRA = 2	CRRA = 3	CRRA = 4	CRRA = 5
Time preference = 3 percent					
All	1.190	1.245	1.284	1.316	1.345
All whites	1.196	1.250	1.288	1.320	1.348
All Blacks	1.154	1.213	1.256	1.293	1.324
All Hispanics	1.222	1.271	1.306	1.335	1.359
Whites: College +	1.215	1.265	1.301	1.331	1.360
Whites: HS +	1.190	1.245	1.284	1.317	1.345
Whites: < HS	1.162	1.220	1.262	1.297	1.327
Blacks: College +	1.190	1.244	1.283	1.316	1.344
Blacks: HS+	1.159	1.217	1.260	1.296	1.327
Blacks: < HS	1.121	1.184	1.230	1.269	1.302
Time preference = 5 percent					
All	1.144	1.213	1.260	1.296	1.327
All whites	1.150	1.219	1.264	1.300	1.330
All Blacks	1.104	1.180	1.230	1.271	1.306
All Hispanics	1.178	1.242	1.283	1.315	1.343
Whites: College +	1.170	1.235	1.278	1.312	1.340
Whites: HS +	1.144	1.214	1.260	1.296	1.327
Whites: < HS	1.114	1.188	1.237	1.276	1.309
Blacks: College +	1.142	1.212	1.258	1.295	1.326
Blacks: HS+	1.109	1.184	1.234	1.275	1.309
Blacks: < HS	1.070	1.150	1.204	1.247	1.283
Time preference = 10 percent					
All	0.993	1.108	1.177	1.227	1.266
All whites	1.000	1.114	1.182	1.231	1.270
All Blacks	0.953	1.073	1.146	1.200	1.243
All Hispanics	1.025	1.136	1.201	1.247	1.284
Whites: College +	1.018	1.130	1.196	1.243	1.280
Whites: HS +	0.993	1.108	1.177	1.227	1.266
Whites: < HS	0.966	1.083	1.154	1.206	1.248
Blacks: College +	0.989	1.105	1.175	1.225	1.265
Blacks: HS+	0.958	1.077	1.150	1.204	1.247
Blacks: < HS	0.924	1.045	1.120	1.176	1.221
r = 3%, λ = 0.5, 1978 birth cohort, retirement age = 67					

wealth. We find that longevity risk pooling very considerably reduces the value of annuitization, consistent with Brown and Poterba (2000). All ethnic and educational

groups still have AEWs well in excess of one, even at low coefficients of risk-aversion, but the between group variations in annuity equivalent wealth are much greater than those in Brown (2003) calculations for single individuals.

To illustrate, black couples with less than a high school education, the highest mortality group, have an AEW of 1.121 when their coefficient of risk-aversion equals one and 1.302 when their coefficient of risk-aversion equals five, compared with Brown (2003) results of 1.296 and 1.534 for black men and 1.453 and 1.587 for black women with the same level of education. In Brown's calculations, the difference between the annuity equivalent wealth of a white college educated male and a black male without a high school education was only 3.7 percent at a coefficient of risk aversion of two, the corresponding difference for females being 0.4 percent. In contrast, the difference between the annuity equivalent wealth of a white college educated couple and a black couple with less than a high school education is 8.1 percent at the same degree of risk aversion. When the coefficient of risk aversion is five, the comparable numbers are 1.2, 0.1, and 5.8 percent.

The lower panels of Table 3 report our results calculated using rates of time preference of 5 and 10 percent. The AEWs of all household types are substantially reduced. At a rate of time preference of 10 percent, and at low levels of risk-aversion, high mortality groups may no longer be better off as a result of annuitization.[17] However, there is little change in the difference between the AEWs of high and low mortality groups. For example, assuming a rate of time preference of ten percent, and a coefficient of risk aversion of five, the difference between the AEWs of white couples with a college education and black couples with less than a high-school education is 5.9 percent, compared with 5.7 percent when the rate of time preference is five percent, and 5.8 percent when the rate of time preference is three percent.

We then consider how our results might be affected by the inclusion of pre-annuitized wealth. Table 4 reports the mean proportion of pre-annuitized to total financial wealth for various classes of HRS households turning 65 during the period 1994-2000.

