PORTFOLIO RISK AND SELF-DIRECTED RETIREMENT SAVING PROGRAMS

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ABSTRACT

Defined contribution retirement plans expose retirement savers to financial market risks. This paper explores the costs of retirement wealth risk. It begins by describing the holding of company stock in 401(k) plans in the United States, an investment choice that yields a poorly diversified retirement portfolio. It then summarizes the composition of household wealth at retirement, and investigates how the degree of diversification in retirement assets affects expected utility. The cost of holding a poorly diversified retirement portfolio is very sensitive to whether or not the retirement saver has other assets that provide a floor for retirement consumption.

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The private pension system in the U.S. is currently undergoing an important transformation. The decades following World War II witnessed rapid growth in defined benefit pension arrangements. Such pensions provide retirees with a nominal annuity that begins at retirement and continues until death. They may also provide income for a surviving spouse. Defined benefit payouts are typically a function of a retiree's wage history, job tenure at the firm, and age at retirement. The financial risk of providing defined benefit pensions is borne by employers. In the U. S., a government insurance fund provides a partial backstop against the risk that pension assets fail to cover promised benefits.

In the last two decades, defined benefit plans have grown slowly, if at all. Defined contribution pension plans, in particular "self-directed" retirement saving plans such as Individual Retirement Accounts and 401(k) plans, have grown substantially. These plans have created a very large pool of retirement assets that are managed by current and future retirees. IOMA (2003) estimates the total value of 401(k) plan assets at $1.4 trillion. The Board of Governors of the Federal Reserve System (2003) estimates that Individual Retirement Accounts hold $2.3 trillion. By comparison, net household financial assets equal $22.7 trillion.

The recent collapse of several highly visible firms such as Enron, Global Crossing, and Polaroid, in which workers held a substantial fraction of their retirement plan assets in company stock, has led to proposals to restrict individual discretion in retirement investing. Workers who hold retirement assets in undiversified and highly volatile portfolios risk retiring with very low balances in their retirement accounts. Investing a retirement account in company stock may be particularly costly because of the potential correlation between company stock returns and the value of the worker's human capital. While the portfolio risks associated with defined contribution plans have been widely noted, with notable exceptions such as Muelbroek (2002) and Ramaswamy (forthcoming), there have been few attempts to evaluate the costs and benefits of different asset allocation strategies for retirement accounts.

The U.S. is not alone in experiencing substantial changes in the structure of private pensions. In the U.K., recent declines in asset values have led the sponsors of many large defined benefit pension plans to institute reforms. Some have closed their plans to new workers. Others have replaced defined benefit plans with defined contribution plans. The Department for Work and Pensions (2002) has proposed changes to the pension regulatory structure that would affect both defined benefit and defined contribution schemes. Emmerson and Wakefield (2003) describe the motivation for reform proposals, and the likely effects of some changes. The U.K.'s increased emphasis on retirement saving vehicles that provide individuals with choice in both contribution rates and in asset allocation, such as Individual Saving Accounts and Self Investment

Personal Pensions, suggests that the policy issues that have already attracted attention in the U.S. are likely to surface in the future in the U.K.

This paper evaluates the impact of portfolio risk in retirement saving accounts on the expected utility of retirement savers. It uses information on the lifetime earning patterns of U.S. workers who are near retirement age to construct hypothetical contribution patterns for retirement saving plans. It combines this information with historical data on the risks and returns of different investment strategies. This makes it possible to perform stochastic simulations that generate distributions of retirement wealth outcomes for different asset allocation rules. These distributions can be summarized by the mean or median value of retirement wealth or by various wealth quantiles. By assuming a particular utility function for retirement savers, I can also compute the certainty equivalent wealth level that would yield the same expected utility value as each wealth distribution. My analysis restricts retirement savers to allocate their portfolios among three assets: index bonds, a broad-based equity portfolio, and a poorly diversified equity portfolio that I label "company stock." The difference between the certainty equivalent level of wealth in the second and third cases provides a measure of the cost of poor diversification.

This paper also presents information on the lifetime earnings trajectories and current wealth holdings of single individuals in the U.S. who are near retirement age. The focus on single individuals avoids many of the complications that arise in modeling the utility of married households. Poterba, et al. (2003) use the same conceptual framework to develop a parallel analysis for married couples.

This paper is divided into five sections. Section one describes company stock holdings in 401(k) plans in the U.S. Data from 2001 show that at many large companies, retirees hold a substantial share of their retirement assets in company stock, rather than in broadly diversified portfolios. This group risks reaching retirement with a relatively low retirement account balance from which to support retirement consumption. The second section develops a simple theoretical structure for evaluating the risks associated with retirement asset portfolios with different volatilities. Section three describes the three key inputs that are needed for the stochastic simulation analysis: the earnings trajectory and associated contribution profile for retirement plan contributors, the return distribution for assets held in retirement accounts, and the non-retirement-account components of wealth for individuals of retirement age. The fourth section reports the results of the stochastic simulation analysis. It includes summary information on retirement account balances at age 63, along with measures of the certainty equivalent value of retirement wealth, under different assumptions about the asset allocation in retirement accounts. A brief conclusion suggests several directions for future work.

1. The Role of Company Stock in 401(k) Plans in the U.S.

Recent public policy debates about the role of self-directed retirement plans in the U.S. were catalyzed by the sharp decline in the stock prices of several companies whose workers held substantial company stock positions in their 401(k) retirement plans. One of the potential drawbacks of providing workers with unrestricted control over the allocation of their retirement saving is that they may select investments that are in some way inappropriate for their saving objectives. The presence of substantial holdings of company stock in such accounts is the most frequent source of criticism for investor choices. In some cases, a substantial fraction of the holding of company stock was compulsory, for example when the firm matched employee 401(k) contributions with company stock. In many other cases, however, the significant company stock holdings were the result of voluntary choices.

IOMA (2003) reports that 24.8% of 401(k) assets were held in company stock, while roughly 60% of 401(k) assets were held in equities of some type. Company stock investments are concentrated at a relatively small set of 401(k) plans. The only workers who can hold company stock are those who are employed at large, publicly-traded firms. Mitchell and Utkus (forthcoming) estimate that 5.3 million workers, or about one 401(k) participant in eight, hold more than 60% of their 401(k) account balance in company stock. Another 2.3 million hold between 41 and 60% of their account in such stock, while 3 million hold between 21 and 40%. Roughly one quarter of 401(k) participants hold more than 20% of their account balance in company stock.

Many of the 401(k) plans with high company stock holdings were originally Employee Stock Ownership Plans (ESOPs). Mitchell and Utkus (forthcoming) note that they were not designed to provide workers with a source for retirement income, but rather as vehicles to encourage employee ownership of company stock. When such ESOPs were converted to 401(k) plans to take advantage of favorable tax provisions, the asset allocation in these plans remained heavily tilted toward company stock. Rauh (2002) suggests that one reason firms may seek to encourage employee ownership in their 401(k) plan is to reduce the likelihood of a hostile takeover.

Table 1 presents information on the share of company stock in the assets of twenty of the largest defined contribution pension plans in the United States in late 2002. The entries range widely, with a mean value of 32.9%. The table also reports an estimate of the standard deviation of the annual return on company stock based on data on daily stock return volatilities for the period 1997-2001. The average standard deviation is 38.8%, which is roughly twice the standard deviation of the annual returns on the Standard and Poor's 500 Index over this time period. The volatility of company stock prices, relative to the volatility of a market portfolio or to other investments, is the source of policy concern about the overweighting of company stock in retirement saving accounts. Poterba (2003a) discusses a range of policy responses to concerns about poorly diversified retirement accounts. These include educating workers about the potential costs of concentrated investments, as well as regulatory constraints on the investment of retirement accounts in company stock.

The present paper provides some insight on the potential cost to a retirement saver of holding a retirement portfolio with a return standard deviation equal to that for a single stock, rather than the market portfolio. The findings offer some insight on the potential cost of being constrained to hold retirement assets in a poorly diversified portfolio, for example when a firm places restrictions on investment options. For those who voluntarily decide to hold poorly diversified portfolios, the estimates of the welfare loss from poor diversification can be interpreted as describing the gain that the investor must expect to receive, from a higher return on the individual stock than on the market, or from other sources, as a result of holding a poorly diversified retirement portfolio.

2. Modeling Retirement Wealth Accumulation in Self-Directed Retirement Plans

A retirement saver's asset allocation choices affect the amount of wealth that he will have at retirement. Modeling the impact of different asset allocation choices on retirement wealth requires information on an individual's retirement plan contributions throughout his working life. These contributions can then be translated into retirement wealth using information on the distribution of investment returns for different asset allocation strategies. This section develops a simple framework for calculating retirement wealth under different return scenarios.

