COMMENTS WELCOME

Utility Evaluation of Risk in Retirement Saving Accounts

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ABSTRACT

The shift from defined benefit to defined contribution pension plans in the United States has drawn new attention to the effect of participants' asset allocation decisions on their financial resources for retirement. This paper develops a stochastic simulation algorithm to evaluate the effect of holding a broadly diversified portfolio of common stocks, or a portfolio of index bonds, on the distribution of 401(k) account balances at retirement. We compare the alternative distributions of retirement wealth both by showing the empirical distribution of potential wealth values, and by computing the expected utility of these outcomes under standard assumptions about the structure of household preferences. Our analysis highlights the critical role of other sources of wealth, such as Social Security, defined benefit pension annuities, and saving outside retirement plans, in determining the expected utility cost of holding equities in the retirement account. Our findings also demonstrate the importance of the equity premium in valuing retirement account asset allocation. Given the historical pattern of returns on stocks and bonds, a household that is not highly risk averse would achieve a higher expected utility by holding a portfolio of stocks rather than bonds.

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The last two decades have witnessed a remarkable shift in the structure of retirement saving in the United States. In 1980, most workers with pension plans participated in defined benefit plans, with benefits determined by the worker's earnings history, years of service, and age at the time of retirement. The investment allocation of assets in defined benefit pension accounts was determined by professional money managers or corporate executives, and the worker controlled his retirement benefit only through the choice of retirement age and job change decisions.

Over the 1980s and 1990s, the U.S. pension system shifted toward a defined contribution structure, with 401(k) plans growing particularly rapidly. In the late 1990s, about 85 percent of pension plan contributions were directed to defined contribution personal retirement accounts. This shift transferred responsibility for investment decisions, contribution rates, and ultimately the draw-down of retirement assets from firms to workers. It replaced the link between retirement income, job change, and final earnings, which were important sources of worker risk, with a link between retirement account balances and the uncertain return on invested assets. The risk that workers bear as a result of fluctuations in the value of assets in retirement accounts has attracted considerable attention in the popular press, often with the claim that workers are now facing riskier retirement prospects than in the past.

This paper presents new evidence on the risk of different investment strategies when evaluated in terms of retirement wealth accumulation. We use two different approaches to describe the risk of investing 401(k) assets in a broadly-diversified portfolio of common stocks, compared to a portfolio of index bonds. The first involves computing the empirical distribution of potential wealth values at retirement resulting from different investment strategies, and then making explicit comparisons of the wealth distributions. If the average return on one asset class, such as corporate stock, is substantially greater than the average return on another asset class, such as bonds, this approach shows that over long horizons, the higher return asset class will outperform the lower-return asset class with very high probability. One criticism of this approach is that it does not adequately consider the potential cost to a retiree of the low levels of wealth at retirement that might emerge from the riskier, but higher expected return, strategy.

Our second evaluation approach is designed to address this issue. We assume that the value that the retiree assigns to the consumption stream after retirement can be parameterized using a simple utility function, in which utility is a function of the stock of wealth at retirement. We then use simulation methods to compute the distribution of wealth at retirement that might emerge under different portfolio investment strategies, and to evaluate the expected utility of this distribution. Comparing the expected utility, which recognizes the potential cost of a small probability of very unfavorable outcomes, provides an alternative to comparing the distributions as a method for evaluating different investment strategies.

We compare the distribution of retirement wealth and the expected utility of retirement wealth for three different investment strategies. The first involves holding only index bonds, the second holds only a portfolio of common stocks similar to the S&P500, and the third invests in a 50/50 mix of index bonds and common stocks. We conduct our analysis at the household level, recognizing that retirement plan investment decisions have implications for all household members. We also treat the evaluation of risk as a collective household decision. To make the retirement wealth calculations as realistic as possible, our simulations are run through the lifetime profiles of Social Security earnings records for each of 759 Health and Retirement Survey (HRS) households. This allows for realistic variation in age-specific labor income flows. We also calculate the level of non-401(k) wealth holdings for these HRS households. We find that the expected utility of retirement wealth is very sensitive to the value of wealth held outside the defined contribution plan, including both liquid wealth and annuitized wealth such as prospective Social Security benefits or defined benefit plan payouts.

The paper is divided into seven sections. Section one describes our basic framework for evaluating the risks associated with the accumulation of retirement saving. The second section discusses our use of earnings histories for a subset of HRS households. These earnings histories are the basis for contribution flows into our hypothetical 401(k) account. Section three describes our decomposition of the wealth holdings of HRS households near retirement age. The wealth data provide the benchmark against which we evaluate the level of 401(k) assets. The fourth section describes our assumptions about the returns to both stocks and index bonds that are available for the retirement saver, and it outlines our simulation algorithm for generating the distribution of plan assets at retirement. Section five presents our results on the distribution of retirement plan balances, and shows the stock of retirement wealth under different assumptions about portfolio allocation. The sixth section reports our expected utility calculations, focusing on different asset allocation strategies during the accumulation phase. A brief conclusion summarizes our findings and suggests several directions for future work, particularly the comparison between the risks of defined contribution and defined benefit retirement plans.

1. A Framework for Modeling Retirement Wealth Accumulation in Self-Directed Retirement Plans

To analyze the risk associated with the accumulation of retirement assets in defined contribution pension plans, we need to model the path of plan contributions over an individual's working life, and to combine these contributions with information on the potential returns to holding 401(k) assets in different investment vehicles. We need to decide whether the unit of observation is the individual or the household and to specify the age at which contributions begin and end. For the initial analysis reported in this paper, we focus our attention on married couples. We do this because we suspect that this group is more homogeneous than non-married individuals, some of whom are never-married and some of whom have lost a spouse. Married couples represent about seventy percent of individuals reaching retirement age. We assume that a fixed fraction of the household's earnings are contributed to a defined contribution plan. We do not address whether the contributions are due to one or both members of the couple participating in a defined contribution plan. We follow Poterba, Venti, and Wise (1998), who report that the average 401(k) contribution represents roughly nine percent of contributing household earnings, including both employer and the employee contributions.

We assume that the couple begins to participate in a 401(k) plan when the husband is 28, and that they contribute in every year in which the household has social security earnings until the husband is 63. Households do not make contributions when they are unemployed or when both members of the couple are retired or otherwise not in the labor force. When the husband is age 63, we assume that both members of the household retire if they have not already, and that contributions cease.

We denote a couple's 401(k) contribution at age a by $C_i(a)$, where we index each couple by i. A household's contribution $C_i(a) = .09*E_i(a)$, where $E_i(a)$ denotes social security covered earnings at age a. We express this contribution in terms of year 2000 dollars. To find the 401(k) balance for the couple at age 63 (a = 63), we need to cumulate contributions over the course of the working life, with appropriate allowance for the returns on 401(k) assets at each age. Let $R_i(a)$ denote the return earned on 401(k) assets that were held at the beginning of the year when the husband in couple i attained age a . The value of the couple's 401(k) assets when the husband is 63 is then given by:

(1) $$W_i(63) = \sum_{t=0}^{35} \left\{ \prod_{j=0}^{t} [1 + R_i(63-j)] \right\} C_i(63-t)$$

We in turn assume that $R_i(a)$ is determined by the returns on stocks and index bonds. The couple may hold a portfolio of all stocks, in which case $R_i(a) = R_{stock}(a)$, all index bonds, in which case $R_i(a) = R_{bond}(a)$, or a 50-50 mix of the two asset classes, in which case $R_i(a) = .5*R_{stock}(a) + .5*R_{bond}(a)$. We discuss below our calibration of the distribution of risky returns associated with holding stocks.

We report the distribution of $W_i(63)$, averaged over the 759 households in our sample, for the three different investment strategies. These three distributions provide some evidence on how each investment strategy might affect the retirement resources of households that pursued them. The difficulty with this approach, however, is that it does not capture the cost of low payouts in the event of unfavorable returns. To allow for differential valuation of wealth in different states of nature, we evaluate the wealth in the 401(k) account using a utility-of-terminal wealth approach. We assume that the household's preferences over wealth-at-retirement (which we now write as W, dropping the household subscript for ease of notation) are described by a constant relative risk aversion (CRRA) utility function

(2) $$U(W) = \frac{W^{1-\alpha}}{1-\alpha}$$

where α is the household's coefficient of relative risk aversion. The utility of household wealth at retirement is likely to depend on both 401(k) and non-401(k) wealth, and thus we need to modify (2) to allow for other wealth:

(3) $$U(W_{401(k)}, W_{non-401(k)}) = \frac{\left(W_{401(k)} + W_{non-401(k)}\right)^{1-\alpha}}{1-\alpha}$$

The difference in the utility associated with different levels of 401(k) wealth is likely to be very sensitive to the household's other wealth holdings, so in the empirical analysis that follows, we summarize the balance sheets of retirement-age households in the Health and Retirement Survey.

To determine the expected utility associated with various investment strategies, we generate hypothetical 35-year 401(k) return histories associated with the all index bonds, 50/50 bonds/stocks, and all stock investment strategies for each household in our sample. Each return history, denoted by h, generates an associated 401(k) wealth at age 63, $W_{401(k),k}(63)$, and a corresponding utility level, U_h, where

(4) $$U_h = \frac{\left(W_{401(k),h} + W_{non-401(k)}\right)^{1-\alpha}}{1-\alpha}$$

We evaluate the expected utility of each portfolio strategy by the probability-weighted average of the utility outcomes associated with that strategy, and denote these expected utility values EU_{SP500}, EU_{Bonds}, and EU_{50-50}, respectively. These utility levels can be compared directly for a given degree of risk tolerance. They can also be translated into certainty equivalent wealth levels (Z) by asking what certain wealth level would provide a utility level equal to the expected utility of the retirement wealth distribution. The certainty equivalent of an all-equity portfolio, for example, is given by:

(5) $$Z_{SP500} = \left[EU_{SP500}(1-\alpha)\right]^{\frac{1}{1-\alpha}} - W_{non-401(k)}$$

We present certainty equivalent calculations of this form to summarize our findings. Note that when the household has non-401(k) wealth, the certainty equivalent of the 401(k) wealth is the amount of 401(k) wealth that is needed, in addition to the non-401(k) wealth, to achieve a given utility level. We treat non-401(k) wealth as nonstochastic throughout our analysis.

2. Earnings Profiles for Current Retirees

Calibrating the expected utility of various 401(k) portfolio strategies requires information on both the earnings histories and the non-401(k) wealth held by these households. We obtained these data from households in the 2000 wave of the Health and Retirement Study (HRS). The HRS is a longitudinal study of the economic and health status of older Americans. In the first wave of the study (1992), in-home interviews were conducted for respondents in the 1931-1941 birth cohorts and their spouses. Follow-up surveys were administered by telephone every two years. The fifth wave of the survey was completed in 2000, and the core final data for this wave was released in September 2002. This wave provides the most recent and complete source of information on the balance sheet of U.S. households around retirement age.

Table 1 shows the relationship between the number of households in various waves of the HRS, and their corresponding household counts for the U.S. population. There were 7580 households in the first wave of the HRS, but various factors, most importantly death or voluntary termination of survey participation, reduced the sample size in subsequent waves. By the 2000 wave, respondents from only 6074 of the original households remained. After accounting for household splits due to divorce and excluding five observations with missing birth years, we had a sample of 6195 households in 2000. The sampling probabilities for these households suggest that they represent 16.7 million U.S. households. Among these households, 4.3 million had a household head, which we define as the husband in the case of married couples, with less than a high school education, 8.6 million had a household head with maximum education attainment of high school or some college, and 3.8 million had a household head with a college or postgraduate education. Because lifecycle earnings profiles differ for households with different levels of education, we present separate earnings histories for these three groups.

We construct an earnings profile for each household using data from the Social Security administrative records file. These data are available for 4233 of the 6195 households in the 2000 wave of the HRS and contain Social Security earnings from 1951-1991. Appendix Table A-1 provides a detailed breakdown of the number of sample households in the HRS that satisfy our further data requirements and are included in our sample. Throughout our analysis, we deflate historical nominal wages by the CPI to construct real wages at each age. For years after 1991 in which a member of the household was still working, we multiply reported HRS wage and salary earnings by a scaling factor equal to the ratio of Social Security administrative earnings in 1991 to reported HRS earnings in the same year. We thereby construct a proxy for Social Security earnings for 1993, 1995, 1997, and 1999. We assume that in even-numbered years for which we do not have a survey response, earnings remained at the same level as in the previous year.

We want to base our simulations on households who have completed their working lives, and potentially to consider their wealth at retirement relative to their final earnings. We therefore construct a measure of final earnings which we view as representative of household labor earnings near retirement. This measure is defined as household earnings in the year before the household's reported retirement year. In dual-earner households, this is the year in which the first retirement takes place. Retirement of either the primary or the secondary earner can therefore trigger the final earnings calculation.

A number of the HRS households reported that all members of the household were still working in 2000, so that we could not define final earnings for them. Extrapolating the HRS data to the nation as a whole using HRS weights, out of 16.7 million households in the survey, 9.0 million had at least one member of the household working, and 2.6 million had two earners. Another group, 0.9 million households, contained someone who reported both working and being retired. These individuals are presumably working part-time or have partially re-entered the labor force. Out of 2.1

million couples for whom we could compute final earnings, and in which the husband was aged 63-67, 1.3 million had at least one person working, 0.5 million had both working, and 0.2 million had at least one person claiming to be both retired and working.

Table 2 presents summary information on the median earnings profiles for households in our sample, including years with no earnings because of unemployment or retirement. The table also reports the number of HRS households that are used to estimate the earnings profiles. We present tabulations for four different sets of households in the HRS universe. The first, in the first column, is the earnings profile for all HRS households with social security earnings histories, regardless of their household structure and whether they had left the labor force by 2000. The second column shows the earnings profile for households with at least one labor force leaver, and for which it is therefore possible to compute final earnings — this represents 3749 of the 4233 households with earnings profiles. The third column further tightens the selection criterion, by limiting the analysis to married couple households at the time of the 2000 HRS survey. This reduces the sample size to 2275 households. Finally, in the last column we restrict the sample to married couples in which the husband was between 63 and 67 in 2000. This limits the sample to only 759 households. This is a relatively homogenous sample that we use for much of our subsequent analysis. In further work we plan to generalize our procedures to all households.