Table 1 shows that households with large amounts of unannuitized wealth also have small proportions of pre-annuitized wealth, and it is therefore not surprising, given

[17] Although some might argue that mandatory annuitization protects those with high discount rates against the consequences of their fecklessness!

the well-documented relationship between wealth, ethnicity and socio-economic class, that Table 4 shows that there is also a strong relationship between ethnicity, socio-economic status and the proportion of pre-annuitized wealth. The mean proportion of pre-annuitized wealth among married couples with a white college-educated husband is 66.0 percent, whereas the mean proportion of pre-annuitized wealth among married couples with a black husband with less than a high school education is 93.5 percent.[18] Among single women, the respective proportions are 59.3 and 98.0 percent. We report sample sizes in brackets.

Table 4 - Married Couples and Single Women - Mean Proportion of Pre-Annuitized Wealth of HRS Households Turning 65 1994-2000- Analyzed by Ethnicity and Education

	Married Couples			Single Women		
	Sample size	Annuitized as % of financial wealth	Annuitized as % of total wealth	Sample size	Annuitized as % of financial wealth	Annuitized as % of total wealth
All	1418	0.775	0.615	519	0.816	0.678
All whites	1142	0.760	0.598	311	0.764	0.621
All Blacks	148	0.916	0.784	155	0.953	0.829
All Hispanics	96	0.947	0.795	44	0.955	0.768
Whites: College +	253	0.660	0.509	36	0.593	0.452
Whites: HS +	640	0.769	0.603	179	0.731	0.579
Whites: < HS	249	0.843	0.678	96	0.902	0.775
Blacks: College +	7	0.944	0.868	17	0.923	0.812
Blacks: HS+	67	0.893	0.731	63	0.929	0.787
Blacks: < HS	74	0.935	0.824	75	0.980	0.868

Notes: 1) HRS household weights 2) 32 husbands and 9 single women reported ethnicity other than white, black, or non-black Hispanic 3) top 1% of wealth distribution excluded

Table 5(a) reports AEW for each type of married couple, taking account of pre-annuitized wealth, and again assuming rates of time preference of three, five, and ten percent. AEW is reduced for all household types. For black couples with less than a high school education, annuity equivalent wealth is now only 1.001 when the coefficient of risk-aversion equals one and the rate of time preference equals three percent. The average household in this category would derive no benefit from mandatory annuitization.

[18] To prevent the sample sizes becoming unacceptably small, we classify households by reference to the education and ethnicity of the husband.

Table 5a - Married Couples - Annuity Equivalent Wealth Allowing for Pre-Annuitized Wealth

	CRRA = 1	CRRA = 2	CRRA = 3	CRRA = 4	CRRA = 5
Time preference = 3 percent					
All	1.092	1.117	1.117	1.153	1.168
All whites	1.101	1.125	1.144	1.160	1.174
All Blacks	1.043	1.102	1.095	1.114	1.130
All Hispanics	1.135	1.157	1.175	1.189	1.203
Whites: College +	1.125	1.148	1.165	1.181	1.194
Whites: HS +	1.092	1.117	1.137	1.153	1.168
Whites: < HS	1.057	1.084	1.105	1.123	1.138
Blacks: College +	1.090	1.116	1.137	1.154	1.169
Blacks: HS+	1.049	1.078	1.101	1.119	1.136
Blacks: < HS	1.001	1.033	1.057	1.077	1.095
Time preference = 5 percent					
All	0.992	1.037	1.067	1.090	1.110
All whites	1.001	1.045	1.075	1.098	1.117
All Blacks	0.941	0.988	1.020	1.046	1.068
All Hispanics	1.035	1.078	1.107	1.129	1.147
Whites: College +	1.025	1.069	1.097	1.120	1.138
Whites: HS +	0.993	1.037	1.067	1.090	1.110
Whites: < HS	0.958	1.003	1.034	1.058	1.079
Blacks: College +	0.987	1.033	1.064	1.088	1.108
Blacks: HS+	0.947	0.994	1.022	1.052	1.073
Blacks: < HS	0.903	0.950	0.983	1.010	1.032
Time preference = 10 percent					
All	0.740	0.809	0.859	0.898	0.931
All whites	0.746	0.816	0.866	0.905	0.938
All Blacks	0.705	0.771	0.819	0.857	0.890
All Hispanics	0.767	0.839	0.891	0.931	0.965
Whites: College +	0.762	0.833	0.884	0.924	0.957
Whites: HS +	0.741	0.810	0.859	0.899	0.932
Whites: < HS	0.719	0.785	0.833	0.872	0.904
Blacks: College +	0.735	0.804	0.853	0.893	0.926
Blacks: HS+	0.709	0.775	0.823	0.862	0.894
Blacks: < HS	0.682	0.744	0.791	0.828	0.861