Consider an individual, denoted by i, who has earnings at age a of $E_i(a)$. Assume that this individual contributes a constant fraction of earnings to a self-directed retirement plan. In the simulations below, this fraction is set to 9%, the average share of salary that Poterba, Venti, and Wise (forthcoming) report that employers and employees contribute to 401(k) plans. Assume that the individual begins to participate in a retirement plan at age 27, and that he leaves the labor force at age 63. No retirement plan contribution is made at age 63, the age at which I evaluate the stock of retirement saving.

Denote the 401(k) contribution at age a by $C_i(a) = .09*E_i(a)$, with earnings measured in constant dollars. In the calibration below, $E_i(a)$ will be set equal to Social Security covered earnings at age a, an earnings level that equals the minimum of actual earnings and the Social Security earnings maximum. The assumption that the individual can contribute to the 401(k) plan in all years with positive earnings does not require that he work at the same firm for 35 years. It does require that he always works for a firm that offers a 401(k) plan. To find the 401(k) balance for individual i when he reaches retirement age (63), I cumulate contributions over the course of the working life and allow for returns on 401(k) assets at each age. I assume that there are no withdrawals before retirement age. Let $R_i(a)$ denote the real return earned on 401(k) assets in the year when the contributor was *a* years old. The 401(k) contributor's assets at age 63 are then:

$$W_i(63) = \sum_{t=0}^{35} \left\{ \prod_{j=0}^{t} [1 + R_i(62-j)] \right\} C_i(62-t) \tag{1}$$

I evaluate the expected utility at age 63 for defined contribution plan participants under different assumptions about their investment strategies. I assume that the utility of a given level of wealth at retirement can be expressed as a constant relative risk aversion value function, where α is the individual's coefficient of relative risk aversion. Wealth at retirement includes both 401(k) and other wealth:

$$U(W_{401(k)}, W_{non-401(k)}) = \frac{\left(W_{401(k)} + W_{non-401(k)}\right)^{1-\alpha}}{1-\alpha} \tag{2}$$

Because the difference in the utility of different levels of 401(k) wealth is likely to be very sensitive to the household's other wealth holdings, some of the empirical work below describes the non-401(k) components of individuals' wealth holdings. Non-401(k) wealth holdings are treated as fixed, even though in practice, both 401(k) and non-401(k) wealth are likely to be affected by common shocks to investment returns.

The expected utility associated with various asset allocation strategies can be evaluated by generating many hypothetical 35-year return histories for the stock market and for "company stock," and evaluating retirement wealth for each of these strategies. I consider five asset allocation strategies: all index bonds, a diversified portfolio of corporate equities, "company stock," a 50/50 mix of bonds and diversified stocks, and a 50/50 mix of bonds and company stock. Conditional on an individual's contribution pattern, for each return history, denoted h, there is an associated 401(k) wealth at age 63 and utility level U_h:

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

The expected utility of each asset allocation strategy can be computed as the average of that strategy's utility outcomes. I denote these expected utility values EU_{Bonds}, EU_{SP500}, $EU_{company\ stock}$, $EU_{50\text{-}50\ Diversified}$, and $EU_{50\text{-}50\ company\ stock}$, respectively.

For a given degree of risk aversion, expected utility levels can be compared directly, but the units of comparison are difficult to interpret. Alternatively, the expected utility levels can be converted into certainty equivalent wealth (Z) by asking what certain wealth level, when evaluated using (3), would generate a utility level equal to the expected utility of the retirement wealth distribution. This calculation conditions on non-401(k) wealth at retirement. For the case of an all-S&P500 portfolio allocation, for example, the certainty equivalent wealth is given by:

$$Z_{SP500} = \left[EU_{SP500}(1-\alpha) \right]^{\frac{1}{1-\alpha}} - W_{non-401(k)} \qquad (4)$$

For an individual without any non-401(k) wealth, the certainty equivalent wealth would simply be the amount of wealth that would yield utility equal to the expected utility of the uncertain wealth distribution. In the presence of non-401(k) wealth, the certainty equivalent is the amount of wealth that must be added to non-401(k) wealth to generate the expected utility level associated with the combination of certain non-401(k) wealth and uncertain 401(k) wealth.

3. Calibration of Earnings, Returns, and Non-401(k) Wealth

This section describes how I calibrate the three key inputs – earnings history, return distribution, and non-401(k) wealth – that the foregoing framework requires to evaluate the expected utility of different asset allocation strategies. The analysis of both earnings records and non-401(k) wealth focuses on single-person households of retirement age. Poterba, et al. (2003) present analogous results for married couples.

3.1 Earnings Profiles and Contribution Histories

My analysis focuses on single individuals who are between the ages of 63 and 67 in the 2000 wave of the Health and Retirement Survey (HRS). The HRS is a longitudinal study that provides the most complete source of information on the earnings history and the balance sheet of U.S. households around retirement age. It began in 1992 with a focus on respondents in the 1931-1941 birth cohorts and their spouses. The fifth wave of the survey was completed in 2000, and the core final data for this wave were released in September 2002. For a subset of HRS participants, survey responses have been linked with information on the respondent's Social Security earnings history between 1951-1991. There are 2357 single person households in the 2000 HRS. Of this group, 1787 have Social Security earnings records, and 1474 of the 1787 have retired, and therefore present complete earnings records. Within this group, 590 are between the ages of 63 and 67 in 2000. I limit my analysis to this sub-sample.

Earnings histories can be used to construct hypothetical 401(k) contribution trajectories. For years prior to 1991, I use reported Social Security earnings. For years after 1991 in which the respondent was still working, the reported HRS earnings are multiplied by a scaling factor equal to the ratio of Social Security administrative earnings in 1991 to reported HRS earnings in the same year. This generates a proxy for Social Security earnings for 1993, 1995, 1997, and 1999. Earnings in even-numbered years are assumed to equal those in the previous odd-numbered year. Nominal Social Security earnings are deflated by the CPI to construct real earnings at each age.

Table 2 presents medians for the earnings trajectories for HRS respondents. The shape of the earnings trajectories determines when, over the course of a working life, workers make contributions to retirement saving plans. The table presents earnings information for different subsets of HRS households to illustrate how sample restrictions affect the earnings trajectory. The first column describes median earnings, in three-year intervals, for all HRS households in year 2000 with earnings histories. This includes married couples as well as single person households. The second column shows the median earnings profile for households with at least one labor force leaver. This group includes 3749 of the 4233 households with earnings profiles. It includes both single households in which the one household member has retired and married couples with at least one retired spouse. The third column presents information on single households who have retired, the 1474 households that form the core group for my analysis. The last four columns focus on the 590 HRS retired single persons who are between the ages of 63 and 67 in 2000, disaggregating this group into those who have never married, those who are divorced, and those who are widows or widowers. There are differences both in the level and the shape of the earnings trajectories across these groups. The never-married group includes very few individuals who were never in the labor force, while the widows and widowers group includes a substantial number of nonparticipants. The differences in labor force attachment across groups contribute to the observed differences in earnings patterns.

Table 2 divides households into three groups based on their educational attainment: less than a high school education; a high school degree, possibly with some college; and those with at least a college degree. It shows several standard patterns with respect to earnings trajectories. First, the earnings trajectories for those with more education are higher than those with less education. The peak of the earnings trajectory is also later for those with more education. The data in column four, for example, show that for singles in the 63-67 age range in 2000, the earnings peak occurred between the ages of 40 and 45. For those with a high school degree and some college, as well as for those with at least a college degree, the earnings peak was between ages 52 and 54. This implies that the highest 401(k) contribution years are earlier in the working career for less educated than for more highly educated workers.

Second, the last four rows show that there are some differences among single households that depend on their route to being single at retirement age. Median earnings at most ages are higher for those who never married than for those who divorced. Widows and widowers tend to have lower earnings than either of the other groups. This may reflect the presence of widows, some of whom did not work outside the home, in this group. Third, comparing the second and third columns of Table 2 shows that the earnings trajectories for those who are single and between the ages of 63 and 67 are lower than the trajectories for couples at the same ages. This can be seen by comparing the entries in the second and third columns of Table 2. For example, the median earnings at ages 46-48 for all households with final earnings and a high school degree but no college degree is $38,000. For the subsample of households who are single, the comparable statistic is $17,900.