The entries in the columns of Table 2 track median earnings for each of the education groups and subsamples that we consider. Not surprisingly, there are very substantial differences in the level, and the shape, of the earnings profile across subgroups. The peak earning level for couples in our sample is up to six percent higher than the peak earning level for all couples with final earnings and up to two times higher than that of all households with earnings histories (including singles). The ratio of peak median earnings to salary early in life is highest for the group with the highest education levels. Median earnings of couples in which the better-educated spouse has at least a college degree are up to a third higher around age 60 than those in couples in which neither has a college degree. The better educated households have lower earnings than the less-educated groups, however, between ages 25-30, when the highly educated group are presumably still accumulating educational human capital.

For comparison, Figures 1A and 1B show the age-earnings profiles for couples with final earnings and a husband between the ages of 63 and 67 in 2000. These figures exclude years in which a household has zero earnings. Figure 1A shows median income relative to age 28 earnings and Figure 1B shows median income in year 2000 dollars. All three educational groups show a decline in the last third of the working life even excluding household-year observations with zero earnings. The shape of the age-earnings profile matters for our computations of 401(k) balances at retirement, and it also affects the interpretation of financial magnitudes that are normalized by final earnings. We therefore analyze the three education groups separately in our computation of simulated 401(k) balances at retirement. We include years of zero earnings in our simulations to account realistically for work interruptions and retirement.

3. Household Balance Sheets and Non-401(k) Wealth for HRS Respondents

We now consider the household balance sheet, to calibrate the non-401(k) wealth that affects the expected utility of retirement wealth. We classify total household wealth into seven categories: the present discounted value of Social Security payments, the present discounted value of defined benefit pensions, the present discounted value of other annuities, the current value of retirement accounts, all other net financial wealth, housing equity, and all other wealth.

The retirement account category includes IRAs, 401(k)s and other defined contribution accounts. Data on DC plan balances were collected for each respondent in the employment module of the HRS, and then aggregated to the household level. Amounts classified as DC wealth include the balances of workers at their present job, plus any balances that workers or retirees left to accumulate in the plans of former employers. “Other net financial wealth” includes stocks, equity mutual funds, bonds, fixed income mutual funds, checking and saving accounts, money market mutual funds and certificates of deposit. We refer to this category below as “financial wealth” despite the fact that it excludes annuitized wealth and retirement account assets. Net housing wealth equals gross home value less mortgages and home loans on the primary residence. The other wealth category includes the net-of-debt value of real estate other than household's principal residence, the value of businesses or farms net any outstanding debt, all assets held in trusts not otherwise classified, vehicles, and all "other" HRS wealth which includes jewelry and expected repayment on personal loans.

The present discounted value (PDV) of Social Security wealth is calculated based on the reported current Social Security payments for members of the household already receiving Social Security, plus reported expected Social Security payments for other members not yet receiving Social Security. We do not use actual Social Security earnings histories to compute expected or accrued Social Security payments for individuals still in the labor force in 2000. Actual earnings histories end in 1991, and there is uncertainty about the date of retirement for individuals still in the labor force.

We used cohort mortality tables for individuals born in 1930 to value Social Security payment streams. Distinct mortality probabilities for men and women were taken from the Social Security Administration (SSA) life tables for the US Social Security Area, as reported by Bell and Miller (2002). The SSA's intermediate-cost scenario discount rates (3.0 percent real, 6.0 percent nominal) were applied to discount future payments, and payments were assumed to be indexed using an expected inflation rate of three percent. In these calculations, we take the joint-and-survivor properties of Social Security into account. We assume that as long as both members of the couple are alive, each respondent receives his or her current or projected Social Security benefits. When only one member of the couple is alive, we assume that the household receives benefits equal to the maximum of the two spouses' benefits.

Of the 6195 observations represented in HRS Wave 5, 2293 reported receiving a defined benefit (DB) pension while 478 reported expecting to receive a DB pension at some future date. Thus, out of the 16.7 million represented households, 7.7 million received or were expecting to receive DB pensions. To determine the PDV of reported DB wealth, we took a similar approach to our valuation of Social Security wealth and valued the annuitized payment streams using the same mortality tables and discounting assumptions. Although some DB plans have cost of living adjustments, most are not indexed to inflation. We therefore assume that all DB pensions have a fixed nominal payout. We make the same assumption for any other other annuities owned by household members.

Table 3 presents information on mean and median wealth levels for the four groups of HRS households whose earnings histories were shown in Table 2. The Social Security earnings history sample is slightly less wealthy than the sample consisting of all households, but the households generally become wealthier as we move from the entire HRS to our most restricted sample of couples with husbands between the ages of 63 and 67 in 2000. We focus on this group in the subsequent analysis, since this is the group that is at, or slightly older than, the typical age of retirement in the most recent HRS survey wave. For this group, we find the median value of a defined benefit pension of $35,400. The mean value, $182,600, is much greater, reflecting the right skewness of the distribution of pension values. For Social Security wealth, the median ($242,000) is actually greater than the mean ($228,900), which reflects the upper limit on Social Security benefits.

Table 3 also shows several wealth aggregates. First, we compute annuitized wealth as the sum of the present discount values of Social Security, defined benefit pensions, and other annuities. We also present the sum of annuitized wealth and all other financial wealth, as well as aggregates reflecting all wealth and all wealth excluding retirement account assets. When we calibrate our simulations with individual households' non-401(k) wealth, we focus on two wealth components: annuitized wealth and all wealth excluding retirement account assets. We do not wish to include retirement account assets in the calibration of non-401(k) wealth on the grounds that we are using our simulations to construct values of retirement accounts. By using the observed values of these wealth components from the HRS, and treating them as non-random when we evaluate the expected utility of 401(k) retirement balances, we are implicitly assuming that changes in 401(k) wealth values do not affect other components of wealth. In future work, we plan to allow for correlation between the returns on assets in 401(k) accounts, and the returns on other components of the household balance sheet.

Table 3 also shows final income for the various HRS sub-samples. Below, we report the ratio of the wealth components to final income, so the variation in final income is of independent interest. In the upper panel of Table 3, the ratio of median Social Security wealth to final income is a little over five, while the ratio of broadly-defined net financial wealth to final income is about three. These statistics suggest the importance of recognizing wealth sources other than defined contribution plans in analyzing the risks of portfolio strategies.

Although Table 3 shows net housing wealth as a balance sheet component, its role in providing resources for retirement consumption is not clear. Several studies, such as Venti and Wise (2001b, forthcoming) and the references cited therein, suggest that retired households do not typically draw down their housing wealth to finance non-housing consumption. This work suggests focusing only on non-housing wealth as we consider the wealth available to support retirement spending. One way to conceptualize this approach is to assume the utility from housing consumption as additively separable from all other consumption in the household's utility function, and to further assume that owner occupied housing generates only housing consumption. The difficulty with this approach is that it is possible that households view their housing equity as a reserve asset that can be tapped to support other consumption in the event of financial difficulty. In this case, housing equity should be combined with financial assets in calculating the household's assets outside defined contribution plans. To allow for this possibility, we present results in which we consider housing as well as other financial assets as the household's non-401(k) wealth at retirement.

Table 4 presents information on wealth holdings across different education subsamples. The results suggest that there are importance differences across groups. The table focuses on the sub-sample of HRS couples that have earnings records and in which the husband is between 63 and 67 in 2000. The summary statistics show the clear link between education and wealth, measured both in absolute dollars and relative to final income. Annuitized wealth alone is $240,800 for the median household with less than a high school education and $375,500 for those with at least a college degree. The dispersion here is mostly due to the disparities across education categories in the level of defined benefit pensions. The present discounted value of Social Security benefits varies relatively little. It is $217,000 for those who never finished high school, and $248,800 for those with at least a college degree. Other financial wealth, which excludes annuitized wealth and retirement account assets, displays a high degree of dispersion, with $8,100 for the median household with less than a high school education and $328,000 for the median household with at least a college degree. These findings suggest that in evaluating 401(k) plan risk, the effect of accounting for non-401(k) assets will vary across education groups.

Table 4 summarizes the average wealth holdings of the different education groups, but it does not characterize the dispersion of wealth within these groups. Table 5 offers further detail on such distributions, showing the 20th, 40th, 60th, and 80th percentiles of the distribution of each wealth component relative to final income. Consider, for example, financial wealth. For households with high school and/or some college education, but no college degree, the 20th percentile value of the ratio of financial wealth to final earnings is 0.1 while the 40th percentile value is1.0 and the 80th percentile value is 7.4. Patterns like this emerge for each of the asset categories, with very substantial dispersion between the lowest and the highest percentiles. These tabulations suggest that one household having a higher educational attainment than another does not guarantee a higher ratio of any given financial asset class to labor income. In particular, the ratio of Social Security wealth to final earnings decreases with education. Venti and Wise (2001a) emphasize the wide range of asset accumulation within like lifetime earnings groups, at all lifetime earnings levels.

The entries in Table 5 show the ratio of wealth components to final earnings. Final earnings vary systematically across education group, however, which makes it difficult to identify the underlying differences in wealth holdings. To facilitate such analysis, Table 6 presents information on the wealth distribution with all entries measured in year 2000 dollars. For the median household in each education group, the results suggest a substantial amount of non-401(k) wealth already in place. The 40th percentile value of total wealth excluding retirement assets less for couples in our sample with less than a high school degree is $311,800, compared with $527,700 for those with at least a high school degree and $1,007,700 for those with at least a college degree. For the 60th percentile these values are $424,900, $708,600, and $1,393,900 respectively. The households in the 60th percentile of the distribution of those with less than a high school degree correspond to those near the 30th percentile in the group with a high school degree and/or some college education, and to those near the 10th percentile in the group with at least a college degree.

4. Asset Market Returns and Equity Premium

Our simulation methodology is designed to calculate the 401(k) wealth at retirement for households with any given earnings profile while accounting for uncertainty in the distribution of financial market returns. We treat the other components of the household balance sheet as non-stochastic, although as we further develop the simulation algorithm that we describe here, we will include a more complete analysis of the uncertainties associated with non-401(k) wealth.

We assume that households have two investment choices in their 401(k) accounts. One is an index bond, with an assured real return of 2.8 percent per year. The current term structure of yields (April 22, 2003) on U.S. Treasury Inflation Protection Securities is upward sloping. For bonds with a maturity of between five and six years, real interest rates are less than two percent. At a maturity of almost thirty years, the yield is between 2.7 and 2.8 percent. Since retirement saving accumulation takes place over long horizons, and to err on the side of generosity in the assumed return on bonds, we assume that investments in index bonds earn a return of 2.8 percent each year, net of inflation.

Index bonds deliver a net-of-inflation certain return only if the investor holds the bonds to maturity. Investors who sell their bonds before maturity, however, are exposed to asset price risk. If real interest rates rise between the time index bonds are purchased and the time they are sold, the price of the bonds can decline, leaving the investor with a capital loss. Similarly, a decline in real interest rates would generate a capital gain. When investors do not know the precise timing of their withdrawals, as they may not when they contemplate retirement with an unknown lifespan, purchasing an index bond is not riskless. These bonds nevertheless seem like the least risky long-term investment available to retirement savers.

The alternative investment in our simulations is a diversified portfolio of large capitalization U.S. stocks. We assume that the uncertain real return on this portfolio is represented by the empirical distribution of returns during the 1926 to 2001 period. Ibbotson Associates (2002) reports the annual return time series, which has an annual average real return of 9.4 percent and a standard deviation of 20.4 percent. Figure 2 presents a histogram of real returns, which shows substantial dispersion.

In an earlier simulation analysis of 401(k) wealth accumulation, Poterba, Venti, and Wise (2001) considered investments in nominal bonds and corporate stock. We consider investments in index bonds rather than corporate bonds in the current project because they are likely to provide a less risky source of long-term returns, and therefore to provide a more natural benchmark for analyzing the risks of corporate stock from the vantage point of retirement income accumulation.

On each iteration of our simulation algorithm, we draw a sequence of 35 real stock returns from the empirical return distribution. The draws are done with replacement and we assume that there is no serial correlation in returns. We then use this return sequence to calculate the real value of each household's retirement account balance at age 63, assuming that their contributions are determined by their earnings history. We consider the full 35-year working life for each household, and we evaluate both a 100 percent equity investment case, and a 50-50 stocks and index bonds case. Since the goal of our procedure is to generate reasonably precise estimates of the distribution of possible wealth outcomes for a given contribution history, we need to repeat our basic iteration many times. We found that with 200,000 replications, we could obtain estimates of the outcome distribution that did not vary substantially from one simulation to another. For each one of the 759 households in our sample, therefore, we simulate their 401(k) balance at age-63 200,000 times. We then summarize these 200,000 outcomes either with a distribution of wealth values at retirement, or by calculating the expected utility associated with this distribution of outcomes.

5. The Distribution of 401(k) Account Balances Under Different Portfolio Strategies

Table 7 shows the distribution of 401(k) plan balances in thousands of year 2000 dollars, averaged across the 759 households in our sample. Households are stratified by education group. The first row in Table 7 shows the results associated with a 100 percent index bond investment. Since the real bond return is certain, there is no uncertainty about the final wealth in this investment scenario. The value of 401(k) wealth varies somewhat across education categories: $172,700 for those with less than a high school degree, $230,400 for those with high school and/or some college, and $248,200 for those with a college degree. As all three groups are assumed to have the same contribution rates out of earnings, these disparities reflect differences across groups in age-earning profiles. The assumption that all households contribute nine percent of their earnings to their 401(k) account is a critical determinant of the overall magnitudes of the final account balances. Account balances could be scaled up or down for alternative assumptions about the contribution rate.