Recall that when there is no pre-annuitized wealth, the difference between the AEWs of white college educated couples and black couples with less than a high school education is 8.1 percent at a coefficient of risk aversion of two and a rate of time preference of three percent. When one incorporates pre-annuitized wealth, the difference

in AEW increases to 11.5 percent. At a coefficient of risk aversion of five, the comparable figures are 5.8 and 9.9 percent.

The increase in the between group variation in annuity equivalent wealth is partly because high mortality groups also have high proportions of pre-annuitized wealth. It also reflects the fact that at higher proportions of pre-annuitized wealth, the longevity insurance provided by an annuity becomes less important and its money's worth more important in determining its value to the household. When there is no pre-annuitized wealth, the difference between high and low mortality households' AEWs decreases substantially with increases in the coefficient of risk-aversion, reflecting the higher value that risk-averse households place on longevity insurance. When one incorporates pre-annuitized wealth, the relationship is much less pronounced, reflecting the decreasing marginal value of further longevity insurance.

Table 5(b) reports similar results for each type of single women, and all single men: there are insufficient single men in the sample to permit an analysis by education and ethnicity. Single women value annuitization more highly than similarly educated married couples because annuity rates are more favorable to them and they do not benefit from longevity risk pooling. Single men obviously have somewhat less favorable annuity rates, and at plausible degrees of risk aversion the effect of their higher mortality on annuity equivalent wealth is approximately offset by the effect of the absence of longevity risk pooling.

Table 5b - Single men and women - Annuity Equivalent Wealth

	CRRA = 1	CRRA = 2	CRRA = 3	CRRA = 4	CRRA = 5
	Time preference = 3 percent				
All men	1.024	1.082	1.123	1.156	1.184
Women					
All	1.245	1.295	1.329	1.357	1.379
All whites	1.267	1.320	1.356	1.385	1.408
All Blacks	1.148	1.185	1.211	1.232	1.250
All Hispanics	1.192	1.214	1.230	1.244	1.255
Whites: College +	1.322	1.383	1.424	1.455	1.481
Whites: HS +	1.270	1.325	1.364	1.394	1.419
Whites: < HS	1.183	1.226	1.257	1.281	1.301
Blacks: College +	1.207	1.247	1.276	1.299	1.318
Blacks: HS+	1.172	1.214	1.244	1.268	1.288
Blacks: < HS	1.069	1.098	1.119	1.130	1.151

Table 5b cont'd - Single men and women					
	Time preference = 5 percent				
All men	0.776	0.838	0.883	0.920	0.950
Women	0.911	0.979	1.027	1.066	1.099
All	1.097	1.169	1.217	1.254	1.284
All whites	1.128	1.204	1.255	1.293	1.324
All Blacks	0.974	1.019	1.052	1.079	1.102
All Hispanics	1.006	1.039	1.064	1.084	1.101
Whites: College +	1.203	1.289	1.344	1.385	1.418
Whites: HS +	1.135	1.214	1.267	1.307	1.339
Whites: < HS	1.023	1.081	1.122	1.155	1.183
Blacks: College +	1.033	1.088	1.127	1.159	1.186
Blacks: HS+	1.001	1.055	1.094	1.126	1.152
Blacks: < HS	0.901	0.933	0.957	0.978	0.995
	Time preference = 10 percent				
All men	0.692	0.765	0.820	0.865	0.903
Women					
All	0.799	0.884	0.948	0.999	1.042
All whites	0.832	0.929	1.000	1.056	1.102
All Blacks	0.681	0.724	0.757	0.785	0.810
All Hispanics	0.692	0.725	0.751	0.772	0.792
Whites: College +	0.919	1.043	1.126	1.189	1.239
Whites: HS +	0.844	0.947	1.021	1.078	1.126
Whites: < HS	0.730	0.792	0.839	0.878	0.912
Blacks: College +	0.726	0.783	0.826	0.862	0.894
Blacks: HS+	0.706	0.759	0.800	0.835	0.865
Blacks: < HS	0.630	0.659	0.681	0.700	0.717