Table 3 presents means rather than medians for the earnings profiles. In most cases, the mean earnings are modestly higher than the median, reflecting the skewness of the earnings distribution. For singles with a high school education but no college degree, for example, the median earnings at the earnings peak, ages 52-54, was $18,600. Mean earnings at the same age were $20,200. The broad patterns in the earnings trajectories are similar for the means and the medians.

3.2 Risk and Return for Different Asset Classes

The stochastic simulations assume that 401(k) investors have access to three investment assets: index bonds, a diversified equity market index, and company stock. I assume that index bonds offer a riskless real return of 2.8% per year, a value close to the 30-year rate on U.S. government TIPS bonds. This rate is somewhat higher than the currently-prevailing yield on long-term inflation-indexed bonds in the U.K. I treat these bonds as offering a riskless return, even though their return is not riskless for any investor whose horizon is not exactly 30 years. If the horizon is shorter, then the bonds need to be redeemed before maturity, and if real interest rates fluctuate, the price of the bond may deviate from par at the time of sale. If the horizon is longer than 30 years, there is reinvestment risk, since the investor must roll-over the bond principal when it matures. The investor may also be unable to find investments yielding a 2.8% riskless return when the interest proceeds are reinvested.

I assume that 401(k) savers have access to a diversified portfolio of stocks that offers a random return which can be represented by the empirical distribution of S&P 500 index returns over the 1926 to 2001 period. Ibbotson Associates (2003) reports the annual return time series. The appropriate return concept for use in equation (1), which defines retirement wealth accumulation, is $R(a) = (P_{a+1} + D_a)/P_a - 1$, where P_a denotes the asset price index at the beginning of period *a* and D_a denotes dividend and interest payments during this period, all measured in constant prices. The average annual real return, measured using this return concept, is 9.4%, with an annual standard deviation of 20.4%. The return distribution has thicker tales than a normal distribution. For example, 3 of the 76 draws show returns between -30 and -40%, and two show positive returns of between 50 and 60%.

The objective in defining the hypothetical return distribution for "company stock" is to preserve the mean return on the overall market portfolio, while doubling the standard deviation of returns. Simply increasing the dispersion of returns as defined by R(*a*), while holding the mean return constant, can lead to theoretically impossible outcomes. For example, defining the "company stock" return in period t as $\mu_a + 2*(R(t) - \mu_a)$, where μ_a is the mean of the annual real return series defined above, could potentially generate "returns" of less than -100%. The difficulty in this case arises from expanding the variance of the arithmetic return, R(*a*), measured over a substantial discrete time interval.

To avoid the problem of "company stock" returns outside the feasible interval, I follow an alternative approach. First, I compute the logarithmic return on the market portfolio, defined as $R_{log}(t) = \log((P_{t+1} + D_t)/P_t)$. The arithmetic mean of the logarithmic returns is the geometric mean return, μ_g. The arithmetic and geometric mean returns are approximately related by the expression $\mu_a = \mu_g + 0.5*\sigma^2$, where σ^2 is the variance of the logarithmic returns. One attractive feature of logarithmic returns is that they cannot give rise to arithmetic returns below -100%. Second, I double the variance of logarithmic returns and construct "logarithmic company stock returns" as $R_{log,company}(t) = \mu_g + 2*(R_{log}(t) - \mu_g)$. Third, I translate these logarithmic returns back to arithmetic company stock returns by computing $R_{company}(t) = \exp(R_{log,company}(t)) - 1$. Finally, I normalize the mean of these arithmetic "company stock" returns to equal the mean of the arithmetic returns on the market portfolio. This preserves the important feature that the average arithmetic return on a portfolio of "company stocks" generated according to this procedure would be the arithmetic mean on the market portfolio. Since the arithmetic mean rises as a function of the variance of logarithmic returns, holding the geometric mean return constant, when the standard deviation of logarithmic returns is doubled, the mean arithmetic return rises. Thus normalization of the arithmetic mean therefore involves reducing all of the values of $R_{company}(t)$. I use the resulting time series of "company stock" returns as an empirical distribution from which to draw hypothetical company stock returns.

To compute the hypothetical retirement wealth of a 401(k) participant, a randomization algorithm draws a sequence of 35 real stock portfolio returns and corresponding "company stock" returns from the empirical return distribution. The draws are done with replacement and there is no serial correlation in returns. For "company stock," this gives rise to the possibility of very high or very low returns over the working life. The return time series is used to calculate the real value of each individual's retirement account balance at age 63, subject to the added assumption that his portfolio strategy remains constant throughout his working life. A natural generalization of this algorithm would allow for age-related shifts in portfolio structure, for example toward greater weighting of bonds as retirement approaches.

To obtain stable estimates of the distribution of possible wealth outcomes for a given contribution history, the stochastic simulations are performed 300,000 times. For each portfolio strategy, this yields 300,000 different simulated values for 401(k) wealth at age 63 for each individual in the HRS sample. These outcomes can then be summarized either by calculating summary statistics for the distribution of wealth at retirement, or by computing a certainty equivalent value for these wealth outcomes.

3.3 Other Wealth Holdings for 401(k) Households

The household balance sheet exclusive of 401(k) wealth is an important determinant of the certainty equivalent of different investment strategies. Following the classification procedures developed in Poterba, et al. (2003), I disaggregate 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. I also consider three wealth aggregates. One combines the present discount values of Social Security, defined benefit pensions, and other annuities. The second adds all other financial wealth to this aggregate. The third wealth aggregate combines all wealth excluding that in retirement accounts. This measure includes housing as well as financial assets.

The retirement account category includes IRAs, 401(k)s and other defined contribution accounts. Data on defined contribution plan balances were collected for each respondent in the employment module of the HRS, and then aggregated to the household level. These plan balances 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. "All 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. Net housing wealth equals gross home value less mortgages and home loans on the primary residence. The other wealth category includes the value of real estate other than the household's principal residence, less any debt on such real estate, the value of businesses or farms net any outstanding debt, all assets held in trusts not otherwise classified, vehicles, and jewelry. It is computed net of outstanding personal loans.

The present discounted value of Social Security wealth is calculated based on the reported current Social Security payments for respondents who are receiving Social Security, and on the expected Social Security payments reported by those who are not yet receiving benefits. Future Social Security payments were discounted using cohort mortality tables for individuals born in 1930, as reported in Bell and Miller (2002). The interest rate assumptions follow the Social Security Administration's intermediate-cost scenario: a 6% nominal interest rate with 3% inflation. Future Social Security payments are assumed to remain constant in real terms. Defined benefit pension benefits are assumed to be fixed in nominal terms and therefore discounted using the 6% nominal interest rate.

Table 4 presents information on wealth levels for four groups of HRS households: the whole HRS sample in 2000, the subsample of single and married households with earnings histories, the subsample with earnings histories and at least one retired household member, and the subsample of retired single households. The table is divided into three panels. The upper panel shows median wealth entries, the middle panel shows the 25th and 75th percentile values, and the lower panel shows the mean. Wealth is highly skewed, so there are large differences between some of the means and medians. The table highlights the differences between the broader HRS sample and the sample that is the focus of my analysis.

Three conclusions emerge from Table 4. First, households with Social Security earnings records are broadly similar to those without; the summary wealth statistics for the "all households" column and the "households with earnings histories" columns are similar. This is also true when one compares households in which one member has left the labor force with the all households group. The households with at least one retiree appear to hold modestly higher wealth than those who have not yet retired. Median total wealth is $470,700 for the group that has retired, compared with $454,800 for the entire HRS sample.

Second, the set of single person households exhibits substantially lower wealth than the broader sample. The table presents this comparison for the subset of HRS households that have at least one member who has left the labor force. The median value of total wealth for all such households is $470,700, compared with $242,600 for the single households. The means are higher but also very different: $833,300 versus $470,400. For Social Security wealth, the difference is more modest than for some of the other wealth components. The middle panel, which shows the wealth holdings at the 25th and 75th percentiles of the distribution, shows that the wealth differences between these groups are larger at higher than at lower percentiles of the wealth distribution. At the lower percentiles of the wealth distribution, many households have no holdings for many wealth components. This renders the differences across various groups relatively small.

Third, Table 4 demonstrates some important regularities about the distribution of retirement account ownership. The median holding in retirement accounts for the whole HRS sample is only $4,500, while the mean is $94,300. While the 25th percentile balance is zero for all of the accounts, by the 75th percentile of the distribution, total retirement account holdings are $80,000. The current pattern, in which retirement account ownership is concentrated among households in the upper tranches of the wealth distribution, will shift over time. The current broad participation in 401(k) plans and similar schemes will lead to a much broader distribution of account ownership when today's middle-aged cohorts reach retirement.