The next two panels of Table 7 show the distribution of 401(k) balances when half, and then when all, of the 401(k) account is invested in corporate stock. The table shows the value for each tenth percentile of the distribution. For households with a high school education, simulated 401(k) wealth is $299,200 at the 20th percentile, and $591,200 at the 80th percentile when the 401(k) account is invested 50 percent in corporate stock.

Figure 3.1.A shows the ratio of 401(k) wealth to final earnings for households with a high school or some college education, for the all-index bond, the mixed, and the all-stock portfolio strategies. Over most of the distribution of possible stock returns, the ratio of wealth to final earnings is higher when the portfolio is half in corporate stock than when it is completely in index bonds. The figure shows that if a household holds the all-equity portfolio, the chance is slightly greater than ten percent that the wealth outcome at retirement will fall below below the outcome for the index bond portfolio. The scale of Figure 3.1.A illustrates why we focus on dollar amounts of the simulation in our tables and analysis. Some households' earnings decline before retirement, resulting in very low final earnings and correspondingly very high ratios of 401(k) balances and other wealth components to final earnings. Taking means over a distribution that includes such extreme values can lead to spurious findings. To highlight this issue, Figure 3.2.A shows the same data as in Figure 3.1.A, but with dollar amounts instead of ratios to final earnings.

One potential difficulty with our simulation procedure is that the historical period over which we measure equity returns may have been abnormal. Mehra and Prescott (2002) discuss this possibility along with other potential explanations for the "equity premium puzzle." To allow for the possibility that the historical distribution of equity returns may overstate the prospective returns on stocks, we also consider a reduced equity return scenario, in which we reduce the expected return on corporate stock by 300 basis points, while leaving the dispersion of returns the same as in the base case. The results of this modification, for both half and all of the 401(k) account invested in corporate stock, are shown in the lower two panels of Table 7 and in Figures 3.1.B and 3.2.B. The results indicate that with a lower equity return, the index bond investment strategy looks more attractive relative to the equity investment strategy. Even with the reduced equity return, however, there is still a relatively low probability that the all-index bonds strategy will outperform a 50-50 mix of index bonds and corporate stock. With the reduced equity return, the retirement wealth in the all index bonds case for a household with high school and/or some college education falls at around the 22nd percentile of the outcome distribution for the 50-50 mix of index bonds and stocks. It falls at around the 31st percentile in the outcome distribution with only stock investment, which attests to the greater volatility, as well as the greater average return, from holding all stocks rather than a 50-50 mix. . Similar patterns emerge in the retirement wealth distributions for the other educational groups.

Evaluating the absolute magnitude of retirement assets as reported in Table 7 is complicated by the fact that assets in the 401(k) account are measured on a pretax basis. Withdrawal of these assets would trigger income tax liability for the beneficiary. Simple corrections for this, such as multiplying by (1-t) where t is a plausible estimate of the marginal tax rate on ordinary income, are not sufficient, because if the assets remain in the 401(k) account for many years after the head of household turns 65, the effective tax burden may be relatively low. Poterba (2003a) presents illustrative calculations on the conversion between balances in taxable and tax-deferred accounts.

6. Certainty Equivalent Measures of the Cost of Uncertain Returns

Table 7 and Figures 3.2.A and 3.2.B are examples of the use of the entire distribution of retirement wealth outcomes to describe the effects of different portfolio strategies. They present information on how different portfolio strategies will affect the average level of retirement wealth, as well as its dispersion. The fraction of retirement wealth outcomes in the all stock or 50-50 stock/index cases that fall below the outcome in the all-index bond case provides some insight on the risks associated with the various strategies. Results similar to these are a key component of "outcomes based" financial planning software that enables clients to determine the probability of reaching retirement wealth goals. These software programs are based on Monte Carlo simulations of future wealth accumulations, and their results provide a "picture" of the risk associated with different investment strategies. Presumably, different investors with different tolerances for risk would prefer different investment strategies.

Results that portray the "picture" of retirement wealth risks provide no *a priori* way to describe how households or groups of households might evaluate these two distributions and thereby decide which portfolio strategy to pursue. At the heart of this difficulty is the question of how households evaluate small probabilities of low retirement plan balances. The "picture" approach does not attempt to evaluate the cost to a household of achieving a retirement wealth outcome below the all-bonds level.

The last part of our analysis is directed to this issue. We compute the expected utility generated by the distribution of retirement resources for each portfolio strategy, using a standard household utility function. We then convert this expected utility to a certainty equivalent wealth measure to value the potential outcomes of different portfolio strategies. Table 8 presents these results assuming that the 401(k) balance is the household's only wealth. By excluding other wealth and assuming that the household is dependent on 401(k) wealth only, these calculations exaggerate the true level of risk faced by the household. Since household consumption risk during retirement is tempered by the existence of non-401(k) wealth, we relax this counterfactual assumption below.

The values in the first panel in Table 8 are based on linear utility (α=0) and are thus the expected values of each investment choice represented in Table 7. The second panel shows that for a household with no wealth outside the retirement account, and whose preferences over wealth are given by U(W) = log W, (α=1) the certainty equivalent value of a portfolio invested in the large-cap equity portfolio is nearly three times as great as the value of the all-index-bond portfolio for a household with a high school education. For a 50/50 index bond and stock portfolio, the certainty equivalent is between 80 and 85 percent larger than the value of the all-index bond investment strategy. As risk aversion rises, the certainty equivalent value for the stock portfolio declines relative to the value of the index bond portfolio. When the household has a relative risk aversion of two, for example, the certainty equivalent of the all stock investment declines to about twice that of the all index bond portfolio, while the certainty equivalent of the 50/50 portfolio falls to around 70 percent of the value of the index bond investment. At a risk aversion of four, the certainty equivalent of an all-stock portfolio allocation is only slightly greater than that of an all-index bond allocation, but the value of a 50/50 portfolio remains considerably larger in certainty equivalent terms.

Figure 4 shows the cumulative distribution of the utility values of the wealth outcomes in the simulated distribution for four different levels of risk aversion. These are transformed values of the constant relative risk aversion utility function in equation (2) for each of the simulated outcomes. The utility values are scaled using a linear transformation, such that zero is the worst empirical outcome and one is the best outcome for each value of α. When $\alpha = 0$, so that the household is risk neutral, the plot of the cumulative distribution function (CDF) for utility levels is the same as the cumulative distribution of the values of wealth at retirement. The 90^{th} percentile outcome is less than 10 percent of the level of the best possible outcome, reflecting the very long upper tail of the empirical distribution. The cumulative density function for the risk neutral household is convex. As risk aversion increases, the distribution of utility diverges more and more from the distribution of wealth, and it becomes clear that raising risk aversion puts more weight on the negative outcomes in the left tail of the potential retirement wealth distribution. The second derivative of the CDF rises as risk aversion increases. When α=4, the CDF is highly concave, as the low retirement wealth outcomes generate very low utility outcomes. As a result, by the fifth percentile of the utility outcome distribution, household utility is already 99 percent of the level of the best utility outcome.

Figures 5.1.A – 5.3.B show the distribution of certainty equivalent wealth values, measured in dollars at age 63, for different levels of risk aversion and for each of our investment strategies. We restrict attention in these figures to households with a high school education. The three sets of figures differ in the assumptions that they make about the household's non-401(k) wealth at retirement.

Figure 5.1.A shows that an all-stock portfolio is preferred to an all-index bond portfolio by investors with risk aversion (α) below approximately 4.25. This is not surprising, since the empirical distribution of historical stock returns has a much higher mean than the index bond portfolio. Thus only a small number of 401(k) wealth outcomes under the partial- or full-equity strategies fall below the value of the index bond portfolio. The variability of returns on corporate stock does not create enough low utility outcomes to lead households with modest risk aversion to choose index bonds over a portfolio with some equity exposure. A 50/50 mixture of stock and index bonds is preferred to an all-bond portfolio by investors at all levels of risk aversion shown in the figure. The value of α that would make a household indifferent between the all-index bonds portfolio strategy and each of the equity exposure strategies can be found at the intersections of the various curves. A value of α greater than eight is needed for a household to prefer all index bonds to a 50-50 index bond-stock mix. For α > 2.75, a household prefers the 50/50 mix to an all-stock portfolio.

Figure 5.1.B. shows that the certainty equivalent of the 50 percent and 100 percent equity allocations declines if the expected return on corporate stock is assumed to be 300 basis points lower than historical returns. The effects are most pronounced at high levels of risk aversion. For $\alpha = 4$, for example, the certainty equivalent of an all-stock allocation falls substantially below that of the all-index bond portfolio when the expected equity return is 6.4 percent, while it is just under 10 percent

higher than the certainty equivalent of the bond portfolio when an average equity return of 9.4 percent (the historical mean) is assumed. Even with $\alpha = 2$, however, the expected utility of following the all-stock investment strategy exceeds that of the all-index bonds strategy when the expected equity return is 6.4 percent. When we reduce the average return by 300 basis points, the levels of α for which stocks and the 50/50 mix are preferred to the index bond portfolio are lower. Investors with $\alpha < 2.25$ prefer the all-stock portfolio strategy over all-index bonds in this case, and those with $\alpha < 4.5$ prefer the 50/50 mix to the all-index bond portfolio even when the expected return on stocks is reduced.

The results in Table 8 and Figures 5.1.A and 5.1.B assume that the 401(k) balance is the only wealth that the household accumulates to provide for retirement support. A sequence of stock market returns that delivers a very low retirement wealth is therefore very costly in terms of household utility. Yet the summary statistics in our earlier tables show that essentially all households have Social Security wealth and a large fraction of households have other wealth as well. To explore the importance of these other sources of retirement income, we repeated our stochastic simulations, taking account of other wealth. In Table 9 and Figures 5.2.A and 5.2.B, we assume that each household in our simulations holds non-401(k) wealth at retirement equal to the present discounted value of their Social Security wealth, DB plan wealth and income annuity wealth. In Table 10 and Figures 5.3.A and 5.3.B, each simulation household receives non-401(k) wealth at retirement equal to their total net worth — including Social Security wealth, DB wealth, and income annuity wealth — but excluding the value of retirement account assets that they report.

Table 9 thus presents findings like those in Table 8, but from simulations that account for the presence of social security, DB wealth, and other income annuities, in addition to simulated 401(k) wealth. The first row of each panel in Table 9 shows that for a couple with a high school education, the index bond portfolio generates the utility level associated with $230,400. This is identical to the index bond portfolio certainty equivalents in Table 8, and it is independent of α, as there is no uncertainty associated with this simulated investment strategy. Comparing the other results in Table 9 with those in Table 8 shows that the certainty equivalent from holding a risky stock portfolio is larger when the household has other sources of financial support than when it does not. For example, households with a high school education and with log utility ($\alpha = 1$) have certainty equivalent wealth equal to $669,300 for the stock portfolio in Table 8, where we assume no non-401(k) wealth. But the certainty equivalent of the 401(k) account rises to $743,600 when Social Security, defined benefit pension wealth, and other income annuity wealth are included as non-401(k) wealth as in Table 9.

Including another non-stochastic wealth component for non-401(k) wealth raises the certainty equivalent of the 401(k) account still further, as shown in Table 10, where all non-retirement account assets reported in the HRS are included in the utility evaluation for each household. For the household with a high school education and log utility, the all-stock portfolio now has a certainty equivalent of $779,600. Therefore, relative to the all-index bond case where the certainty equivalent is $230,400, the all stock investment generates a certainty equivalent that is 2.9 times greater if there is no wealth, 3.2 times greater than the case with Social Security, DB, and other annuity wealth, and 3.4 times greater than if non-401(k) wealth consists of all HRS wealth excluding retirement accounts. This increase in certainty equivalent wealth with larger levels of non-stochastic wealth is a feature of the constant relative risk aversion utility function.

At higher levels of risk aversion, the assumptions that we make about non-401(k) wealth are more important than at lower risk aversion values. The all stock strategy has a certainty equivalent of $252,800 for α=4 when we assume households have no non-401(k) wealth as in Table 8. This is only ten percent higher than the certainty equivalent of the all index bond strategy, $230,400. However, the certainty equivalent of the all stock strategy rises to $443,300 in Table 9 and $517,600 in Table 10. These values are 1.9 times and 2.2 times the values with the all index bond portfolio.

7. Conclusions and Directions for Further Work

This paper presents new evidence on the valuation of risky retirement saving assets when investors have a choice between investing in corporate stocks and index bonds. We find that the historical return distribution for equities leads investors to earn higher expected utility, in most cases, if they invest primarily in stocks rather than in index bonds. We have explored the robustness of this finding to reducing the expected return on corporate stocks by 300 basis points per year. While this shifts the distribution of retirement balances to lower values, and reduces the expected utility of holding stocks, we still find that only highly risk averse investors would choose not to hold corporate stocks.

Data on asset allocation in retirement accounts is broadly consistent with the expected utility results that emerge from our simulations. Bergstresser and Poterba (2003) report that of the 51.1 million households in the 2001 Survey of Consumer Finances with some assets in a tax-deferred account, just over twenty percent (10.4 million) hold only bonds. The overall allocation between stocks and bonds in tax-deferred accounts is similar to that in defined benefit plans, which are managed by professional investment managers. One important difference is that there is a higher concentration of company stock in defined contribution plan accounts.

One of our goals is to compare two alternative approaches to evaluating the riskiness of portfolio strategies for retirement wealth accumulation. First, we presented "pictures" of the distribution of wealth outcomes for different investment allocation rules. This approach is closely related to the techniques used by many financial planners, who show clients the set of outcomes that they might achieve under a given set of assumptions about future returns and investment strategy. It is also the approach that we, and others, have used in past studies that considered the returns to different investment strategies. Feldstein and Ranguelova (2001) use a related approach to summarize the potential returns associated with different investment strategies in a partially-privatized Social Security system. Second, we tried to synthesize the information in the distribution of wealth outcomes by computing an expected utility measure corresponding to each distribution. This approach allows for the possibility that the marginal utility of wealth declines with wealth, so that a given increment to wealth is more valuable when wealth is at a low level than when it is high.

