

## **REDUCING SOCIAL SECURITY PRA RISK AT THE INDIVIDUAL LEVEL – LIFECYCLE FUNDS AND NO-LOSS STRATEGIES**

James Poterba  
MIT and NBER

Joshua Rauh  
University of Chicago Graduate School of Business and NBER

Steven Venti  
Dartmouth College and NBER

David Wise  
Harvard University Kennedy School of Government and NBER

July 2006  
Revised December 2006

### **ABSTRACT**

This paper examines how following different personal retirement account (PRA) asset allocation strategies over the course of a worker's career would affect the distribution of retirement wealth and the expected utility of wealth at retirement. It considers rules that allocate a constant portfolio fraction to various assets at all ages, as well as "lifecycle" rules that vary the mix of portfolio assets as the worker ages. The analysis simulates retirement wealth using asset returns that are drawn from the historical return distribution. The expected utility associated with different PRA asset allocation strategies, and the ranking of these strategies, is sensitive to four features of markets and households: the return on corporate stock, the worker's relative risk aversion, the amount of non-PRA wealth that the worker will have available at retirement, and the expense ratios charged for the investment. At modest levels of risk aversion, or in the presence of substantial non-PRA wealth at retirement, the historical pattern of stock and bond returns implies that the expected utility of investing completely in diversified stocks is greater than that from any of the more conservative strategies. Higher risk aversion or lower expected returns on stocks raises the expected utility of portfolios that include less risky assets. There often exists a fixed-proportions portfolio of stocks and inflation-indexed government bonds that yields expected utility at retirement that is at least as high as that from typical lifecycle investment strategies. When asset allocation is near the allocation that generates the highest expected utility, variation in expense ratios has a greater effect on retirement utility than variation in asset allocation.

We are grateful to Tonja Bowen for outstanding research assistance, to Morningstar for providing us with mutual fund data, and to the National Institute of Aging for research support. This research was supported by the U.S. Social Security Administration through grant #10-P-98363-1-03 to the National Bureau of Economic Research as part of the SSA Retirement Research Consortium. The work was also supported by NIA grant P01-AG005842. The findings and conclusions expressed are solely those of the authors and do not represent the views of SSA, any agency of the Federal Government, or the NBER.

Retirement savers in a Social Security system with a personal retirement account (PRA) component would face the challenge of deciding how to allocate their PRA portfolios across a broad range of asset classes and across many different financial products. Asset allocation decisions have important consequences for retirement wealth accumulation, since they affect the expenses of investing as well as the risk of low returns. The goal of this paper is to assess the relative risk associated with alternative asset allocation strategies in PRAs. It also offers insight on the consequences of different asset allocation rules in current private-sector defined contribution (DC) plans, such as 401(k) plans.

Quantifying the risk associated with DC pension plans, and examining how individual choices affect this risk, is an active topic of research. Samwick and Skinner (2004) compare the risks associated with defined benefit and defined contribution plans for workers with a set of stylized wage and employment trajectories. Many other studies have examined the risk of different investment strategies in the context of lifetime saving programs that resemble DC plans. Campbell and Viceira (2002) and Cocco, Gomes, and Maenhout (2005) explore the optimal asset allocation between stocks and bonds for lifecycle savers. Shiller (2005) tabulates the distribution of possible terminal wealth values when investors follow age-dependent asset allocation rules in a saving program that he models on a defined contribution Social Security system. Poterba, Rauh, Venti, and Wise (2005), hereafter PRVW (2005), examine how several different portfolio allocation strategies over the lifecycle affect retirement wealth.

Previous findings about the level of retirement wealth associated with defined contribution saving programs, and about the risk of such wealth, are very sensitive to assumptions about the expected return on corporate stock. Stocks have offered substantially higher average returns than bonds over the eighty year sample that is often used to calibrate the return distributions. PRVW (2005) find that this has an important effect on the distribution of retirement wealth for alternative asset allocation rules. Greater exposure to stocks leads to a higher average retirement account balance. For a risk neutral retirement saver facing the historical return distribution, and choosing a fraction

between zero and one hundred percent of her portfolio to allocate to stocks, this suggests that allocating the entire portfolio to stocks is optimal. As the risk aversion of a retirement saver increases, the optimal share of the retirement portfolio that is held in stocks declines.