Table 5 expands on the information in Table 4 by disaggregating HRS households according to their current marital status and marital history. The first three columns correspond to single households, while the last column focuses on married couples. The table demonstrates the substantial wealth differences between married and single households of retirement age. It also suggests that widows and widowers are of somewhat higher wealth than those who are divorced or separated, or than those who never married. The table is limited to households headed by someone between the ages of 63 and 67 in 2000. The entries show only modest differences across the different groups of single households with respect to Social Security wealth. There are large differences with respect to housing wealth. The median Social Security wealth for all three groups of single households falls between \$118,000 and \$140,000, while for married couples, the median is nearly double this level at \$242,000. The finding that single households have lower total wealth than married households is relevant for the interpretation of the simulation results below, since they focus on single households. If this group has lower wealth than the married segment of the population, it will be more reluctant to hold poorly diversified positions in retirement accounts.

Wealth differences emerge when the population is stratified by marital status, and they also emerge when households are distinguished according to their educational attainment. Table 6 presents information on wealth holdings across different education subsamples. The table is restricted to single retired households with household heads between the ages of 63 and 67, the sample of 590 individuals noted above. The results suggest important inter-group differences. Median annuitized wealth varies from \$113,100 for those with less than a high school degree to \$211,900 for those with a college degree or beyond. 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 \$106,700 for those who never finished high school and \$152,600 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 a median of zero for households with less than a high school education and \$57,000 for households with at least a college degree. Housing equity also varies very substantially across groups. Given the importance of non-401(k) wealth in determining risk tolerance for retirement account investments, these summary statistics suggest that the cost of a poorly diversified retirement account may vary substantially across education groups.

The lower panels of Table 6 present information on the 25th and 75th percentiles of the wealth distribution, as well as on mean wealth, for different education groups. Mean wealth varies across education groups even more dramatically than median wealth. The 25th and 75th percentiles of the wealth distribution show that the largest wealth disparities occur in the upper strata of the wealth distribution. The comparisons between those at different points in the wealth distribution, conditional on education and household status, demonstrates that there are important disparities in wealth holdings within groups stratified based on education or marital status. This dispersion can lead to important differences in the risk tolerance of households with regard to fluctuations in their self-directed retirement wealth.

4. Simulation Evidence on the Cost of Volatility in Retirement Resources

The data on earnings profiles, return distributions, and non-401(k) wealth summarized above can be brought together to estimate each household's distribution of 401(k) plan balances at retirement under different assumptions about 401(k) asset allocation. These distributions can also be translated into certainty equivalent wealth measures.

4.1 The Distribution of 401(k) Balances at Retirement

Table 7 presents information on the distribution of 401(k) balances at retirement, in thousands of year 2000 dollars, for single person retirement-age households. The retirees are stratified by education group. The first row in Table 7 shows the results associated with a portfolio strategy that places all 401(k) assets in inflation-indexed bonds. Since these bonds are assumed to be riskless, there is no uncertainty about the final wealth in this investment scenario. The average value of the 401(k) balance at retirement in this case is $57,100 for those with less than a high school degree, $92,400 for those with a high school degree but no college degree, and $131,500 for those with at least a college degree. Each of these averages is the mean of the retirement balances for all of the households in each education group. All three groups are assumed to have the same contribution rates out of earnings, so these disparities reflect differences across groups in the level and shape of age-earning profiles. The assumption that all households contribute 9% of their earnings to their 401(k) account is a critical determinant of the overall magnitude of the final account balances. Account balances could be scaled up or down proportionally to allow for alternative assumptions about the contribution rate. Incorporating time-varying or age-dependent contribution rates would require further simulations, however.

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 a diversified corporate stock portfolio. The table shows the average account value for several quantiles of the wealth distribution. If the 401(k) account is invested half in a broad-based portfolio of corporate stock, the average of the 20^{th} percentile values for 401(k) wealth at retirement for individuals with a high school but no college degree is $117,400. The comparable value at the 80^{th} percentile is $226,700. Both values are higher, $168,600 and $325,200, for the group with at least a college education. Not surprisingly, the entries for the lowest percentiles of the distribution are lower when the 401(k) assets are fully invested in the corporate stock portfolio than when only half of the assets are in corporate stock. This reflects the risk of unfavorable return on the stock portfolio. However, through most of the distribution, the 401(k) wealth at retirement is greater with the all-stock strategy than with the all-bonds strategy. For retirees with a high school education, for example, by the twentieth percentile of the distribution, the entries associated with a 100% diversified corporate stock strategy are above those for the 50-50 mix. This reflects the greater return, as well as greater risk, associated with the corporate stock portfolio.

Finally, the last two panels of Table 7 show the results from investing half, and then all, of the 401(k) account in "company stock." The arithmetic mean return on "company stock" is the same as that on the diversified stock portfolio, but the standard deviation is twice as great. Thus, not surprisingly, the dispersion of wealth outcomes is much greater in the "company stock" case. The 20th percentile of the distribution when the entire portfolio is invested in company stock would fall somewhere between the first and the fifth percentiles of the distribution from an investment in a diversified stock portfolio. The median for the all-company stock strategy falls between the 10th and 20th percentiles of the diversified stock portfolio case. This is because the possibility of very low returns at some point during the wealth accumulation period exposes households to a substantial risk of reaching retirement with a small account balance. But the upper tail of the distribution is much higher for the company stock case, reflecting the possibility of drawing many very favorable returns in the course of a stochastic simulation. The 90th percentile value of the distribution for the company stock investment is more than twice that of the 90th percentile value for the case of a diversified stock portfolio. The mean wealth at retirement is very similar in the company stock and diversified stock portfolio cases. Since the expected value of an investment of \$1, held for 35 years, is $(1+\mu_a)^{35}$, where μ_a is the arithmetic mean return, and since "company stock" and the diversified equity portfolio have the same arithmetic mean return, the expected value of retirement wealth accumulation should be similar in the two cases.

Assets in 401(k) accounts are measured on a pretax basis, which complicates the evaluation of retirement plan assets such as those in Table 7. 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 reaches retirement age, the effective tax burden may be relatively low. Poterba (2003b) presents illustrative calculations on the conversion between balances in taxable and tax-deferred accounts. For households at retirement age, assets held inside a 401(k) account are typically worth less than the same assets held outside the tax-deferred setting, because of the tax that remains to be paid on the 401(k) principal. Precise translation of tax-deferred into taxable assets requires detailed information, however, on household characteristics and post-retirement financial plans.

4.2 Certainty Equivalent Wealth for Different Portfolio Strategies

The stochastic simulations yield retirement wealth distributions for each of the alternative portfolio strategies, but these distributions do not offer any insight on how a household might evaluate the different potential outcomes associated with different strategies. In particular, there is a tradeoff between the chance of very low returns with high volatility strategies, and the prospect for high returns with such strategies. One way to evaluate the choice among different strategies is to select a parametric utility function and to calculate the expected utility associated with each strategy. These portfolio-strategy specific values, EU_{SP500}, $EU_{Company}$, EU_{bonds}, $EU_{50\% SP500}$, and $EU_{50\% Company}$, can be compared directly. They are easier to interpret, however, if one finds the amount of wealth that an individual would need for sure to generate the same utility level at retirement.

The certainty equivalent computation must be conditioned on the level of non-401(k) wealth available to the retiree. I present two cases, one ignoring any other wealth, and the other conditioning on all wealth except for the 401(k) balance. Since retiree-specific earnings histories are used to calculate retiree-specific distributions of 401(k) balances at retirement, it is possible to use actual non-401(k) wealth at retirement in performing the certainty equivalent calculations. Treating the observed values of non-401(k) wealth as non-random makes the strong assumption that changes in 401(k) wealth are not correlated with other wealth components. This is unlikely, since variation in 401(k) balances due to stock market fluctuations are likely to be reflected in non-401(k) wealth as well.

Table 8 presents the certainty equivalent calculations that assume that retirees have no wealth at retirement other than their 401(k) balances. Each entry in the table shows the average across all individuals in a given education category of the certainty equivalent wealth that would make them as well off, at age 63, as the distribution of retirement wealth that emerges from stochastic simulations under a particular assumption about asset allocation. The stochastic simulations use individual-specific earnings histories, along with a common set of distributional assumptions for asset returns, to compute individual-specific certainty equivalent values.