Both the "picture" and the parametric utility function approaches are useful. The "picture" provides the information that any household that is considering retirement saving needs to evaluate the various investment strategies. It could be used, and sometimes is used, by financial planners who are trying to elicit a household's preferences with respect to risk. The planner can show the household several distributions of potential wealth outcomes, and then ask which of these outcome distributions is preferred. In such a setting, different households would be expected to reach different conclusions about which strategy to pursue. This would reflect heterogeneity in their risk preferences.

The parametric utility function approach starts from the premise that a household's relative risk aversion can be characterized by a single parameter. Conditional on this parameter, it is straightforward to characterize the optimal portfolio strategy for the household. This approach assumes away the problems associated with eliciting a household's preferences with regard to risk and it requires strong parametric assumptions about the form of the household's utility function. When it is reasonable to maintain these assumptions, however, the parametric utility function approach delivers simple rankings of different portfolio strategies.

The parametric utility function approach can potentially provide some guidance on the extent to which observed portfolio choices can be reconciled with the optimizing choices of households that are trying to maximize their expected utility. Any analysis of such choices requires data on assets held outside retirement accounts as well as inside these accounts, since there are important asset location issues that combine tax planning with investment choices in both taxable and tax-deferred accounts. If we are prepared to assume that past returns will characterize future returns on various asset classes, we can make estimates of how risk averse a household would have to be to forego any investment in corporate stock, or to hold only one quarter of its overall portfolio in stock. From these calculations, one could implicitly evaluate the fraction of households in the overall population that would need to have risk aversion above a given level in order to rationalize observed portfolio holdings.

The findings in this paper suggest a number of promising directions for future work. One is to develop a richer stochastic structure for the determination of 401(k) balances as well as the other components of the household balance sheet. The states of nature in which defined contribution plan balances are low are likely to be states of nature in which other wealth balances are also low, for example because aggregate stock market returns have been low. To the extent that fluctuations in real interest rates affect 401(k) values, and that such movements also affect the present discounted value of Social Security benefits and defined benefit pension benefits, virtually all of the balance sheet components may exhibit some covariance.

It should also be possible to extend our framework to consider other assets that could be held in the retirement account. There is particular interest in the role of employer stock in 401(k) plans, as indicated in Mitchell and Utkus (2003), Munnell and Sunden (2002), and Poterba (2003b). While we have focused on index bonds as a low-risk investment strategy for 401(k) investors, we could also consider investments in corporate bonds, which expose investors to inflation risk. Our earlier work on portfolio holdings in 401(k) plans, Poterba, Venti and Wise (2001b), considered the risk of investment portfolios with nominal bonds and corporate stock.

A second natural direction for further work concerns the comparison between the risks associated with defined benefit and defined contribution pension arrangements. Samwick and Skinner (2001) use data from the Survey of Consumer Finances (SCF) to compare the risks of the two types of retirement schemes from the standpoint of retirement income security. The SCF includes detailed information on the structure of pension arrangements for survey respondents, through the Pension Provider Survey, but it does not include data on the earnings history for survey participants. Yet the risks associated with defined benefit plans depend significantly on the pattern of job changes, job loss, and retirement decisions for individual worker, as documented in a series of papers by Kotlikoff and Wise and reviewed in Kotlikoff and Wise (1989). The HRS data, linked with Social Security Administration earnings records, make it possible to assess these risk sources in defined benefit plans. We are currently developing an algorithm to evaluate DB plan risk.

Finally, further work can explore the extent to which simple utility functions, such as power functions of wealth, provide an adequate description of the criterion that individuals use to evaluate their choices in the face of asset price risk. There is a long tradition, as indicated by many studies that are cited in surveys by Rabin (1998) and Starmer (2000), of finding inconsistencies with standard expected utility analysis. Kahneman and Tversky (1979) is a seminal example. Even within the framework of parametric CRRA utility functions, there is little consensus on the "correct" valu e of the relative risk aversion coefficient. We are concerned more generally that choices predicted by the CRRA function may be a poor guide to actual behavior when the distribution of wealth outcomes includes values near zero. We hope to gain a better understanding of individual preferences over uncertain levels of future retirement assets by developing a set of survey questions designed to elicit respondent preferences over alternative wealth outcomes. We hope to include these questions on household surveys like the Health and Retirement Survey. Kapteyn and Teppa (2002) have had some success in using a similar approach to explain household portfolio choices as a function of risk preference, as revealed by a set of survey questions. Ultimately, we aim to improve our ability to judge how individuals rank the distributions associated with different asset allocation and saving strategies.

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Table 1: Sample Composition and Education Attainment, Health and Retirement Survey

	Survey Households	Population Counterpart
HRS Wave 1 (1992)	7580	18.6 million
HRS Wave 5 (2000)	6074	n/a
Excluding households with missing birth years and accounting for household splits (Wave 5)	6195	16.7 million
Head < high school	1823	4.3 million
Head high school or some college	3103	8.6 million
Head college degree or more	1269	3.8 million
With Social Security earnings history	4233	11.6 million
Head < high school	1228	3.0 million
Head high school or some college	2123	6.0 million
Head college degree or more	882	2.7 million

Source: Authors' tabulations from HRS.

Table 2: Average Income Trajectories for HRS Households in 2000

Age Range	Median Including Zeros: Households with SS Histories	Median Including Zeros: Households with Final Earnings	Median Including Zeros: Couples with Final Earnings	Median Including Zeros: Couples with Final Earnings, Male 63-67	Mean Including Zeros: Households with SS Histories	Mean Including Zeros: Households with Final Earnings	Mean Including Zeros: Couples with Final Earnings	Mean Including Zeros: Couples with Final Earnings, Male 63-67
Less than High School Education ($ thousands)								
25-27	9.8	12.3	21.2	18.6	13.0	14.2	19.5	17.6
28-30	14.4	16.9	25.4	24.4	15.8	17.1	23.7	21.5
31-33	17.3	20.3	26.8	28.2	18.1	19.7	26.9	26.8
34-36	19.9	22.9	29.5	33.1	20.6	22.4	30.4	30.7
37-39	21.7	24.8	34.4	34.9	22.8	25.0	34.3	34.0
40-42	22.8	26.3	37.6	42.1	24.5	27.1	37.4	38.2
43-45	21.6	26.1	40.0	42.3	25.2	28.0	38.9	40.4
46-48	20.8	24.7	42.0	41.2	25.7	28.6	40.3	39.4
49-51	19.8	24.2	40.0	41.2	25.1	28.2	39.6	40.1
52-54	17.6	21.7	38.4	40.1	24.2	27.3	38.4	38.7
55-57	13.8	18.7	32.7	33.7	21.7	24.7	34.6	34.9
58-60	6.1	11.8	25.8	29.2	17.9	20.6	28.8	31.1
61-63	0.0	1.1	6.6	11.6	11.3	13.3	18.1	20.3
64-66	0.0	0.0	0.0	0.0	4.2	4.9	7.3	4.2
High School Degree and/or Some College ($ thousands)								
25-27	20.4	21.8	26.5	26.4	18.8	19.6	26.3	25.2
28-30	24.9	25.7	28.3	26.8	21.5	22.4	30.0	27.9
31-33	26.3	26.7	33.6	34.6	23.8	24.9	33.1	33.9
34-36	28.4	30.2	36.4	36.3	26.7	28.0	36.8	36.4
37-39	32.9	34.0	41.2	41.5	30.0	31.7	41.4	41.0
40-42	34.0	35.6	45.6	47.5	32.5	34.4	44.8	45.8
43-45	34.7	37.0	48.0	49.7	34.3	36.3	47.4	48.3
46-48	34.9	38.0	50.6	51.6	35.8	37.9	49.9	48.6
49-51	33.7	36.7	51.2	50.7	35.8	38.1	50.3	49.1
52-54	31.0	33.9	49.0	50.3	35.2	37.5	49.8	49.5
55-57	26.0	29.1	44.7	44.3	33.2	35.6	46.8	48.0
58-60	15.0	18.6	32.8	37.3	27.4	29.6	39.1	46.5
61-63	0.0	0.1	4.6	19.9	15.7	17.0	22.8	33.5
64-66	0.0	0.0	0.0	0.0	6.2	6.8	9.3	8.6
College Degree and/or Some Post-Graduate ($ thousands)								
25-27	20.9	22.4	24.8	24.8	19.5	20.3	23.6	22.1
28-30	26.2	26.5	28.7	26.8	23.5	24.5	29.0	26.4
31-33	27.4	29.1	33.6	32.5	26.2	27.7	32.5	30.8
34-36	34.0	34.7	37.0	36.0	30.2	31.9	37.0	33.5
37-39	36.6	37.7	42.5	41.1	34.3	36.4	42.2	39.4
40-42	41.9	43.7	48.4	48.1	38.7	41.2	47.9	47.1
43-45	46.2	47.3	54.5	53.8	42.7	45.5	52.8	51.2
46-48	49.0	51.8	59.1	58.1	46.7	50.0	58.5	53.8
49-51	53.0	56.9	63.1	62.7	48.6	52.0	60.5	56.6
52-54	51.7	56.0	63.5	65.5	50.7	54.4	63.5	59.4
55-57	46.5	51.2	62.0	59.8	53.0	56.9	64.4	59.4
58-60	24.2	30.2	40.8	44.8	40.3	43.2	49.6	55.0
61-63	0.0	0.4	3.1	21.7	23.4	25.2	30.3	45.4
64-66	0.0	0.0	0.0	0.0	11.0	11.8	14.9	12.8
Sample Size Information by Education Group								
Less Than HS	1228	1027	595	180	1228	1027	595	180
HS / Some College	2123	1912	1116	390	2123	1912	1116	390
College / Postgrad	882	810	564	189	882	810	564	189
Total	4233	3749	2275	759	4233	3749	2275	759
Weighted Sample Size by Education Group (Millions of Households)								
Less Than HS	3.0	2.5	1.5	0.4	3.0	2.5	1.5	0.4
HS / Some College	6.0	5.4	3.2	1.1	6.0	5.4	3.2	1.1
College / Postgrad	2.7	2.5	1.8	0.6	2.7	2.5	1.8	0.6
Total	11.6	10.4	6.4	2.1	11.6	10.4	6.4	2.1

Table 3: Household Balance Sheets, HRS Households in 2000 (Thousands of Dollars)

Wealth Component	All Households	Households with SS Histories	Households with Final Earnings	Couples with Final Earnings	Couples with Final Earnings, Male 63-67
Medians					
Social Security	159.9	162.1	172.3	222.3	242.0
DB Pension	0.0	0.0	0.0	27.6	35.4
Other Annuity	0.0	0.0	0.0	0.0	0.0
Retirement Accounts	4.5	4.6	8.0	24.5	30.0
IRA	0.0	0.0	0.0	8.0	11.0
401(k) and Other DC	0.0	0.0	0.0	0.0	0.0
Other Financial Wealth	30.0	29.0	35.0	70.0	88.8
Housing Equity	70.0	65.0	69.0	87.0	91.0
Other Wealth	15.0	15.0	16.0	26.0	30.0
SS + DB + Other Annuity	215.3	218.4	225.9	285.4	316.4
+ other financial	286.3	285.5	300.1	405.3	460.6
Total Excl. Retirement Accts	422.0	414.5	436.6	582.4	652.3
Total	454.8	447.6	470.7	636.4	713.2
Final Earnings	—	—	35.1	48.2	45.8
Means					
Social Security	160.7	163.2	170.8	207.2	228.9
DB Pension	136.3	145.8	145.0	195.3	182.6
Other Annuity	5.0	5.2	4.8	5.2	5.1
Retirement Accounts	94.3	94.5	101.4	135.0	154.3
IRA	66.0	65.6	69.4	92.5	106.8
401(k) and Other DC	28.3	28.9	31.9	42.5	47.5
Other Financial Wealth	181.6	187.6	200.3	253.3	287.2
Housing Equity	104.2	95.5	97.8	121.3	123.7
Other Wealth	129.5	108.0	113.3	141.9	141.6
SS + DB + Other Annuity	302.0	314.3	320.5	407.8	416.6
+ other financial	483.7	501.9	520.8	661.1	703.8
Total Excl. Retirement Accts	717.4	705.4	732.0	924.3	969.1
Total	811.7	799.9	833.3	1059.3	1123.4
Final Earnings	—	—	44.6	56.0	55.1
Sample Size					
Number of Households	6195	4233	3749	2275	759
Weighted Size ('000s)	16709.5	11648.1	10390.1	6403.2	2084.4

Source: Authors' tabulations from 2000 wave of the Health and Retirement Survey.