Calculations of the entire distribution of annuity equivalent wealth

We create a subjective life table for each HRS household, using the GHM methodology discussed previously. We first check that our subjective life tables represent "reasonable" beliefs. Our average optimism index, ψ is 0.81. We expect it to be less than one because the sample excludes individuals institutionalized at baseline, who probably had higher than average mortality. We then calculate subjective life expectancies for each group, and compare them with the predictions of life tables for the appropriate class of individual.

Table 6 reports our results. For whites, life expectancy varies appropriately with gender and education. Consistent with our estimate of ψ, subjective life expectancy is

somewhat higher than the predictions of life tables. The education related difference in subjective life expectancies is also slightly less than those shown by the life tables. A possible explanation for this is Perry (2005) finding that the less well educated, who may also fail to understand the questions, are more likely to answer that they have a one hundred percent chance of living to the target age.

Table 6 - Comparison of self-Assessed with Life-Table Life Expectancy at Age 65

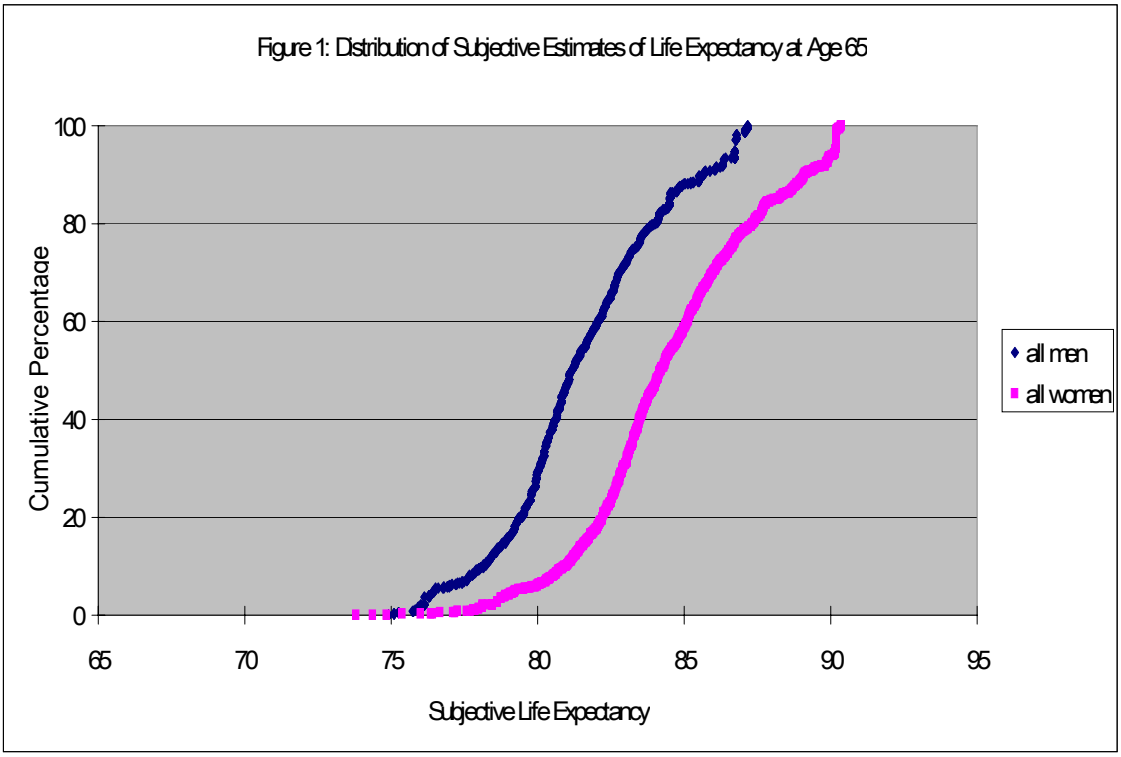
	Life Table	Self-Assessed
	Men	
All	15.55	16.51
All whites	15.72	16.46
All Blacks	13.35	17.26
All Hispanics	17.30	15.65
Whites: College +	16.83	16.88
Whites: HS +	15.63	16.48
Whites: < HS	14.39	15.95
Blacks: College +	14.90	16.88
Blacks: HS+	13.37	17.57
Blacks: < HS	12.97	17.00
	Women	
All	18.83	19.54
All whites	18.93	19.55
All Blacks	17.28	20.07
All Hispanics	20.06	18.45
Whites: College +	19.77	20.29
Whites: HS +	18.93	19.65
Whites: < HS	18.00	18.59
Blacks: College +	18.47	19.38
Blacks: HS+	17.50	20.36
Blacks: < HS	16.42	19.93