Over the past three decades personal retirement accounts, such as those in 401(k) plans and similar programs, have become the predominant form of retirement saving in the private sector. The conversion from defined benefit to defined contribution - personal account plans in the private sector has led to the introduction of financial products intended to reduce market risk. Some plan sponsors have begun to offer participants investment options that permit them to avoid asset allocation decisions. One such innovation in the financial services marketplace is the “lifecycle fund” that automatically varies the share of the saver’s portfolio that is held in stocks and in bonds as a function of the saver’s age or years until retirement. These funds have been one of the most rapidly growing financial products of the last decade. They offer investors the opportunity to exploit time-varying investment rules, typically reducing equity exposure as retirement approaches, without the need to make active investment management choices. In this paper, we consider the effect of such lifecycle investment strategies on the distribution of retirement wealth.

Our previous research on lifecycle asset allocation patterns, PRVW (2005), considered how lifecycle allocation affects the distribution of retirement assets and the expected utility of reaching retirement with a given asset stock. We tried to capture the potential utility of an investment strategy with a high mean retirement balance but a small probability of a very poor outcome. We recognized that wealth held outside the saver’s DC plan can have an important effect on utility associated with retirement assets at retirement. We used Social Security earnings histories, rather than simple stochastic processes, to model household contribution flows to DC plans. Our results capture the wide degree of heterogeneity in household earnings experiences.

This paper builds on our earlier methodology in several ways. First, we model the asset allocation trajectories implied by the lifecycle funds. Second, we model the returns to retirement

investing using realistic expense ratios and consider the impact of expense ratios on the accumulation of retirement wealth. Third, we calculate expected utilities over a range of fixed-allocation and simple lifecycle strategies to derive the optimal strategy within a given class of strategies. We then compare the returns from typical lifecycle fund strategies with those from strategies that yield the best certainty equivalent utility. Many of the proposals for PRAs that have been discussed in policy debates in recent years would allow individuals to channel a small proportion of their Social Security taxes to a PRA. Our analysis, however, considers a setting in which a substantial fraction of salary is devoted to the PRA. We view such a system as a potential replacement for the current Social Security system. By denying participants the safety of a Social Security defined benefit “floor” under their retirement wealth, we may over-estimate the riskiness of PRA investments.

We find that 100% stock portfolios tend to dominate when households have low risk aversion, when expected equity returns are equal to the historical average, or when households have significant amounts of non-PRA wealth. More conservative strategies yield the greatest utility for households with higher risk aversion, when expected equity returns are lower, or when households have low non-PRA wealth. The typical lifecycle investment product is valuable as a more conservative strategy but its value is reduced by the generally high expense ratios that investors will pay. The largest expense ratios arise when the funds are invested in high-expense actively-managed equity funds, although sometimes there are surcharges for rebalancing between low-cost funds. Investors who would prefer more conservative strategies can often increase their certainty equivalent wealth through an optimally chosen fixed-proportions portfolio. If investors are incapable of rebalancing on their own, lifecycle products may add value, but whether they add value net of their expense ratios depends on the household’s risk aversion and amount of non-PRA wealth.

The paper is divided into five sections. The first section summarizes theoretical research on the optimal pattern of age-related asset allocation. It then describes the lifecycle funds that have become increasingly popular in the retirement saving market. Section two describes the algorithm that we use to simulate the distribution of retirement plan assets under different asset allocation rules

during the accumulation period. This discussion draws heavily on PRVW (2005). Section three describes our strategy for calibrating the simulation model, for selecting the sample of households for analysis, and for assigning distributions of returns to each of the assets in our study. The fourth section presents the various lifecycle asset allocation rules that we consider, including some that involve age-independent asset allocation rules. It then reports our central findings about the distribution of retirement account balances under these different rules as well as the expected lifetime utility at retirement under various rules. There is a brief conclusion.