Table 4: Household Balance Sheets, HRS Households with Final Earnings, Males Aged 63-67

	All Education Levels	Less than High School Degree	High School and/or Some College	College and/or Postgraduate
Medians				
Social Security	242.0	217.0	248.5	248.8
DB Pension	35.4	0.0	46.6	100.0
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	30.0	0.0	29.0	126.1
IRA	11.0	0.0	9.5	80.0
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	88.8	8.1	71.0	328.0
Housing Equity	91.0	60.0	87.0	130.0
Other Wealth	30.0	18.0	25.0	70.0
SS + DB + Other Annuity	316.4	240.8	323.6	375.5
+ other financial	460.6	267.3	441.2	838.9
Total Excl. Retirement Accts	652.3	362.3	601.7	1102.4
Total	713.2	378.7	673.6	1303.4
Final Earnings	45.8	35.7	46.2	56.8
Means				
Social Security	228.9	206.8	234.4	235.0
DB Pension	182.6	57.2	112.6	416.7
Other Annuity	5.1	1.1	5.7	7.1
Retirement Accounts	154.3	39.5	114.2	321.4
IRA	106.8	31.2	89.0	200.0
401(k) and Other DC	47.5	8.3	25.2	121.4
Other Financial Wealth	287.2	68.9	180.4	665.1
Housing Equity	123.7	71.9	106.7	197.1
Other Wealth	141.6	78.0	92.9	286.2
SS + DB + Other Annuity	416.6	265.1	352.7	658.8
+ other financial	703.8	334.1	533.1	1323.9
Total Excl. Retirement Accts	969.1	484.0	732.7	1807.2
Total	1123.4	523.5	846.9	2128.6
Final Earnings	55.1	37.5	55.0	68.7
Sample Size				
Number of Households	759	180	390	189
Weighted Size (' 000s)	2084.4	428.8	1097.7	557.9

Table 5: Distribution of Household Balance Sheet Items as a Ratio to Final Earned Income HRS Married Households with Final Earnings and Males Aged 63-67 in 2000

	All Education Levels	Less than High School Degree	High School and/or Some College	College and/or Postgraduate Degree
20th Percentile				
Social Security	3.0	3.6	3.2	2.1
DB Pension	0.0	0.0	0.0	0.0
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	0.0	0.0	0.0	0.2
IRA	0.0	0.0	0.0	0.0
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	0.1	0.0	0.1	1.5
Housing Equity	0.8	0.3	0.8	1.2
Other Wealth	0.2	0.1	0.2	0.4
SS + DB + Other Annuity	4.2	4.5	4.2	3.5
+ other financial	5.8	4.9	5.8	7.4
Total Excl. Retirement Accounts	8.1	6.7	8.1	10.7
Total	8.6	6.8	8.8	12.4
40th Percentile				
Social Security	4.4	4.9	4.6	3.4
DB Pension	0.0	0.0	0.2	0.0
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	0.2	0.0	0.2	1.4
IRA	0.0	0.0	0.0	0.7
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	1.1	0.1	1.0	4.5
Housing Equity	1.6	1.2	1.5	2.2
Other Wealth	0.5	0.3	0.5	1.0
SS + DB + Other Annuity	5.2	6.3	6.3	6.1
+ other financial	7.3	6.8	9.1	13.8
Total Excl. Retirement Accounts	12.6	8.9	12.3	19.2
Total	13.5	9.1	13.5	22.8
60th Percentile				
Social Security	5.7	6.7	5.9	4.9
DB Pension	1.7	0.3	1.7	2.8
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	1.3	0.1	1.2	3.5
IRA	0.7	0.0	0.7	2.3
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	3.3	0.6	3.0	9.2
Housing Equity	2.5	1.8	2.3	3.1
Other Wealth	1.3	0.9	1.0	2.5
SS + DB + Other Annuity	8.8	8.3	8.6	9.7
+ other financial	13.7	9.3	12.7	20.9
Total Excl. Retirement Accounts	18.3	12.9	17.4	28.3
Total	21.2	13.4	19.9	33.3
80th Percentile				
Social Security	9.2	9.8	9.4	7.6
DB Pension	4.6	2.9	4.4	7.3
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	4.6	1.0	3.8	11.2
IRA	3.3	0.5	2.9	6.6
401(k) and Other DC	0.5	0.0	0.3	2.0
Other Financial Wealth	9.1	2.9	7.4	19.3
Housing Equity	4.8	4.3	4.3	8.6
Other Wealth	4.0	2.3	3.0	6.6
SS + DB + Other Annuity	14.0	11.8	13.2	17.3
+ other financial	23.0	15.7	20.1	46.5
Total Excl. Retirement Accounts	32.5	21.2	26.9	59.0
Total	38.9	22.7	30.9	63.8

Table 6: Distribution of Household Balance Sheet Items ($ thousands)
HRS Married Households with Final Earnings and Husbands Aged 63-67 in 2000

	All Education Levels	Less than High School Degree	High School and/or Some College	College and/or Postgraduate
20th Percentile				
Social Security	151.2	138.5	176.4	136.3
DB Pension	0.0	0.0	0.0	0.0
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	0.0	0.0	0.0	11.0
IRA	0.0	0.0	0.0	0.0
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	2.0	-1.0	4.8	94.0
Housing Equity	39.0	7.0	44.0	80.0
Other Wealth	10.0	2.8	10.0	16.0
SS + DB + Other Annuity	199.7	151.2	214.1	229.3
+ other financial	241.1	148.6	253.7	455.7
Total Excl. Retirement Accts	347.5	202.0	374.7	675.2
Total	357.5	203.1	384.7	718.4
40th Percentile				
Social Security	216.5	194.2	224.8	215.4
DB Pension	0.0	0.0	8.9	0.0
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	11.0	0.0	12.0	93.0
IRA	0.0	0.0	0.0	40.0
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	40.0	1.0	39.0	242.0
Housing Equity	78.0	45.0	73.0	105.0
Other Wealth	20.5	10.0	20.0	47.0
SS + DB + Other Annuity	272.3	217.9	277.4	320.7
+ other financial	374.5	229.6	376.3	729.5
Total Excl. Retirement Accts	536.3	311.8	527.7	1007.7
Total	575.4	313.6	565.0	1097.2
60th Percentile				
Social Security	261.1	235.7	265.1	284.6
DB Pension	84.8	10.4	84.8	192.0
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	59.0	4.0	50.0	185.0
IRA	34.0	0.0	31.0	133.0
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	156.0	18.0	124.5	411.3
Housing Equity	105.0	75.0	100.0	175.0
Other Wealth	51.0	28.0	40.0	114.5
SS + DB + Other Annuity	353.9	277.0	358.7	477.4
+ other financial	559.5	311.9	496.7	945.3
Total Excl. Retirement Accts	812.5	424.9	708.6	1393.9
Total	882.5	430.6	811.5	1641.8
80th Percentile				
Social Security	311.7	277.0	309.7	327.4
DB Pension	221.4	132.0	191.2	389.0
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	220.0	36.0	180.0	448.9
IRA	150.0	19.5	106.9	310.0
401(k) and Other DC	20.0	2.0	13.0	104.5
Other Financial Wealth	400.0	90.0	285.8	960.0
Housing Equity	170.0	110.0	150.0	300.0
Other Wealth	147.0	90.0	127.0	295.0
SS + DB + Other Annuity	504.4	364.5	462.0	660.4
+ other financial	888.4	440.9	707.9	1754.9
Total Excl. Retirement Accounts	1212.8	657.6	1001.0	2299.5
Total	1422.4	772.3	1134.4	3312.0

Table 7: Simulated Distribution of 401(k) Balance at Retirement in Thousands of Year 2000 Dollars

Investment Strategy/Percentile	Less than High School Degree	High School and/or Some College	College and/or Postgraduate
100% Riskless Bonds	172.7	230.4	248.2
50% Riskless Bonds, 50% Large-Cap Corporate Stocks			
1	54.6	75.5	83.4
5	162.9	217.9	233.4
10	188.4	251.3	267.8
20	225.1	299.2	316.9
30	256.0	339.7	358.1
40	286.0	378.8	397.9
50	317.2	419.7	439.2
60	352.0	465.1	485.1
70	393.6	519.3	539.7
80	448.7	591.2	611.8
90	538.1	707.9	728.6
Mean	345.8	456.9	475.8
100% Large-Cap Corporate Stocks			
1	15.8	22.8	26.4
5	127.7	172.0	185.4
10	171.5	229.6	244.8
20	246.6	328.2	345.7
30	321.7	426.6	445.4
40	404.6	535.1	554.7
50	502.1	662.6	682.5
60	623.8	821.7	841.2
70	787.8	1035.9	1053.8
80	1036.2	1360.8	1374.7
90	1517.0	1989.7	1992.8
Mean	730.1	960.9	972.9
50% Riskless Bonds, 50% Large Cap Stocks (Risk Premium Reduced by 300 basis points)			
1	41.8	58.4	65.7
5	120.4	162.0	176.4
10	138.7	186.0	201.5
20	164.8	220.3	237.0
30	186.9	249.2	266.8
40	208.2	277.1	295.5
50	230.4	306.1	325.2
60	255.0	338.2	358.1
70	284.4	376.6	397.2
80	323.3	427.3	448.6
90	386.3	509.4	531.7
Mean	250.3	331.9	350.8
100% Large Cap Stocks (Risk Premium Reduced by 300 basis points)			
1	10.0	14.8	17.9
5	70.8	96.8	107.7
10	93.4	126.8	139.6
20	131.7	177.3	192.7
30	169.6	227.1	244.4
40	211.1	281.4	300.5
50	259.5	344.8	365.5
60	319.6	423.3	445.5
70	400.2	528.4	552.0
80	521.7	687.0	711.4
90	755.5	991.9	1016.2
Mean	369.4	487.8	506.6

Table 8: Certainty Equivalent Wealth in Thousands of Year 2000 Dollars for Different Portfolio Allocation Rules and Expected Stock Returns, Assuming no Wealth Other than 401(k)

Investment Strategy / Risk Aversion	Less than High School Degree	High School and/or Some College	College and/or Postgraduate
alpha = 0			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	345.8	456.9	475.8
100% Stocks	730.1	960.9	972.9
50% Bonds, 50% Equity Return Reduced 300bp	250.3	331.9	350.8
100% Stocks, Equity Return Reduced 300bp	369.4	487.8	506.6
alpha = 1			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	317.8	420.7	440.4
100% Stocks	506.2	669.3	690.3
50% Bonds, 50% Equity Return Reduced 300bp	230.9	306.9	326.2
100% Stocks, Equity Return Reduced 300bp	262.7	349.6	370.8
alpha = 2			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	292.3	387.7	408.0
100% Stocks	355.5	473.3	498.0
50% Bonds, 50% Equity Return Reduced 300bp	213.2	284.1	303.5
100% Stocks, Equity Return Reduced 300bp	190.1	255.5	276.6
alpha = 4			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	248.1	330.4	351.4
100% Stocks	186.1	252.8	276.4
50% Bonds, 50% Equity Return Reduced 300bp	182.4	244.3	263.8
100% Stocks, Equity Return Reduced 300bp	106.0	146.0	164.0

Table 9: Certainty Equivalent Wealth in Thousands of Year 2000 Dollars for Different Portfolio Allocation Rules and Expected Stock Returns, Assuming Non-401(k) Wealth = Social Security + Defined Benefit + Other Annuities

Investment Strategy / Risk Aversion	Less than High School Degree	High School and/or Some College	College and/or Postgraduate
alpha = 0			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	345.8	456.9	475.8
100% Stocks	730.1	960.9	972.9
50% Bonds, 50% Equity Return Reduced 300bp	250.3	331.9	350.8
100% Stocks, Equity Return Reduced 300bp	369.4	487.8	506.6
alpha = 1			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	328.7	435.1	455.7
100% Stocks	562.0	743.6	772.9
50% Bonds, 50% Equity Return Reduced 300bp	239.9	318.6	338.4
100% Stocks, Equity Return Reduced 300bp	301.5	400.8	425.5
alpha = 2			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	313.4	415.5	437.5
100% Stocks	454.0	603.9	641.4
50% Bonds, 50% Equity Return Reduced 300bp	230.4	306.6	327.1
100% Stocks, Equity Return Reduced 300bp	256.3	342.6	370.0
alpha = 4			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	287.2	381.9	406.0
100% Stocks	330.1	443.3	485.6
50% Bonds, 50% Equity Return Reduced 300bp	214.0	285.7	307.1
100% Stocks, Equity Return Reduced 300bp	200.8	270.9	299.5

Table 10: Certainty Equivalent Wealth in Thousands of Year 2000 Dollars for Different Portfolio Allocation Rules and Expected Stock Returns, Assuming Non-401(k) Wealth = All HRS Wealth Excluding Retirement Accounts

Investment Strategy / Risk Aversion	Less than High School Degree	High School and/or Some College	College and/or Postgraduate
alpha = 0			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	345.9	456.8	475.8
100% Stocks	730.6	960.9	973.1
50% Bonds, 50% Equity Return Reduced 300bp	250.4	331.9	350.9
100% Stocks, Equity Return Reduced 300bp	369.6	487.8	506.7
alpha = 1			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	331.7	440.8	464.2
100% Stocks	580.5	779.6	831.2
50% Bonds, 50% Equity Return Reduced 300bp	241.9	322.6	344.2
100% Stocks, Equity Return Reduced 300bp	311.7	420.3	455.6
alpha = 2			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	319.0	426.2	453.5
100% Stocks	483.2	660.9	734.1
50% Bonds, 50% Equity Return Reduced 300bp	234.3	314.0	337.9
100% Stocks, Equity Return Reduced 300bp	272.3	373.5	418.3
alpha = 4			
100% Riskless Bonds	172.7	230.4	248.2
50% Bonds 50% Stocks	297.0	400.7	434.4
100% Stocks	368.5	517.6	609.8
50% Bonds, 50% Equity Return Reduced 300bp	220.9	298.8	326.7
100% Stocks, Equity Return Reduced 300bp	222.4	312.3	366.6

Appendix Table A-1: Household Sample Counts

	HRS 2000*	SS Earnings Only	Final Earnings Only	Couples w/ Final Earnings	Couples with Final Earnings and Male Aged 63-67
	Unweighted Observations				
Total	6195	4233	3749	2275	759
Couples	3838	2446	2275	0	0
Singles	2357	1787	1474	0	0
At Least One Person Working	3269	2194	2096	1413	459
Couples with Both Working	899	592	581	581	166
Receives DB Pension	2293	1609	1430	1027	373
Expects DB Pension	478	370	364	270	72
Receives Social Security	3681	2550	2203	1411	575
Has IRA	2531	1737	1618	1192	417
Has DC	1333	884	862	629	216
	Weighted Observations (Millions of Households)				
Total	16.7	11.6	10.4	6.4	2.1
Couples	10.4	6.8	6.4	6.4	2.1
Singles	6.4	4.8	4.0	0.0	0.0
At Least One Person Working	9.0	6.2	5.9	4.0	1.3
Couples, Two People Working	2.6	1.8	1.7	1.7	0.5
Receives DB Pension	6.3	4.5	4.0	2.8	1.0
Expects DB Pension	1.4	1.1	1.0	0.8	0.2
Receives Social Security	9.7	6.9	6.0	3.9	1.6
Has IRA	7.5	5.2	4.9	3.6	1.2
Has DC	3.8	2.6	2.5	1.9	0.6

* Accounting for household splits and excluding households with missing birthdays. Each HRS household is defined uniquely by its household identifier (HHID) and wave 5 sub-household identifier (GSUBHH).