The entries in Table 8 show results for several different levels of risk aversion, parameterized by α. The values in the first panel are based on linear utility (α=0). The entries are therefore the expected values of the retirement wealth presented in Table 7. For the all bonds case, the certainty equivalent values are the same as the wealth values reported in Table 7 for all levels of risk aversion, since bond returns are certain. The second panel of Table 8 shows that for a retiree with no wealth outside the retirement account, and whose preferences over wealth are given by U(W) = log W, the case with α=1, the certainty equivalent wealth associated with investing in the diversified equity portfolio is more nearly three times the certainty equivalent wealth of the all-index-bond strategy. This is true at all three levels of education shown in the table. For a 50/50 index bond and stock portfolio, the certainty equivalent wealth is between 80 and 85% larger than that from the all-index bond investment strategy. As risk aversion rises, the certainty equivalent wealth associated with the all-stock portfolio strategy declines relative to that from the all-bonds strategy. For someone with $\alpha = 2$, for example, the certainty equivalent wealth of the all stock investment declines to about twice that of the all index bond portfolio. At a risk aversion of four, the certainty equivalent wealth 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.

The results also provide insight on the cost, in utility terms, of moving from a diversified equity portfolio to "company stock." The certainty equivalent wealth of "company stock" in the risk-neutral case is slightly greater than that from the diversified equity portfolio. The equality of the arithmetic mean returns for these two portfolios should generate similar certainty equivalent values when the investor is risk neutral. The difference between the certainty equivalent wealth values for the diversified stock and the company stock portfolios rises as the individual's risk aversion increases. For risk aversion of one, for example, the certainty equivalent wealth of company stock is about 40% of the certainty equivalent of a broad-based portfolio. At a risk aversion of four, the certainty equivalent of the "company stock" portfolio is roughly one tenth of that of the diversified equity portfolio. These results highlight the importance of risk tolerance in determining the cost of holding a non-diversified portfolio.

The results in Table 8 assume that retiree has no retirement wealth outside the 401(k) account. Yet the earlier tables make clear that most retirees have other sources of wealth. The cost of a sequence of stock market returns that delivers a very low retirement wealth is therefore not likely to be as costly in practice as the results in Table 8 suggest. Table 9 addresses this issue by computing certainty equivalent wealth conditional on each individual's actual non-401(k) wealth. For each draw of asset returns, the individual receives a different 401(k) wealth at retirement, but the values of non-401(k) wealth for all calculations are set to the individual's measured non-401(k) wealth in the HRS.

The presence of non-401(k) wealth for virtually all retirement-age individuals has an important effect on the effective degree of risk tolerance with respect to 401(k) type investments. The entries in Table 9 show that introducing non-401(k) wealth at retirement substantially raises the certainty equivalent wealth associated with a risky 401(k) portfolio strategy relative to the certainty equivalent wealth of a more conservative strategy. For the logarithmic utility case, for example, α=1, there are substantial differences in the certainty equivalent wealth values in Tables 8 and 9. For an individual with a high school education but not a college degree, the certainty equivalent wealth of holding 401(k) assets in a broadly diversified equity portfolio is $292,200. This compares with a value of $254,200 for the analogous entry in Table 8. In "company stock," the certainty equivalent is $184,300, compared with $105,300 in Table 8. The difference in the certainty equivalent wealth values is even greater at higher levels of risk aversion. For example, with α=4, the certainty equivalent wealth for the company stock portfolio strategy is $87,900, compared with $12,500 in Table 8. When α=4, the certainty equivalent wealth of the company stock strategy is slightly less than the certainty equivalent value of the all bond portfolio strategy for individuals with less than a college education, and slightly more for those with a college degree. This reflects the different levels of non-401(k) wealth for different investor categories.

These findings suggest that even at modest levels of relative risk aversion, expected utility is substantially higher when individuals hold a diversified stock portfolio instead of "company stock." "Company stock" may, however, deliver an expected utility level at least as great as an investment in riskless inflation-indexed bonds. For relative risk aversion levels of one and two, expected utility is greater with company stock than with index bonds when I recognize the non-401(k) wealth that households hold at retirement. The inequality reverses, and index bonds are preferred, when individuals are assumed to have no wealth other than their 401(k) balance at retirement. The ranking of different portfolio strategies is therefore sensitive to the assumed volatility of the stock portfolio investment, and to the level of other resources that are available at retirement.

The summary statistics in Tables 8 and 9 may understate the cost of holding a poorly diversified 401(k) account, and overstate the certainty equivalent value of the "company stock" investment, for several reasons. First, the broadly diversified portfolio is limited to equities. A well-diversified portfolio that included other assets, such as bonds, small stocks, investment real estate, and perhaps other assets, would have an even lower standard deviation than the diversified portfolio considered above. This would make the certainty equivalent wealth associated with a diversified portfolio higher than that reported above, but it would not affect the certainty equivalent wealth from the poorly diversified portfolio. Second, the assumed standard deviation for individual company stock corresponds to that for very large firms with defined contribution plans. For workers in smaller publicly traded firms, more like the average firm on the New York Stock Exchange, the standard deviation would be higher. It would be higher still for a typical NASDAQ firm. Finally, the calculations do not recognize any correlation between returns on company stock and either the returns on other financial assets or the individual's earnings trajectory. If there is a positive correlation with both, then prospective retirees have an additional hedging motive for avoiding investments in company stock.

The substantive importance of the correlation between company stock returns and human capital returns is not clear. Some workers with general skills, such as clerical workers or computer consultants, may experience a very small decline in their prospective labor income when the firm they work for experiences difficult times. For other more specialized workers, however, the human capital effects of company stock price movements may be substantial.

5. Conclusions

This paper presents three empirical findings. First, a substantial minority of investors in 401(k) retirement plans hold significant amounts of company stock in these plans, thereby raising the volatility of their retirement wealth relative to what it would be if they invested in a broadly diversified portfolio of common stocks or other assets. While this paper does not address the question of whether such company stock holdings are voluntary or compulsory, in many cases the holdings are probably voluntary. Explaining the factors that lead workers to invest in company stock remains an active area for ongoing research.

Second, there is a tradeoff between higher volatility assets, and higher return assets, in asset allocation decisions in self-directed retirement accounts. Holding higher volatility assets without any compensating improvement in expected returns will reduce expected utility, but when more volatile assets offer higher returns, the choice among different portfolio allocation strategies will depend on risk tolerance. This distinction is illustrated by comparing investments in diversified equity portfolios and in company stock.

Finally, the impact of higher volatility assets on expected utility at retirement is very sensitive to the set of other assets that are likely to comprise the non-401(k) balance sheet at retirement. In particular, when a retiree has an assured income stream in retirement from Social Security or a defined benefit pension plan, he will be much more risk tolerant with respect to 401(k) plan investments than if he does not have access to such sources of retirement wealth. There are substantial differences across education classes in the level of non-401(k) retirement wealth, which imply that the potential cost of a poorly diversified retirement account is likely to vary across sub-groups within the population.

The stochastic simulation results underscore the importance of recognizing that retirement accumulation decisions are made as part of a broader household wealth accumulation plan. Discussions of the cost of risky retirement account investments that do not consider the other resources available to households when they reach retirement age are likely to overstate the cost of holding risky assets in retirement portfolios. This insight should be considered when designing regulatory policy with respect to self-directed retirement saving accounts.

There are several directions for future work that emerge from the current findings. First, the analysis could be improved by allowing for stochastic variation in the non-401(k) sources of wealth at retirement. If the value of non-retirement financial assets vary in response to some of the same underlying shocks that may affect the value of retirement wealth, then there is likely to be a positive correlation between retirement and non-retirement wealth. Such a correlation will reduce the certainty equivalent wealth of risky investments in 401(k) accounts. It will also dampen the findings about the role of non-401(k) wealth in protecting retirement savers against fluctuations in the value of their retirement accounts, since movements in the value of 401(k) accounts could be positively correlated with fluctuations in the value of non-401(k) assets.

Second, it would be useful to explore alternative assumptions about the volatility and return trade-offs that are associated with different investment options. As Mehra and Prescott's (forthcoming) discussion of the "equity premium puzzle" suggests, there are a number of reasons for suspecting that the historical mean equity return and standard deviation for equities may overstate the prospective return on stocks relative to that on bonds. If this is the case, then the certainty equivalent calculations presented in this paper overstate the actual return to holding company stock or a diversified common stock portfolio.

Finally, the analysis relies critically on the assumption that agents maximize expected utility with a constant relative risk aversion utility function. A substantial body of research suggests that in many contexts, household decisions in the presence of uncertainty fail to conform to the predictions of this framework. Rabin (2000), for example, notes that assuming modest risk aversion over large gambles implies virtual risk neutrality for small gambles, a prediction that often fails in reality. Since the gambles considered in this paper are substantial, standard expected utility models may offer reasonable guidance regarding household behavior. Future work should nevertheless try to develop tractable alternatives to the expected utility framework, and to calibrate these alternatives in a way that could be used to evaluate household decision making.