Notes: Sample size, 1,543 married couples with husband aged 63 to 65 at date of any of the HRS wave 1 to 5 interviews

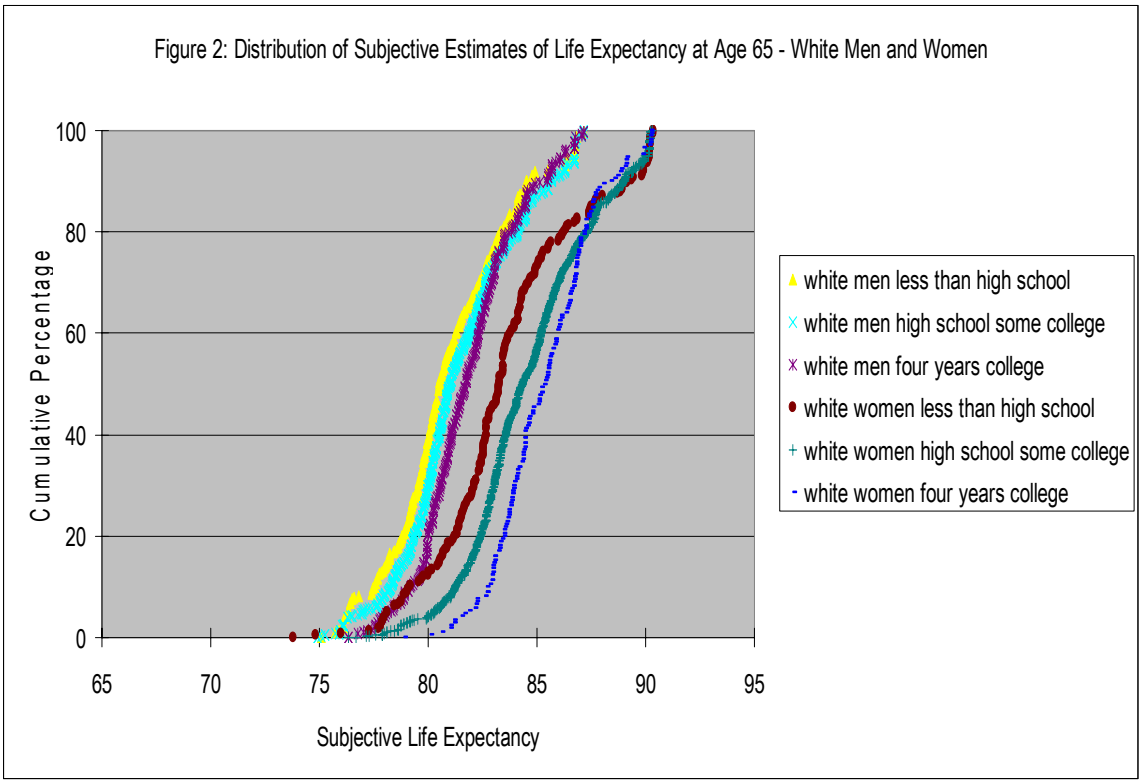
We find that, in contrast to whites who are more optimistic than the predictions of life tables, Hispanics are somewhat less optimistic. As previously mentioned, life table data may overstate Hispanic life expectancy, and Hispanics' subjective estimates of their life expectancy may therefore be closer the truth than calculations based on the NLMS. On the other hand, blacks are much more optimistic than the predictions of life tables,

reflecting the optimism of their raw subjective survival probabilities, referred to previously.[19] We considered estimating the model separately for blacks and non-blacks. We chose not to do this because, as mentioned previously, we have no evidence that differences in comprehension or interpretation of the question contributed significantly to the differences in responses. In the absence of evidence to the contrary, we take the responses at face value, and conclude that black individuals really do believe they have greater longevity at older ages than non-blacks.