Figure 1A: Median Household Income in the HRS Relative to Age 28 Earnings, Three-Year Moving Average

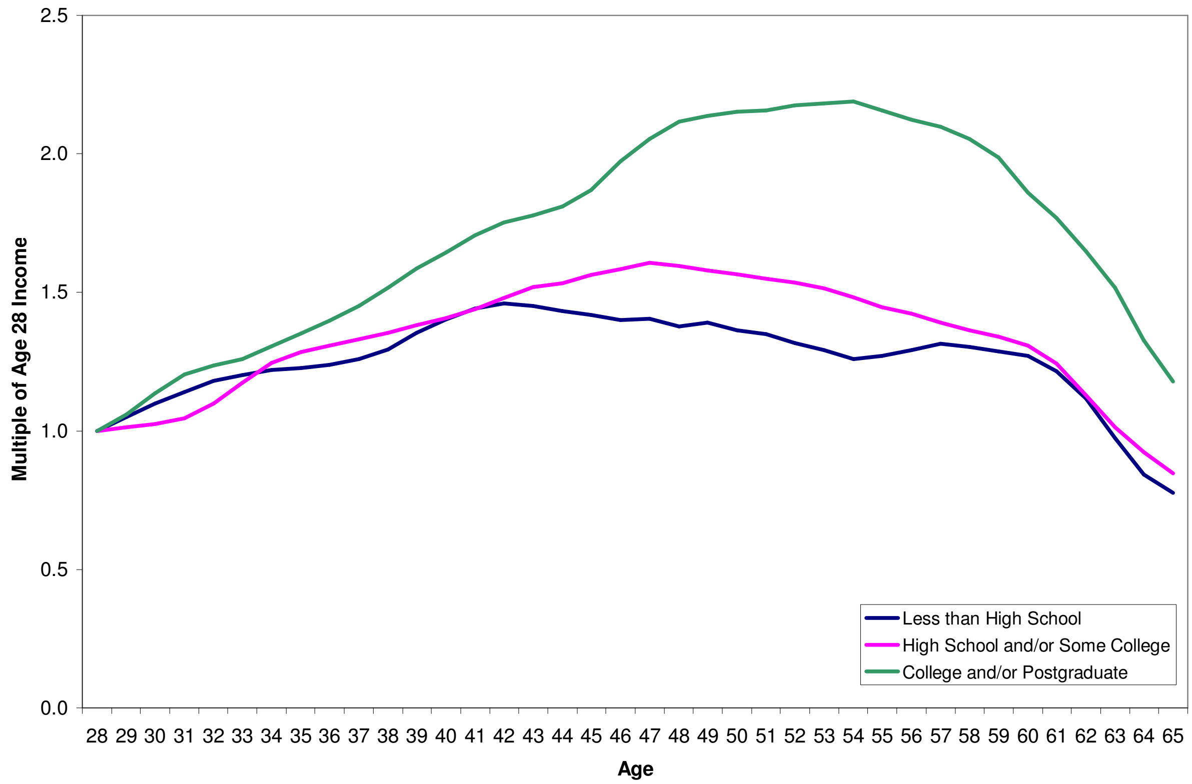


Figure 1B: Median Household Income in the HRS in Year 2000 Dollars, Three-Year Moving Average

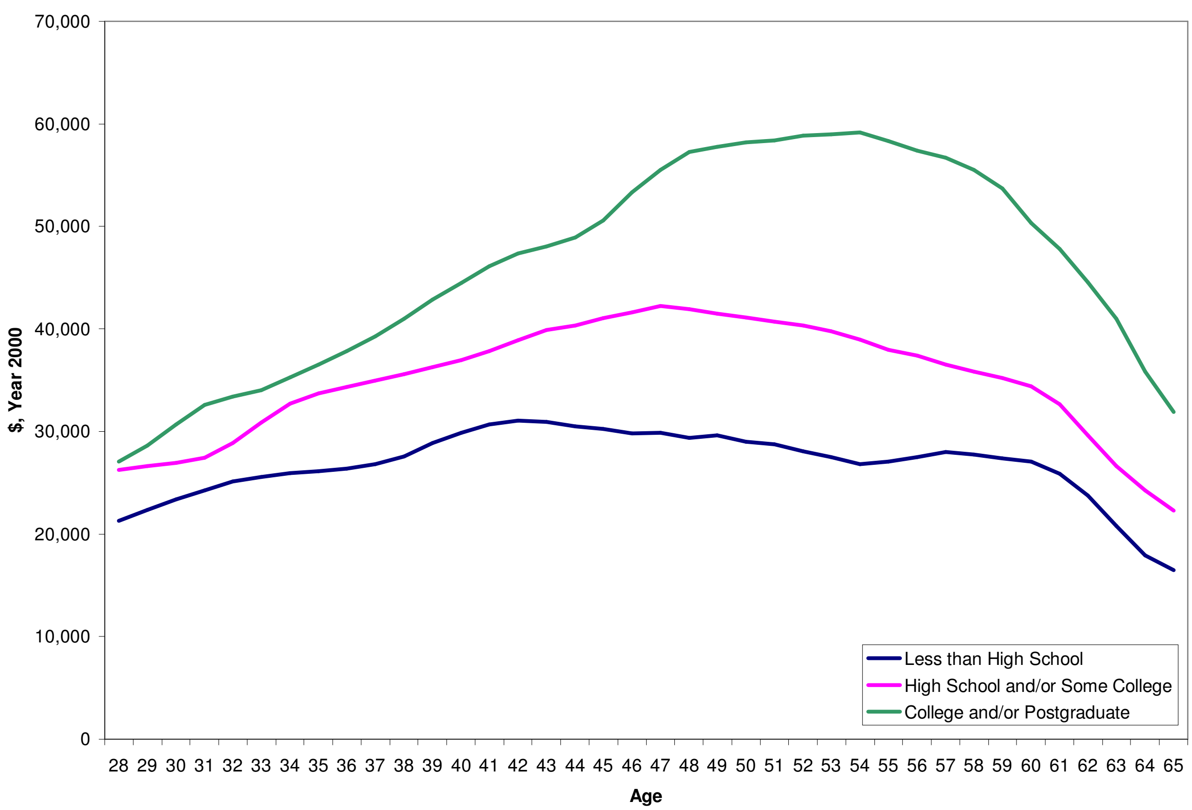


Figure 2: Empirical Distribution of Real S&P 500 Equity Returns

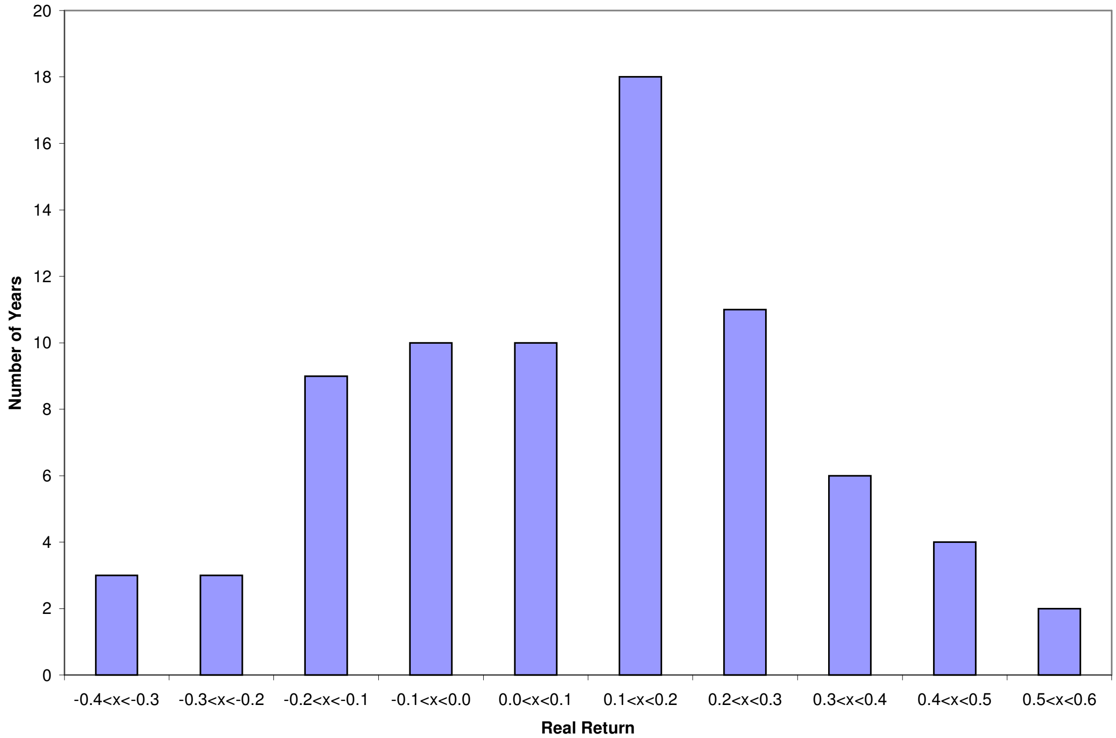


Figure 3.1.A: Cumulative Density Functions of 401(k) Wealth Relative to Final Earnings for Households with High School or Some College Education

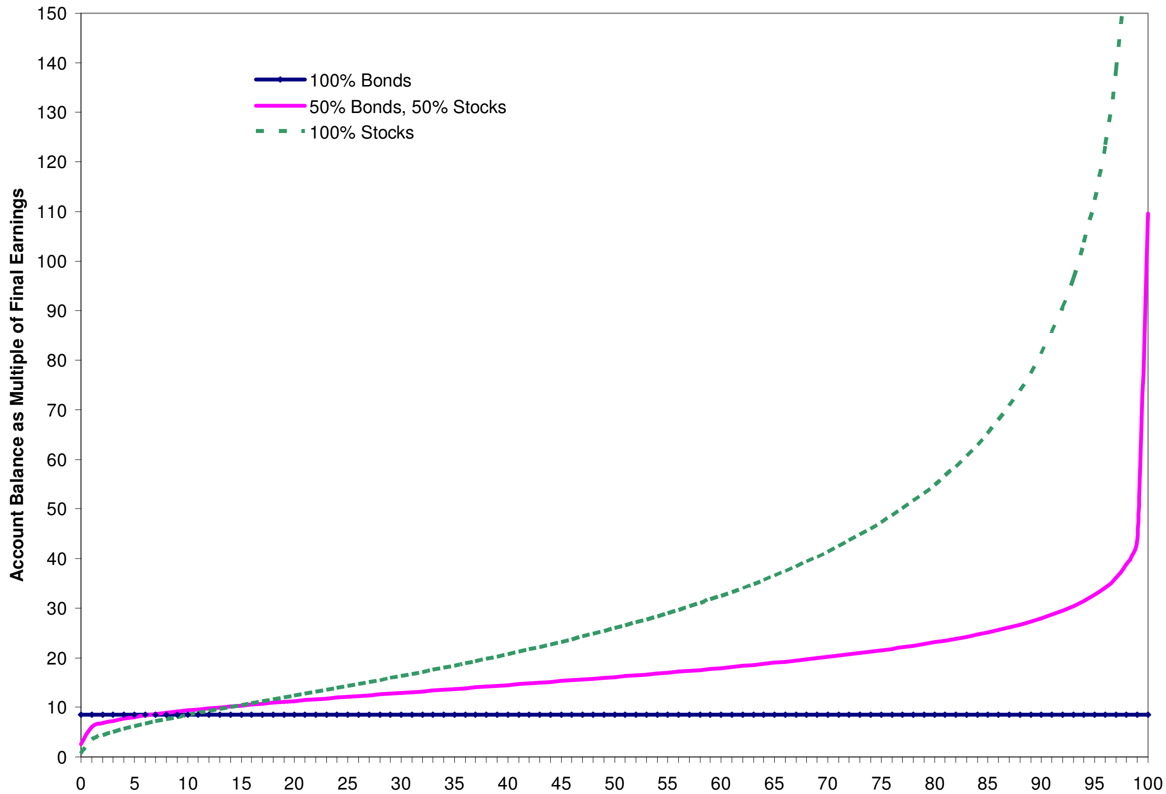


Figure 3.1.B: Cumulative Density Functions of 401(k) Wealth Relative to Final Earnings for Households with High School or Some College Education