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Table 1: Own-Company Stock Holdings in 20 Largest U.S. Defined Contribution Plans, 2001

Company	Plan Assets (billion dollars)	Percentage in Company Stock	Annual Standard Deviation of Stock Return
IBM Corp.	16.9	12%	0.394
General Electric Corp.	16.9	68%	0.331
General Motors Corp.	16.3	21%	0.349
Verizon Communications Inc.	13.3	38%	0.334
Lockheed Martin Corp.	12.9	36%	0.366
Procter & Gamble Co.	9.8	90%	0.366
United Technologies Corp.	8.7	25%	0.368
SBC Communications Inc.	8.6	44%	0.353
E.I. DuPont de Nemours & Co. Inc.	8.5	12%	0.360
Hewlett-Packard Co.	8.1	9%	0.513
AT&T Corp.	7.8	14%	0.418
Citigroup Inc.	7.4	37%	0.411
ChevronTexaco Corp.	7.1	60%	0.275
Philip Morris Cos. Inc.	6.9	28%	0.380
BP America Inc.	6.5	42%	0.286
Lucent Technologies Inc.	6.2	3%	0.625
Shell Oil Co.	6.2	19%	0.304
Wells Fargo & Co.	6.1	48%	0.337
American Airlines Inc.	5.8	0%	0.489
Merrill Lynch & Co.	5.7	52%	0.497

Notes: Entries are calculated from data provided by Pensions and Investments magazine. Entries for Boeing, Ford, Lucent, and Verizon, all of which have sufficient defined contribution plan assets to be included in the twenty largest plans, are excluded for lack of information on company stock ownership.

Table 2: Median Income Trajectories for HRS Households in 2000

Age	Households with Social Security Histories	Households with Final Earnings	Singles with Final Earnings	With Final Earnings, Singles Aged 63-67: All *	Widow(ers)	Divorced	Never Married
Less than High School Education ($ thousands)							
25-27	9.8	12.3	1.1	0.4	0.4	0.8	0.5
28-30	14.4	16.9	2.4	0.7	0.7	1.3	0.2
31-33	17.3	20.3	5.3	4.1	3.6	5.1	4.0
34-36	19.9	22.9	8.2	8.6	7.9	9.9	11.7
37-39	21.7	24.8	8.7	7.2	7.6	7.2	7.3
40-42	22.8	26.3	8.8	10.2	10.2	9.9	16.6
43-45	21.6	26.1	9.6	10.3	10.1	9.4	18.3
46-48	20.8	24.7	8.8	9.6	8.1	9.0	16.5
49-51	19.8	24.2	7.8	7.1	6.6	8.3	14.1
52-54	17.6	21.7	7.0	8.1	9.4	8.1	11.7
55-57	13.8	18.7	4.2	7.7	6.0	11.9	6.2
58-60	6.1	11.8	0.0	1.2	1.1	7.1	0.0
61-63	0.0	1.1	0.0	0.2	0.0	5.1	1.9
64-66	0.0	0.0	0.0	0.0	0.0	0.0	0.0
High School Degree and/or Some College ($ thousands)							
25-27	20.4	21.8	5.9	2.8	0.0	4.7	13.8
28-30	24.9	25.7	6.0	2.6	0.0	7.0	15.8
31-33	26.3	26.7	8.5	5.9	1.0	10.7	17.9
34-36	28.4	30.2	12.3	9.6	7.0	8.9	23.0
37-39	32.9	34.0	15.5	13.1	9.6	13.7	24.6
40-42	34.0	35.6	17.8	16.5	10.9	19.1	26.7
43-45	34.7	37.0	18.5	17.8	13.8	19.1	26.6
46-48	34.9	38.0	17.9	17.5	14.5	18.0	26.7
49-51	33.7	36.7	17.4	17.9	14.5	20.2	27.0
52-54	31.0	33.9	17.0	18.6	15.1	20.8	26.7
55-57	26.0	29.1	13.6	16.6	11.4	19.8	22.3
58-60	15.0	18.6	5.0	12.5	8.1	17.0	14.0
61-63	0.0	0.1	0.0	3.8	3.3	3.9	5.4
64-66	0.0	0.0	0.0	0.0	0.0	0.0	0.0
College Degree and/or Some Post-Graduate ($ thousands)							
25-27	20.9	22.4	8.9	10.9	3.0	10.0	21.0
28-30	26.2	26.5	8.2	11.6	1.3	9.2	25.3
31-33	27.4	29.1	10.6	10.6	0.2	7.4	23.9
34-36	34.0	34.7	20.3	20.2	0.0	17.5	33.8
37-39	36.6	37.7	24.3	17.5	1.1	18.5	36.7
40-42	41.9	43.7	27.1	23.5	7.6	24.6	43.2
43-45	46.2	47.3	29.1	27.7	14.3	28.9	40.5
46-48	49.0	51.8	30.5	27.4	13.9	30.5	37.3
49-51	53.0	56.9	33.2	28.6	16.6	35.4	37.2
52-54	51.7	56.0	30.9	29.1	15.8	35.5	34.3
55-57	46.5	51.2	27.3	26.3	18.5	31.7	21.0
58-60	24.2	30.2	11.5	19.3	15.2	27.1	8.0
61-63	0.0	0.4	0.0	6.9	2.2	13.2	4.8
64-66	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sample Size and (Weighted Sample size) by Education Group							
Less Than HS	1228 (2991)	1027 (2511)	432 (1050)	187 (441)	99 (223)	74 (185)	11 (27)
HS / Some College	2123 (5985)	1912 (5410)	796 (2220)	310 (847)	150 (400)	124 (349)	34 (92)
College / Postgrad	882 (2672)	810 (2468)	246 (717)	93 (266)	27 (80)	44 (121)	20 (60)
Total	4233 (11648)	3749 (10390)	1474 (3987)	590 (1558)	276 (703)	242 (655)	65 (180)

* Includes 276 widows and widowers, 242 divorced or separated singles, 65 never married, and 7 singles whose previous marital status is indeterminate. Source: Author's tabulations from 2000 Health and Retirement Survey. Households with zero earnings are included in the data sample.

Table 3: Mean Income Trajectories for HRS Households in 2000

Age	Households with Social Security Histories	Households with Final Earnings	Singles with Final Earnings	With Final Earnings, Singles Aged 63-67: All *	Widowed	Divorced	Never Married
Less than High School Education ($ thousands)							
25-27	13.0	4.2	6.7	5.1	4.2	6.2	5.1
28-30	15.8	17.1	8.0	6.3	4.9	8.1	5.8
31-33	18.1	19.7	9.7	8.6	7.0	10.6	9.2
34-36	20.6	22.4	11.3	10.6	9.0	12.6	12.0
37-39	22.8	25.0	12.1	11.1	9.7	13.1	9.7
40-42	24.5	27.1	12.6	12.2	11.2	13.5	14.8
43-45	25.2	28.0	12.7	12.0	11.0	13.1	16.2
46-48	25.7	28.6	12.4	11.8	10.7	12.7	16.8
49-51	25.1	28.2	12.2	11.7	10.3	13.1	15.9
52-54	24.2	27.3	11.7	11.5	10.7	12.8	11.7
55-57	21.7	24.7	10.8	10.9	9.7	12.9	9.3
58-60	17.9	20.6	9.1	9.8	8.7	11.8	7.2
61-63	11.3	13.3	6.6	7.8	6.2	10.1	7.7
64-66	4.2	4.9	1.6	1.3	1.2	1.5	1.3
High School Degree and/or Some College ($ thousands)							
25-27	18.8	19.6	10.1	8.3	6.7	9.1	12.1
28-30	21.5	22.4	11.6	9.5	7.4	10.8	14.0
31-33	23.8	24.9	13.2	11.8	9.0	14.2	15.5
34-36	26.7	28.0	15.5	13.6	11.8	14.1	19.2
37-39	30.0	31.7	17.7	15.8	13.9	16.4	21.6
40-42	32.5	34.4	19.4	18.2	16.2	19.0	24.8
43-45	34.3	36.3	20.3	19.5	17.5	20.1	25.9
46-48	35.8	37.9	20.7	19.5	17.6	20.1	24.8
49-51	35.8	38.1	20.6	20.0	16.5	22.5	25.3
52-54	35.2	37.5	19.9	20.2	17.0	22.4	25.5
55-57	33.2	35.6	19.5	22.2	16.3	29.2	21.2
58-60	27.4	29.6	15.9	21.7	15.6	29.5	18.5
61-63	15.7	17.0	8.8	15.5	12.3	19.1	14.6
64-66	6.2	6.8	3.2	4.3	5.1	4.0	2.5
College Degree and/or Some Post-Graduate ($ thousands)							
25-27	19.5	20.3	12.1	12.3	9.3	11.7	17.0
28-30	23.5	24.5	13.7	13.6	8.6	13.1	20.0
31-33	26.2	27.7	16.0	15.8	10.1	16.0	22.2
34-36	30.2	31.9	19.5	18.3	11.9	17.4	27.8
37-39	34.3	36.4	22.2	20.6	13.6	21.3	29.4
40-42	38.7	41.2	24.7	24.3	17.7	25.8	31.7
43-45	42.7	45.5	27.5	25.9	20.3	27.5	31.3
46-48	46.7	50.0	29.2	26.3	20.3	29.0	30.7
49-51	48.6	52.0	31.3	29.0	23.0	32.3	32.2
52-54	50.7	54.4	32.0	30.1	24.1	35.0	30.1
55-57	53.0	56.9	38.6	39.5	57.5	33.4	30.5
58-60	40.3	43.2	27.4	28.9	29.6	30.1	27.6
61-63	23.4	25.2	12.7	20.5	17.7	24.0	18.5
64-66	11.0	11.8	4.3	4.6	3.7	5.4	4.5
Sample Size Information by Education Group							
Less Than HS	1228	1027	432	187	99	74	11
HS / Some College	2123	1912	796	310	150	124	34
College / Postgrad	882	810	246	93	27	44	20
Total	4233	3749	1474	590	276	242	65