Figures 1 and 2 show the distribution of estimates of life expectancy at age 65 for all men and women, and for the three educational groups of white men and women. Life expectancy varies from nine years ten months for white men with less than a high school education to 25 years three months for white women with a college education. There is much greater education related variation at the bottom of the distribution than at the top, suggesting that the educated are uniformly healthy, whereas there is a larger distribution of remaining life expectancy among the less well educated.



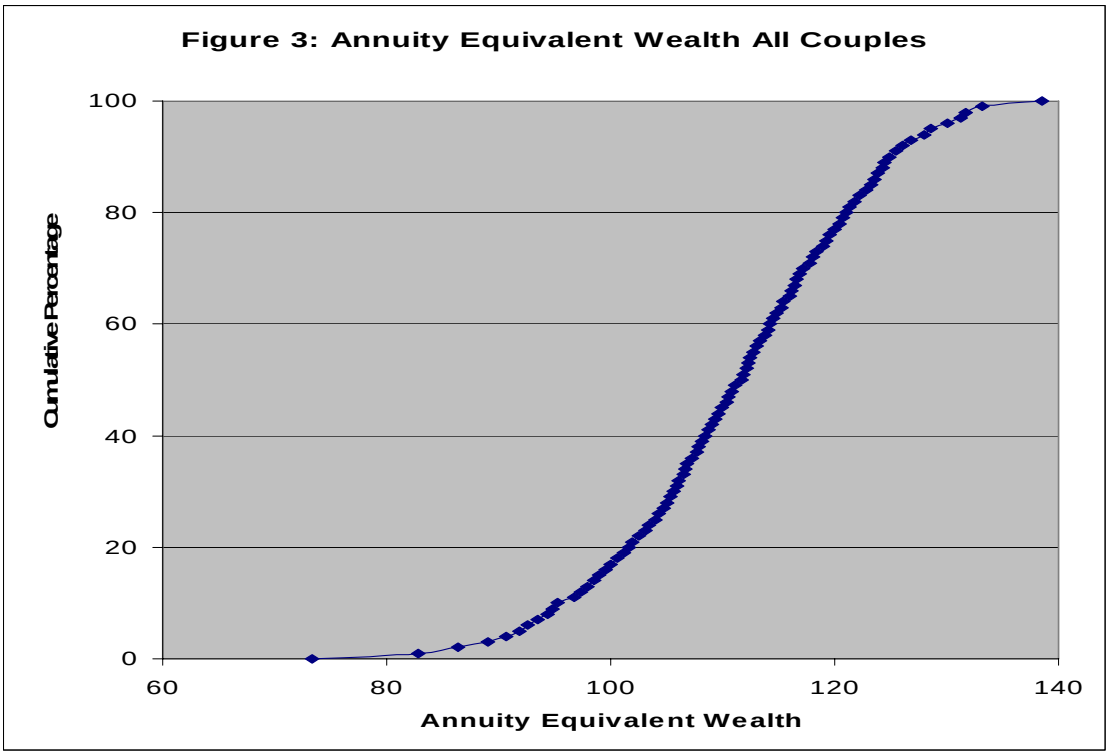
[19] There has been a debate in the demographic literature as to whether a "mortality crossover" occurs at older ages with blacks enjoying lower mortality than whites at very advanced ages. It is generally agreed that black mortality is higher at all ages up to 75. Preston, et.al. (1996) believe that findings of a mortality crossover are the result of errors and inconsistencies in the data.