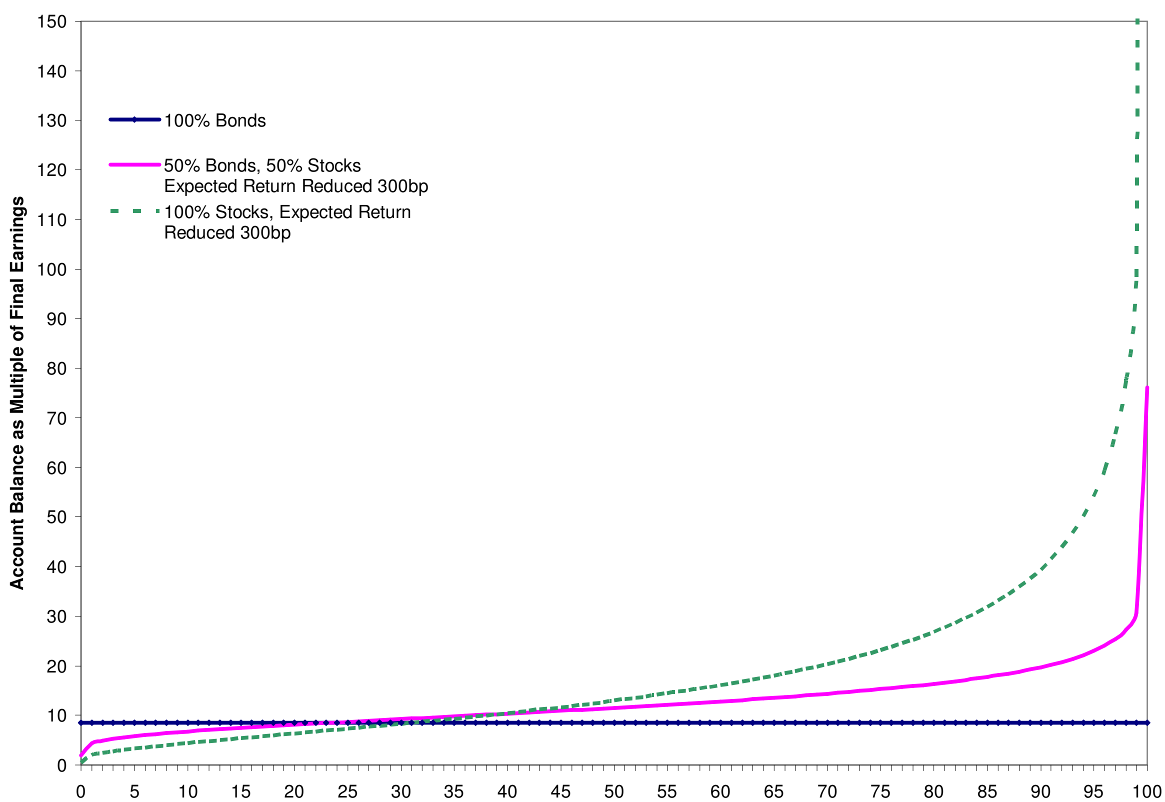


Figure 3.2.A: Cumulative Density Functions of 401(k) Wealth for Households with High School or Some College Education

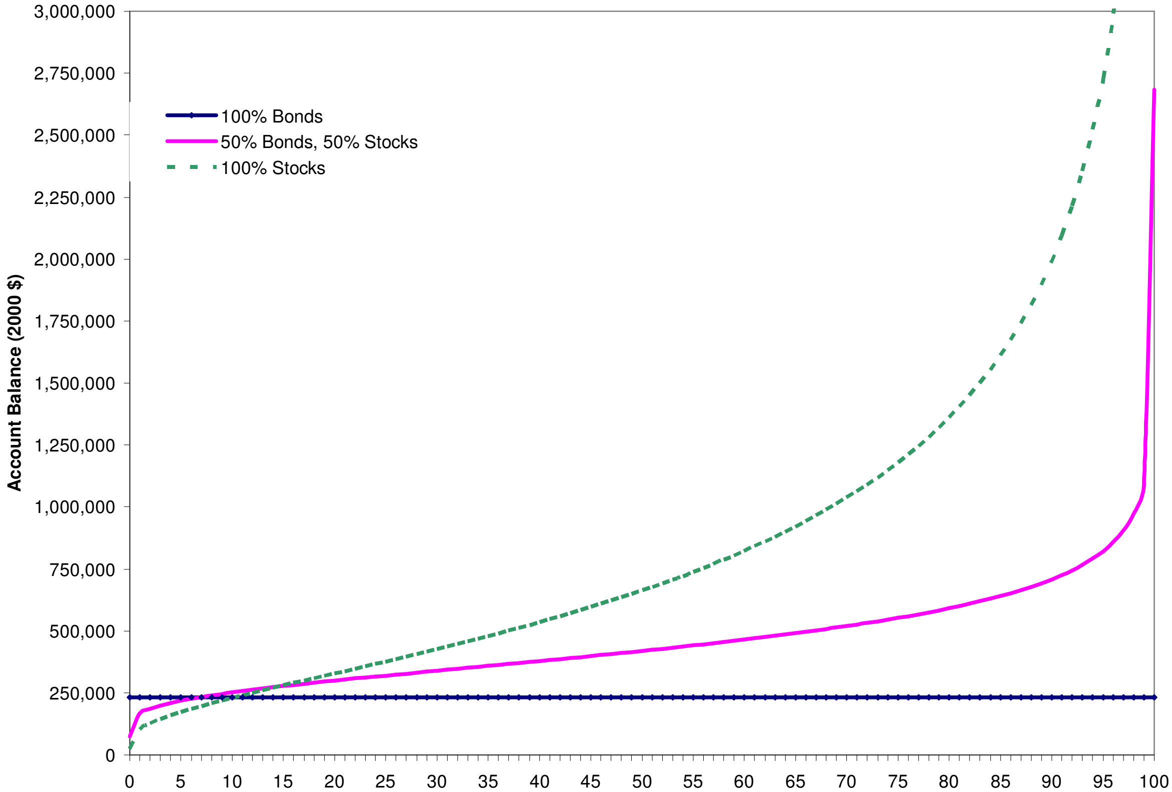


Figure 3.2.B: Cumulative Density Functions of 401(k) Wealth for Households with High School or Some College Education

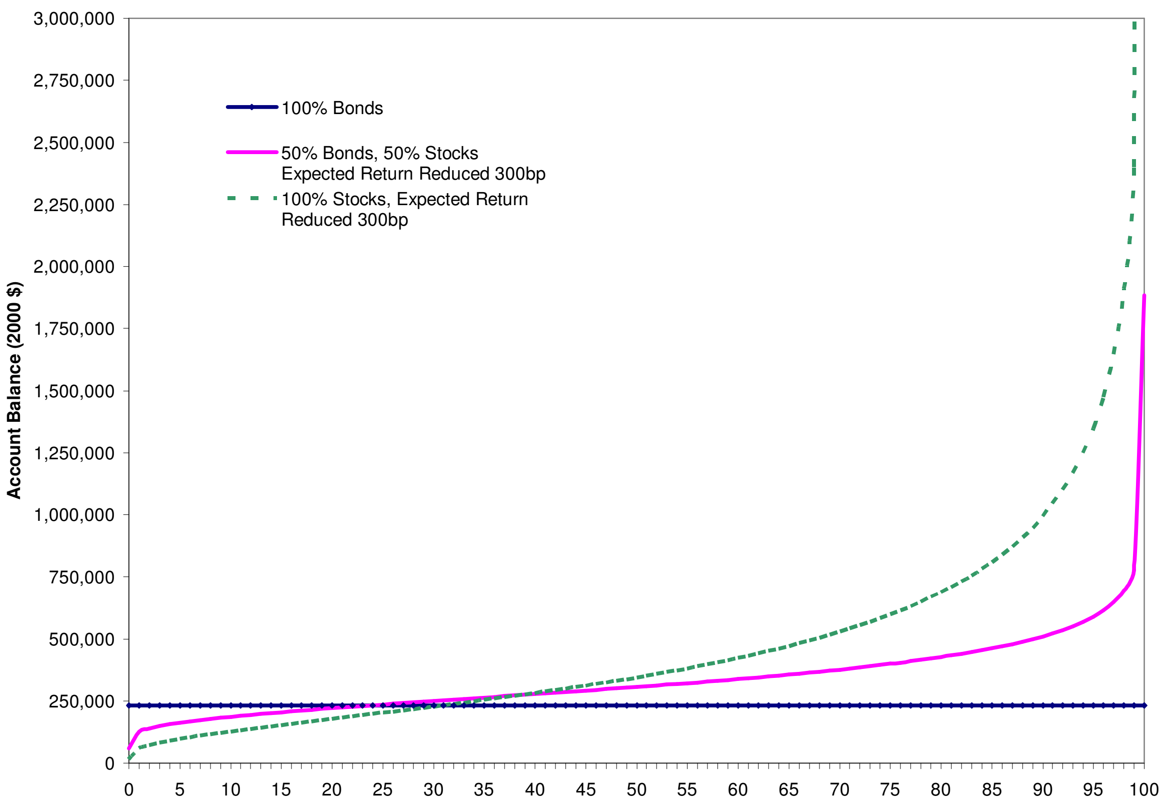
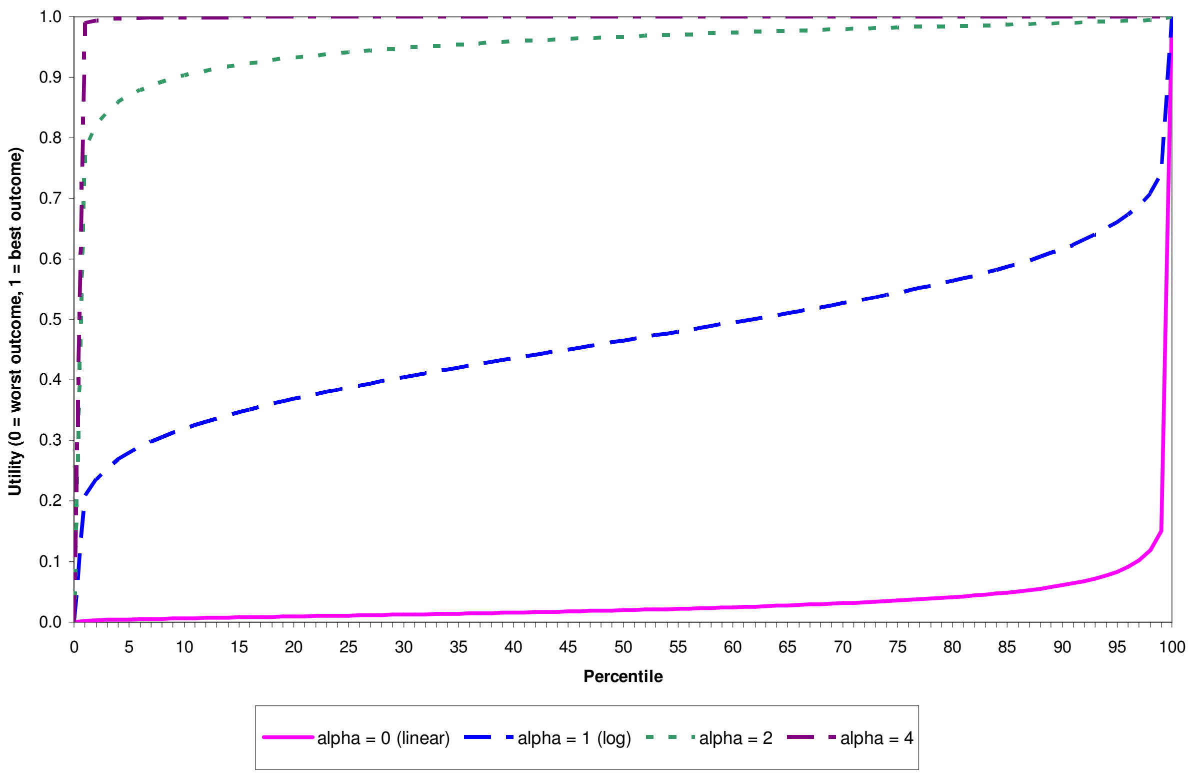


Figure 4: Cumulative Density Functions of Different Utility Functions for Households with High School or Some College Education



This figure shows the cumulative distribution of the utility values of the wealth outcomes in the simulated distribution for four different levels of risk aversion. The initial scale of the utility values varies that comes from the simulation model depends on the risk aversion parameter. In this figure, all utility values are scaled so that zero is the worst outcome for a given alpha and one is the best outcome for a given alpha. The Von-Neumann Morgenstern (VNM) utility function over which expected utility is calculated is unique up to an affine transformation. The linear transformation necessary to put each utility value on a 0-1 scale is therefore a legitimate transformation that preserves the VNM function’s properties. Furthermore, since the actual utility magnitudes of outcomes across different alphas are not comparable, the scale on which we represent the distribution of outcomes can be arbitrary as long as the VNM ordering is preserved.