Notes: See notes to Table 2.

Table 4: Household Balance Sheets, HRS Households, 2000

Wealth Component	All Households	Households with Social Security Histories	Households with Final Earnings	Singles with Final Earnings	Singles with Final Earnings, Aged Aged 63-67
Medians					
Social Security	159.9	162.1	172.3	123.9	126.8
DB Pension	0.0	0.0	0.0	0.0	0.0
Other Annuity	0.0	0.0	0.0	0.0	0.0
Retirement Accounts	4.5	4.6	8.0	0.0	0.0
- IRA	0.0	0.0	0.0	0.0	0.0
- 401(k) and Other DC	0.0	0.0	0.0	0.0	0.0
Other Financial Wealth	30.0	29.0	35.0	6.0	6.0
Housing Equity	70.0	65.0	69.0	35.0	35.0
Other Wealth	15.0	15.0	16.0	6.0	5.0
SS + DB + Other Annuity	215.3	218.4	225.9	142.6	146.2
+ Other Financial	286.3	285.5	300.1	170.7	174.8
Total Excluding Retirement Accounts	422.0	414.5	436.6	236.4	236.4
Total	454.8	447.6	470.7	242.6	242.4
25th/75th Percentile					
Social Security	82.1/238.7	88.7/238.2	100.1/244.1	64.6/162.1	85.9/160.7
DB Pension	0.0/111.9	0.0/119.0	0.0/117.4	0.0/54.7	0.0/63.3
Other Annuity	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
Retirement Accounts	0.0/80.0	0.0/79.0	0.0/85.0	0.0/27.0	0.0/20.0
- IRA	0.0/45.0	0.0/44.7	0.0/50.0	0.0/11.0	0.0/10.0
- 401(k) and Other DC	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
Other Financial Wealth	0.1/180.0	0.1/175.0	0.4/196.0	0.0/80.0	0.0/84.0
Housing Equity	16.0/130.0	15.0/125.0	20.0/125.0	0.0/85.0	0.0/83.0
Other Wealth	4.0/66.0	4.0/64.0	5.0/68.0	0.8/20.0	0.8/18.0
SS + DB + Other Annuity	115.9/338.1	120.4/341.6	128.2/348.3	79.6/215.3	96.9/213.4
+ Other Financial	137.5/539.2	140.8/539.2	152.5/563.5	89.1/312.3	109.4/314.0
Total Excl. Retirement Accounts	207.3/789.9	205.2/783.7	221.9/812.5	122.5/436.6	131.8/436.1
Total	214.2/885.4	209.9/879.9	229.4/915.6	124.4/480.7	134.7/479.1
Means					
Social Security (SS)	160.7	163.2	170.8	112.2	118.4
DB Pension	136.3	145.8	145.0	64.1	81.2
Other Annuity	5.0	5.2	4.8	4.1	7.0
Retirement Accounts	94.3	94.5	101.4	47.3	46.2
- IRA	66.0	65.6	69.4	32.4	35.4
- 401(k) and Other DC	28.3	28.9	31.9	14.9	10.8
Other Financial Wealth	181.6	187.6	200.3	115.1	97.3
Housing Equity	104.2	95.5	97.8	60.1	58.7
Other Wealth	129.5	108.0	113.3	67.5	47.1
SS + DB + Other Annuity	302.0	314.3	320.5	180.4	206.6
+ other financial	483.7	501.9	520.8	295.5	303.9
Total Excluding Retirement Accounts	717.4	705.4	732.0	423.1	409.7
Total	811.7	799.9	833.3	470.4	455.8
Number of Households	6195	4233	3749	1474	590
Weighted Sample Size ('000s)	16709.5	11648.1	10390.1	3986.9	1554.7

Source: Author's tabulations as described in the text.

Table 5: Household Balance Sheet Information, Retired HRS Households with Household Heads Aged 63-67 in 2000

Wealth Component	Widow(er)s	Divorced or Separated	Never Married	Married Couples with Husband 63-67 and Retired
Medians				
Social Security	139.2	118.8	119.2	242.0
DB Pension	0.0	0.0	10.9	35.4
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	0.0	0.0	0.0	30.0
IRA	0.0	0.0	0.0	11.0
401(k) and Other DC	0.0	0.0	0.0	0.0
Other Financial Wealth	9.2	4.6	7.5	88.8
Housing Equity	48.0	20.0	20.0	91.0
Other Wealth	6.0	5.0	5.0	30.0
SS + DB + Other Annuity	156.4	132.9	143.5	316.4
+ other financial	191.6	160.6	177.7	460.6
Total Excl. Retirement	258.2	219.4	234.9	652.3
Total	269.6	222.6	234.9	713.2
25th/75th Percentile				
Social Security	97.2/165.8	70.2/149.2	77.9/169.3	175.9/297.3
DB Pension	0.0/67.4	0.0/51.0	0.0/85.0	0.0/180.9
Other Annuity	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
Retirement Accounts	0.0/21.5	0.0/20.0	0.0/12.0	0.0/156.0
- IRA	0.0/11.9	0.0/7.0	0.0.8.0	0.0/101.0
- 401(k) and Other DC	0.0/0.0	0.0/0.0	0.0/0.0	0.0/7.0
Other Financial Wealth	0.0/84.0	0.0/65.0	-0.2/148.1	8.5/305.2
Housing Equity	0.0/90.0	0.0/71.0	0.0/90.0	52.0/150.0
Other Wealth	1.0/18.0	0.5/18.0	0.4/13.9	12.0/114.5
SS + DB + Other Annuity	109.9/230.7	82.8/200.2	87.8/249.3	223.1/455.5
+ other financial	115.6/307.7	93.1/295.2	119.9/370.9	273.2/771.1
Total Excl. Retirement	150.0/437.9	122.2/412.5	141.9/447.9	393.8/1060.7
Total	154.3/509.9	122.7/424.6	141.9/447.9	410.7/1224.3
Means				
Social Security	127.7	108.9	121.2	228.9
DB Pension	73.7	95.4	65.9	182.6
Other Annuity	15.3	0.0	0.9	5.1
Retirement Accounts	40.0	59.0	25.2	154.3
IRA	31.5	42.8	24.4	106.8
401(k) and Other DC	8.5	16.2	0.8	47.5
Other Financial Wealth	80.8	97.7	91.1	287.2
Housing Equity	73.6	44.5	50.8	123.7
Other Wealth	68.8	29.7	27.8	141.6
SS + DB + Other Annuity	216.7	204.2	188.0	416.6
+ other financial	297.6	302.0	279.1	703.8
Total Excl. Retirement	440.0	376.2	357.7	969.1
Total	480.0	435.2	382.9	1123.4
Number of Households	276	242	65	759.0
Weighted Sample Size	703	655	180	2084.0

Source: Author’s tabulations as described in the text.