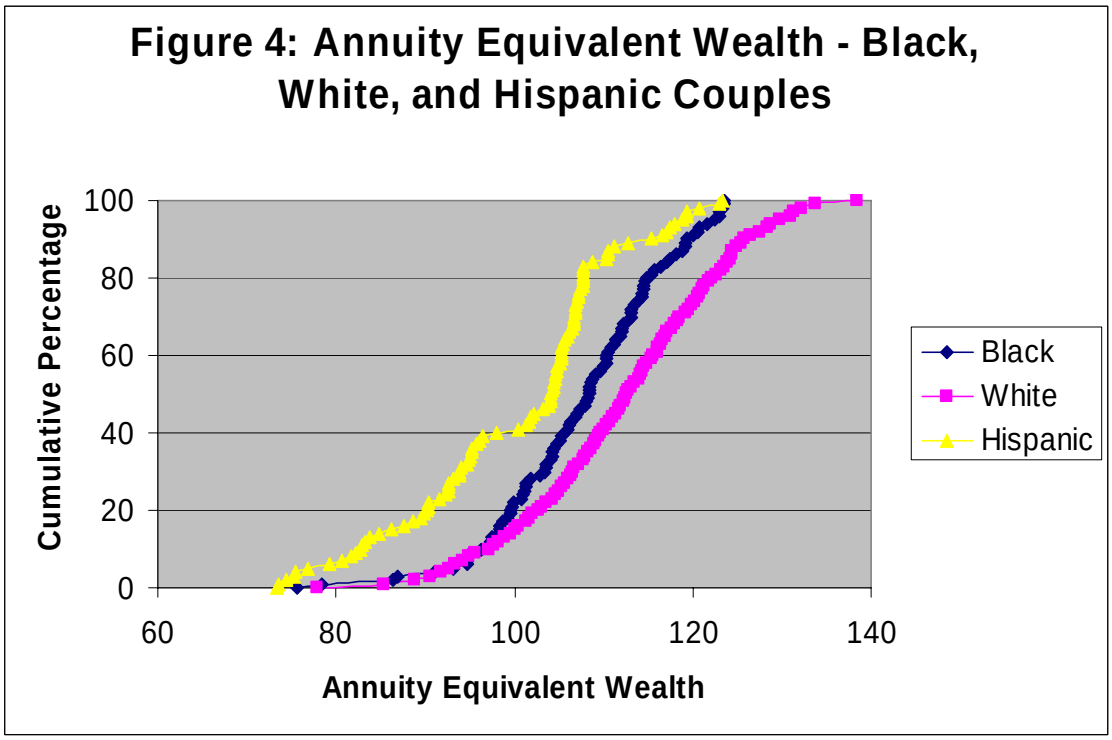


Overall, 47.7 percent of households fall into the most risk-averse category. There was little variation in risk aversion with education or ethnicity, although it is possible that we are failing to identify socio-economic differences in the proportions of households that are highly risk-averse, given the high percentage of households falling into the most risk-averse category.

We calculate household level annuity equivalent wealth at age 65 to correspond with the age at which Dushi and Webb (2004) calculated proportions of pre-annuitized wealth. Figure 3 shows the cumulative distribution of annuity equivalent wealth for all married couples, and Figure 4 the distributions for blacks, whites, and Hispanics. Among married couples, 16.5 percent have an annuity equivalent wealth of less than one and would perceive themselves as being worse off under mandatory annuitization, given our assumptions about household preferences. Median annuity equivalent wealth is 1.122, and the median coefficient of risk aversion is four.[20]