### 1. Optimal Age-Dependent Asset Allocation Rules and the Rise of Lifecycle Funds

Financial economists have a long tradition of studying how a rational, risk-averse, long-lived consumer would choose to allocate wealth between risky and riskless assets at different ages. Samuelson (1969), in one of the first formal analyses, challenged the conventional wisdom that an investor with a long horizon should invest a larger fraction of wealth in risky assets because of the possibility to average returns over a long period. This result is related to the earlier, more general observation by Samuelson (1963) that taking repeated identical uncorrelated risks augments the risk of the final outcome, rather than reducing it. In the context of the lifecycle portfolio selection problem, when returns on the risky asset are serially uncorrelated and there is no labor income, a rational investor should hold the same fraction of wealth in risky assets at all ages. This analytical result runs counter to the suggestion of many financial advisors, who suggest that investors reduce their equity exposure as they approach retirement. Merton (1969) derives similar results in the context of a lifetime dynamic optimization framework.

Perhaps in part because this result is inconsistent with much financial practice, subsequent research has tried to uncover reasons why an investor might choose to reduce equity exposure at older ages. Bodie, Merton, and Samuelson (1988) argue that younger investors have greater flexibility in their subsequent labor supply decisions, and that they should consequently be more tolerant of risk. They suggest that younger investors may rationally choose to hold a higher fraction of their portfolio

in stock than older investors. Gollier (2001) and Gollier and Zeckhauser (2002) derive the conditions under which the option to rebalance a portfolio in the future affects portfolio choice. Their results suggest that under specific assumptions about the structure of utility functions, the optimal portfolio share devoted to equity will decline with age. Campbell et al. (2001), and Campbell and Viceira (2002) develop numerical solutions to dynamic models which can be used to study optimal portfolio structure over the lifecycle if shocks to labor income follow specific stochastic processes and investors have power utility. Cocco, Gomes, and Maenhout (2005) solve such a model in the presence of non-tradable labor income and borrowing constraints. They find that a lifecycle investment strategy that reduces the household's equity exposure as it ages may be optimal depending on the shape of the labor income profile. An important parameter is the correlation of shocks to the labor income process with investment shocks. Jagannathan and Kocherlakota (1996) demonstrate that the higher this correlation, the less the optimal asset allocation shifts away from equities as the individual ages.

The empirical evidence on age-specific patterns in household asset allocation suggests at best weak reductions in equity exposure as households age. Gomes and Michaelides (2005) survey recent research on the correspondence between theoretical models of lifecycle asset allocation and empirical evidence on actual investment patterns. Ameriks and Zeldes (2004) and Poterba and Samwick (2001) present empirical evidence on how portfolio shares for stocks, bonds, and other assets vary over the lifecycle. The general conclusion is that equity shares decline very little at older ages, although Ameriks and Zeldes (2004) find some evidence that some households cash out their equity holdings when they reach retirement or annuitize their accumulated holdings in DC accounts.

To cater to the perceived desire of investors to reduce their equity exposure as they age, and to help investors overcome the problems of inertia in retirement asset allocation that are documented by Samuelson and Zeckhauser (1988), several financial institutions have created lifecycle funds. These funds are usually designed for an investor with a target retirement date. Lifecycle funds were available from Fidelity Investments as early as 1988, and there were at least 250 target-year lifecycle funds in the mutual fund marketplace in 2005. Several major mutual fund families now offer a

sequence of different funds targeted to investors with different retirement dates. In some cases the lifecycle fund is a “fund of funds” that invests in a mix of other mutual funds, while in other cases the fund manager holds a specific pool of assets and alters the asset mix as the fund ages.