Figure 5.1.A: Certainty Equivalents and Risk Aversion for Households with High School or Some College Education, Baseline Equity Returns and No Wealth Other than 401(k)

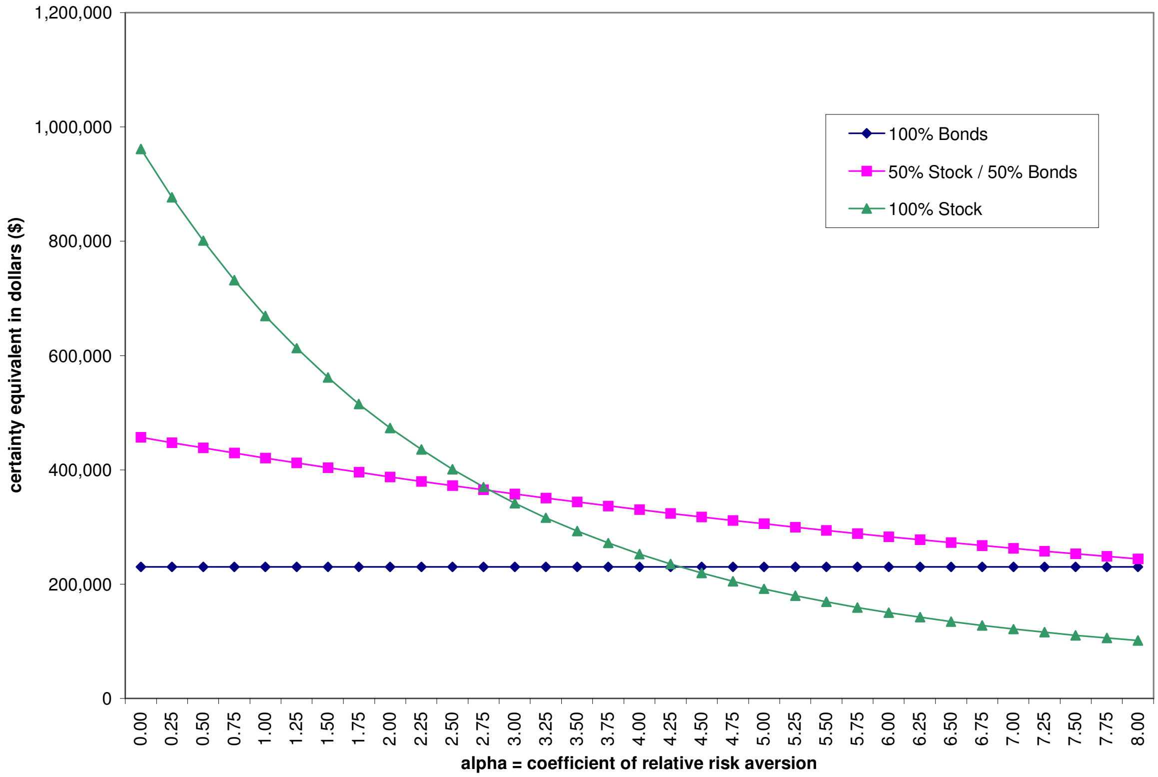


Figure 5.1.B: Certainty Equivalents and Risk Aversion for Households with High School or Some College Education, Reduced Equity Premiums and No Wealth Other than 401(k)

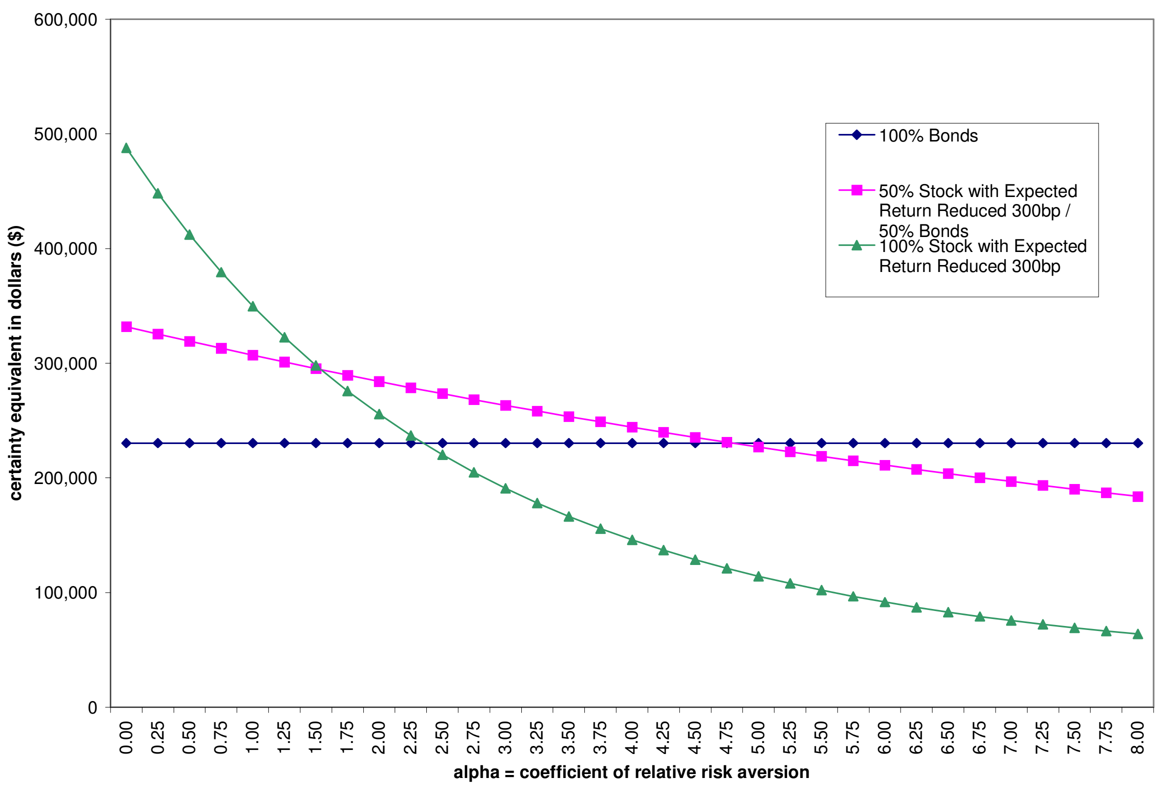


Figure 5.2.A: Certainty Equivalents and Risk Aversion for Households with High School or Some College Education, Baseline Equity Returns and SS + DB + Annuity Wealth

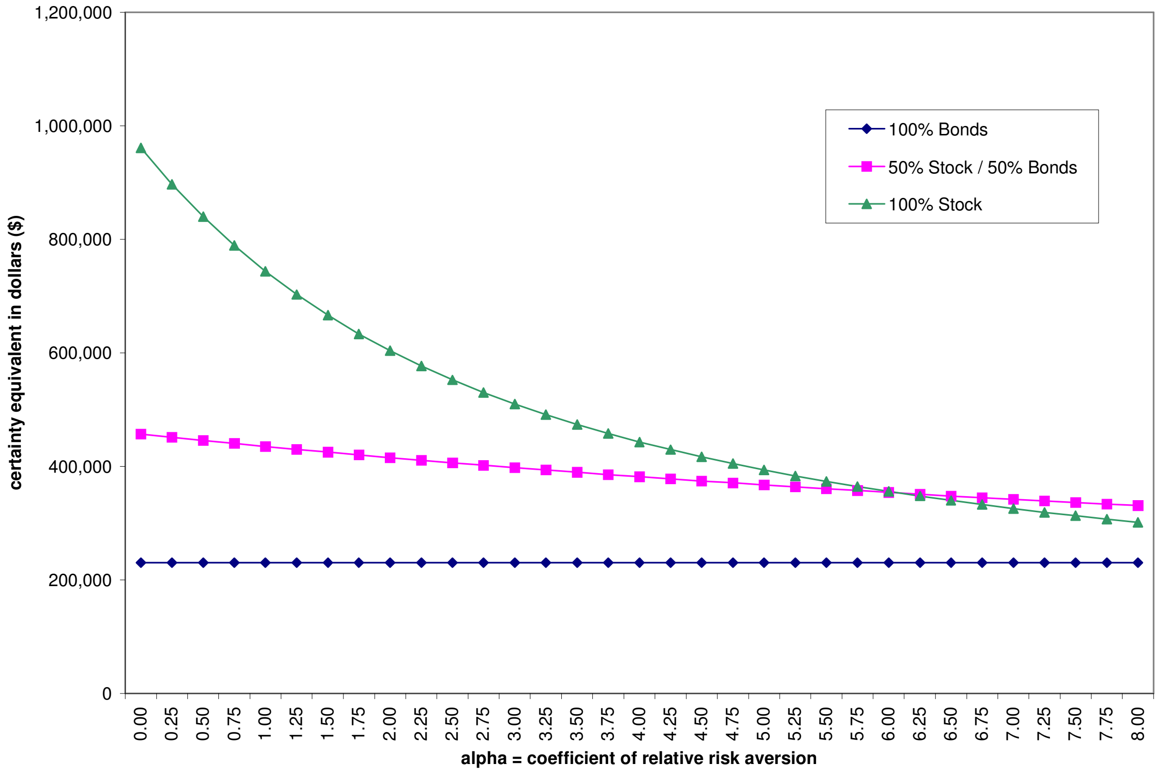


Figure 5.2.B: Certainty Equivalents and Risk Aversion for Households with High School or Some College Education, Reduced Equity Premiums and SS + DB + Annuity Wealth

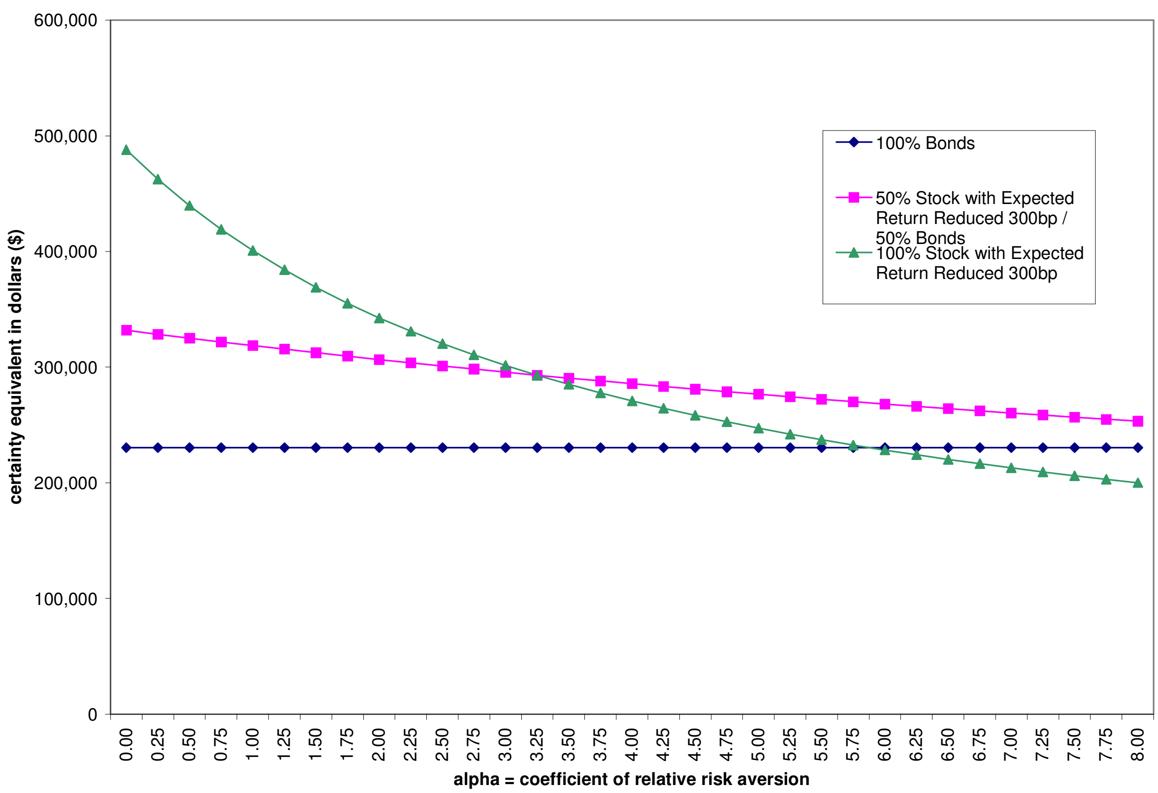


Figure 5.3.A: Certainty Equivalents and Risk Aversion for Households with High School or Some College Education, Baseline Equity Returns and All Non-401(k) Wealth

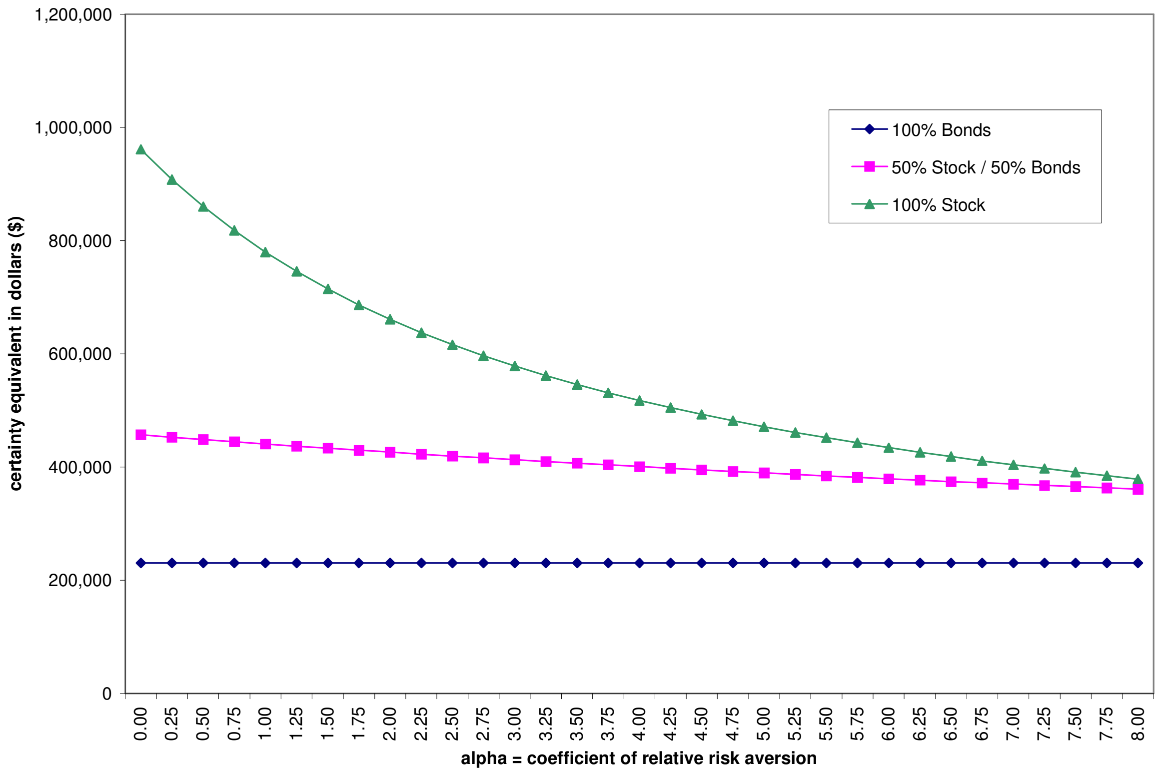


Figure 5.3.B: Certainty Equivalents and Risk Aversion, for Households with High School or Some College Education Reduced Equity Premiums and All Non-401(k) Wealth