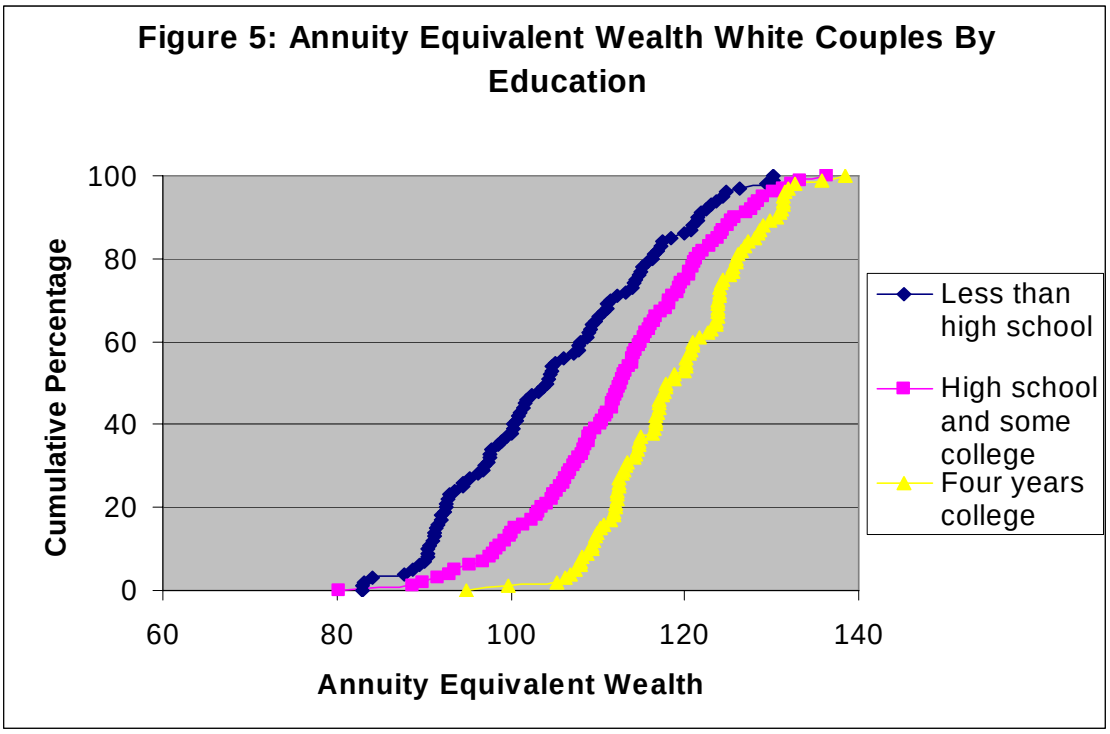
[20] The simulations predicted annuity equivalent wealth of 1.153 at the same degree of risk aversion. As people are, on average, slightly optimistic, one might have expected subjective annuity equivalent wealth to be slightly greater than 1.153. The reason that subjective annuity equivalent wealth is slightly less is that





the value of annuitization increases with age and that the simulations assumed annuitization at age 67, whereas the calculations based on subjective mortality beliefs assumed annuitization when the older spouse turned 65

The percentages reporting annuity equivalent wealth of less than one vary little across ethnic groups, reflecting the relative optimism of black households about their life expectancy. Among white households, the percentages with AEW of less than one vary from 36.5 among those where both spouses have less than a high school education, to 13.8 among those with high school or some college, and only 1.5 percent for those with four years, college education. The sample size is insufficient to permit a similar analysis of black and Hispanic households.



5. Conclusions

Previous research has shown that traditionally disadvantaged groups receive a lower "money's worth" from mandatory annuitization on uniform terms than the more privileged. This same research has shown that, in expected utility terms, the average single individual with no pre-annuitized wealth in each of the educational and racial groups studied would reap substantial benefits relative to a counterfactual of no

annuitization. The research also showed that there is almost no between group difference in the magnitude of that benefit.

We show that if one takes account of pre-annuitized wealth and longevity risk-pooling within marriage and assumes the three percent rate of time preference used in previous research, the average household in each group obtains only a small benefit from mandatory annuitization. However, in contrast to previous research, we find that there are now substantial differences between groups in the value of annuitization. This finding has important implications for one's assessment of the overall progressivity of the Social Security system, and it would appear that, in expected utility terms, the system is not as redistributive as was previously thought.

Even within groups, there will be substantial heterogeneity not only in mortality beliefs, but also in willingness to accept risk, and proportions of pre-annuitized wealth, characteristics which economic theory indicates also affect the value households place on annuitization. Our analyses show that significant minorities of some groups may correctly perceive themselves as being net losers under mandatory annuitization even when the average household in the group perceives itself as being a net gainer.

Acknowledgments

We would like to thank Jeffrey Brown for providing us with invaluable tables of relative mortality risk, and Irena Dushi and Cori Uccello for providing important data analyses. We would also like to thank Jeffrey Brown, Irena Dushi, Marjorie Flavin, Kathleen McGarry, Sara Rix, and Cori Uccello for very helpful comments.

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