Figure 1 shows the rapid growth in lifecycle fund assets during the last eleven years. The figure indicates that lifecycle funds held \$5.5 billion in March 2000, and that their assets had grown to \$47.1 billion by 2005. Many of these funds are offered in 401(k) plans. Marquez (2005) reports that Hewitt Associates estimates that 38% of all 401(k) plans offer lifecycle funds. At a time when Clements (2005) reports that the proliferation of investment options 401(k) plans has come under fire, lifecycle funds offer a way to combine both stock and fixed income options into a single fund, and to offer investors a time-varying asset allocation mix. Lifecycle funds are sometimes suggested as a natural choice for the default investment option in automatic enrollment 401(k) programs.

The lifecycle funds offered at different fund families follow different age-phased asset allocation rules. Table 1 reports summary information on the lifecycle funds offered at leading mutual fund companies, which we define as the set of mutual fund companies tracked by Morningstar. The table shows the average mix of stocks and bonds currently held by funds targeting different retirement years. Many fund prospectuses indicate the mix of various asset categories that will be held for an investor at specific ages. We have interpolated between ages, when necessary, to estimate the asset mix at a standardized set of ages.

The table also shows the net asset holdings and weighted average expense ratios of funds with different retirement years. The expenses paid by investors in these funds, which typically range between 60 and 80 basis points per year, are substantially larger than would be paid if an investor selected index mutual funds from a company offering no-load index funds with low expense ratios and then rebalanced among them over time. For example, equity index funds, government bond index funds and money market mutual funds can be obtained from Vanguard with no load fees and expense ratios of 10 to 20 basis points. However, if investors find it difficult to conduct such rebalancing on

their own, or for other reasons neglect planned rebalancing, they might be willing to pay the additional expenses associated with target-year lifecycle funds in which the rebalancing happens automatically.

The high expense ratios for lifecycle funds are sometimes due to expenses that the fund charges that are greater than the expenses charged by the individual funds held by the lifecycle fund. In other cases, the expenses are high because the lifecycle fund is not investing in the lowest-cost mutual fund products but rather in more expensive actively managed mutual funds.

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

To analyze the distribution of PRA wealth at retirement that is induced by different asset allocation strategies, 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 PRA assets in different investment vehicles. We do this following the approach in PRVW (2005). Rather than using information on household earnings patterns to estimate a stochastic model for the earnings process, and then using that model to simulate earnings paths for our analysis, we draw actual lifetime earnings histories from a large sample of households and carry out simulations by combining the contribution paths for various earnings histories with simulated patterns of asset returns. We focus our analysis on married couples because they are financially more homogeneous than non-married individuals, some of whom never married and others of whom have lost a spouse. About seventy percent of the individuals reaching retirement age are in married couples.

We assume that nine percent of the household's earnings are contributed to a defined contribution plan each year. We further assume that the couple begins to participate in a PRA 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. We assume that both members of the household retire when the husband is 63 if they have not done so already, and that they do not contribute to a retirement plan after that age.

To formalize our calculations, we denote a household by subscript  $i$ , and denote their PRA contribution at age  $a$  by  $C_i(a) = .09*E_i(a)$  for  $E_i(a)$  the household's total earnings at age  $a$ . We assume that under this PRA system there is a fixed contribution rate of 9%. We express this contribution in year 2000 dollars. We do not restrict  $E_i(a)$  to be covered earnings, but rather assume that contributions are made for 9% of all wage and salary earnings.

To find the PRA 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 asset returns. Let  $R_i(a)$  denote the net-of-expense return earned on PRA 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 PRA assets when the husband is 63 is then given by:

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

$R_i(a)$  depends on the year-specific returns on stocks and bonds, on the mix of stocks and bonds that the household owned when the husband was  $a$  years old, and on the expense ratio. If the couple holds an all-stock portfolio, then  $R_i(a) = (1 - \theta_{\text{stock}})*R_{\text{stock}}(a)$ , where  $\theta_{\text{stock}}$  is the assumed annual expense ratio on an equity fund. If the couple holds all bonds,  $R_i(a) = (1 - \theta_{\text{bond}})*R_{\text{bond}}(a)$ . A mixture of the two is of course possible. If the couple invests in a lifecycle mutual fund, the asset return at age  $a$  will be  $(1 - \theta_{\text{bond}})*R_{\text{lifecycle}}(a)$ , which corresponds to the return on the mix of bonds and stocks that will be held by the lifecycle fund on behalf of an investor of age  $a$ .