Table 6: Household Balance Sheet by Educational Category, Single Retirees Aged 63-67 in 2000

	All Education Levels	Less than High School Degree	High School and/or Some College	College and/or Postgraduate Degree
Medians				
Social Security	126.8	106.7	136.4	152.6
DB Pension	0.0	0.0	0.0	37.5
Other Annuity	0.0	0.0	0.0	0.0
Retirement Accounts	0.0	0.0	0.0	5.0
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	6.0	0.0	14.0	57.0
Housing Equity	35.0	1.0	40.0	70.0
Other Wealth	5.0	1.0	6.0	10.0
SS + DB + Other Annuity	146.2	113.1	160.4	211.9
+ other financial	174.8	119.9	198.4	361.5
Total Excl. Retirement Accounts	236.4	144.9	254.8	523.1
Total	242.4	144.9	271.1	536.1
25th/75th Percentile				
Social Security	85.9/160.7	73.4/131.0	91.0/162.8	97.8/182.1
DB Pension	0.0/63.3	0.0/3.7	0.0/68.8	0.0/184.0
Other Annuity	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
Retirement Accounts	0.0/20.0	0.0/0.0	0.0/29.5	0.0/70.0
- IRA	0.0/10.0	0.0/0.0	0.0/25.0	0.0/35.0
- 401(k) and Other DC	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0
Other Financial Wealth	0.0/84.0	0.0/5.0	0.0/98.8	6.0/273.0
Housing Equity	0.0/83.0	0.0/50.0	0.0/90.0	3.0/137.0
Other Wealth	0.8/18.0	0.0/7.0	1.2/20.0	5.0/75.0
SS + DB + Other Annuity	96.9/213.4	75.4/147.7	110.1/217.2	115.1/334.7
+ other financial	109.4/314.0	70.2/160.6	126.8/314.1	205.9/695.1
Total Excl. Retirement Accounts	131.8/436.1	89.2/227.3	158.6/441.8	294.0/1012.4
Total	134.7/479.1	90.6/227.3	161.7/495.0	294.0/1078.1
Means				
Social Security	118.4	98.2	123.9	134.4
DB Pension	81.2	14.4	51.7	285.9
Other Annuity	7.0	0.4	10.8	6.1
Retirement Accounts	46.2	5.3	39.8	134.0
IRA	35.4	2.0	34.9	92.2
401(k) and Other DC	10.8	3.3	4.9	41.8
Other Financial Wealth	97.3	12.5	86.8	270.9
Housing Equity	58.7	28.2	58.5	110.0
Other Wealth	47.1	18.5	42.4	109.5
SS + DB + Other Annuity	206.6	113.0	186.4	426.3
+ other financial	303.9	125.5	273.2	697.2
Total Excl. Retirement Accounts	409.7	172.1	374.1	916.6
Total	455.8	177.4	413.9	1050.6
Number of Households	590	187	310	93
Weighted Sample Size ('000s)	1554.7	441.2	847.3	266.2

Source: Author's tabulations as described in the text.

Table 7: Distribution of Simulated 401(k) Balances at Retirement

	Less than High School Degree	High School and/or Some College	College and/or Degree
100% Riskless Bonds	57.1	92.4	131.5
50% Riskless Bonds, 50% Diversified Stocks			
1	18.1	31.2	44.2
5	53.9	86.5	124.1
10	62.3	99.2	142.4
20	74.4	117.4	168.6
30	84.7	132.7	190.5
40	94.6	147.5	211.6
50	104.9	162.8	233.6
60	116.4	179.8	258.0
70	130.2	200.0	287.0
80	148.4	226.7	325.2
90	178.0	269.9	387.1
Mean	114.4	176.3	252.9
100% Diversified Stocks			
1	5.3	9.9	13.8
5	42.2	68.3	98.8
10	56.7	90.4	130.8
20	81.6	127.8	184.7
30	106.5	164.8	238.1
40	133.9	205.3	296.5
50	166.3	252.6	364.8
60	206.6	311.4	449.4
70	260.9	390.1	562.8
80	343.2	508.6	733.5
90	502.3	736.5	1061.8
Mean	241.6	359.4	518.7
50% Riskless Bonds, 50% "Company Stock"			
1	4.5	8.9	12.0
5	24.2	41.0	58.7
10	31.3	52.2	74.8
20	43.2	70.8	101.5
30	54.9	88.8	127.5
40	67.8	108.4	155.5
50	82.9	131.1	188.2
60	101.6	159.2	228.6
70	126.9	196.7	282.4
80	165.3	253.3	363.7
90	240.3	362.7	520.8
Mean	118.6	182.6	262.1
100% "Company Stock"			
1	0.4	0.9	1.1
5	6.2	11.7	16.4
10	9.8	17.9	25.4
20	17.5	31.0	44.4
30	27.3	47.1	67.8
40	40.6	68.5	98.8
50	59.8	98.5	142.5
60	89.2	143.8	208.2
70	138.7	218.9	316.7
80	236.2	364.0	526.0
90	506.1	757.5	1095.3
Mean	261.0	387.7	560.9

Note: Entries are in thousands of year 2000 dollars.

Table 8: Certainty Equivalent Value of 401(k) Balance Distribution for Different Portfolio Allocation Rules, Setting Non-401(k) Retirement Wealth to Zero

Coefficient of Relative Risk Aversion and Portfolio Allocation Strategy	Less than High School Degree	High School and/or Some College	College and/or Postgraduate Degree
$\alpha = 0$			
100% Riskless Bonds	57.1	92.4	131.5
50% Bonds 50% Diversified Stocks	114.4	176.3	252.9
100% Diversified Stocks	241.6	359.4	518.7
50% Bonds, 50% “Company Stock”	118.6	182.6	262.1
100% “Company Stock”	261.0	387.6	560.9
$\alpha = 1$			
100% Riskless Bonds	57.1	92.4	131.5
50% Bonds 50% Diversified Stocks	105.0	163.0	234.1
100% Diversified Stocks	167.0	254.2	368.0
50% Bonds, 50% “Company Stock”	84.7	134.0	192.8
100% “Company Stock”	64.1	105.3	153.2
$\alpha = 2$			
100% Riskless Bonds	57.1	92.4	131.5
50% Bonds 50% Diversified Stocks	96.5	150.9	216.8
100% Diversified Stocks	116.7	182.3	265.1
50% Bonds, 50% “Company Stock”	62.4	101.5	146.4
100% “Company Stock”	22.8	41.5	59.4
$\alpha = 4$			
100% Riskless Bonds	57.1	92.4	131.5
50% Bonds 50% Diversified Stocks	81.7	129.6	186.6
100% Diversified Stocks	60.6	99.9	146.0
50% Bonds, 50% “Company Stock”	37.2	63.7	91.7
100% “Company Stock”	6.1	12.5	16.7

Note: Entries are in thousands of year 2000 dollars.

Table 9: Certainty Equivalent Wealth for Different Portfolio Allocation Rules, Recognizing Actual Non-401(k) Retirement Wealth for HRS Households

Coefficient of Relative Risk Aversion and Portfolio Allocation Strategy	Less than High School Degree	High School and/or Some College	College and/or Postgraduate Degree
$\alpha = 0$			
100% Riskless Bonds	57.2	92.4	132.3
50% Bonds 50% Diversified Stocks	114.3	176.3	252.6
100% Diversified Stocks	241.3	359.2	516.0
50% Bonds, 50% “Company Stock”	118.6	182.6	262.1
100% “Company Stock”	261.0	387.6	560.9
$\alpha = 1$			
100% Riskless Bonds	57.2	92.4	132.3
50% Bonds 50% Diversified Stocks	109.5	170.0	245.3
100% Diversified Stocks	190.5	292.2	432.1
50% Bonds, 50% “Company Stock”	99.7	157.4	231.8
100% “Company Stock”	112.9	184.3	289.2
$\alpha = 2$			
100% Riskless Bonds	57.2	92.4	132.3
50% Bonds 50% Diversified Stocks	105.1	164.2	238.7
100% Diversified Stocks	157.8	247.9	376.0
50% Bonds, 50% “Company Stock”	87.1	140.3	210.9
100% “Company Stock”	75.6	128.8	211.9
$\alpha = 4$			
100% Riskless Bonds	57.2	92.4	132.3
50% Bonds 50% Diversified Stocks	97.6	154.2	227.0
100% Diversified Stocks	119.7	194.6	306.5
50% Bonds, 50% “Company Stock”	71.6	118.2	183.3
100% “Company Stock”	50.0	87.9	152.2

Note: Entries are in thousands of year 2000 dollars.