We use simulation methods to estimate the distribution of  $W_i(63)$ , averaged over the households in our sample, for various asset allocation strategies. By comparing the distributions of retirement plan assets under each of these strategies, we can learn how these strategies affect retirement resources. The distribution of outcomes is of substantial interest, but it does not capture the household's valuation of different levels of retirement resources. It can provide information on the potential frequency of low wealth outcomes, but it does not provide a metric for comparing these outcomes with more favorable retirement wealth values.

To allow for differential valuation of wealth in different states of nature, we evaluate the wealth in the PRA account using a utility-of-terminal wealth approach. We assume that all households have identical preferences over wealth at retirement. We drop the household subscript  $i$ , and assume that the utility of wealth is described by a constant relative risk aversion (CRRA) utility function

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

where  $\alpha$  is the household's coefficient of relative risk aversion. The utility of household wealth at retirement is likely to depend on both PRA and non-PRA wealth, so we modify (2) to recognize this wealth:

$$(3) \quad U(W_{PRA}, W_{non-PRA}) = \frac{(W_{PRA} + W_{non-PRA})^{1-\alpha}}{1-\alpha}$$

Since the effect of a change in PRA wealth on household utility is sensitive to the household's other wealth holdings, we consider other assets on the household balance sheet in our empirical analysis.

For a given household, each return history, denoted by  $h$ , generates a level of PRA wealth at age 63,  $W_{PRA,h}$ , and a corresponding utility level,  $U_h$ , where

$$(4) \quad U_h = \frac{(W_{PRA,h} + W_{non-PRA})^{1-\alpha}}{1-\alpha}$$

We evaluate the expected utility of each portfolio strategy by the probability-weighted average of the utility outcomes associated with that strategy. These utility levels can be compared directly for a given degree of risk tolerance, and they can be translated into certainty equivalent wealth levels ( $Z$ ) by asking what certain wealth level would provide utility equal to the expected utility of the retirement wealth distribution. The certainty equivalent of an all-equity portfolio, for example, denoted by the subscript  $SP500$ , is given by:

$$(5) \quad Z_{SP500} = [EU_{SP500}(1-\alpha)]^{\frac{1}{1-\alpha}} - W_{non-PRA}$$

When a household has non-PRA wealth, the certainty equivalent of the PRA wealth is the amount of PRA wealth that is needed, in addition to the non-PRA wealth, to achieve a given utility level. We treat non-PRA wealth as nonstochastic throughout our analysis.

Our approach to computing DC plan balances at retirement resembles one of the strategies developed in Samwick and Skinner (2004). Part of their empirical analysis considers the pension benefits that a sample of workers would earn under several stylized defined benefit and defined contribution plans. It considers the benefits experience of a sample of actual workers, with actual earnings histories, under each plan. It does not, however, explore the sensitivity of retirement wealth to alternative investment strategies.

Our approach exploits the rich cross-sectional variation in household earnings trajectories. We use a large sample of Health and Retirement Survey (HRS) households to compute contribution paths for a PRA plan, and we then randomly assign return histories to these contribution paths. The result is a distribution of retirement balances for each household in the HRS sample. We combine the wealth outcomes by aggregating households into three broad educational categories to report our findings, but each entry in the table below represents an average over the outcomes for many individuals. Our strategy can be thought of as drawing an HRS household at age 27 and giving it two independent draws: first a wage trajectory, which could be the actual wage trajectory for any of our sample households who have a particular education level, and then a lifetime vector of asset returns, which could be any of 200,000 draws. The return trajectory will determine the household's retirement wealth, conditional on the contribution flow.

### 3. Calibration of PRA Wealth Simulations

We select a subsample of married HRS households for analysis, construct their earnings trajectories, and measure their non-PRA wealth at retirement. We then simulate retirement wealth

based on these households' Social Security earnings records. Our sample of households is larger than that in PRVW (2005). We include all HRS couples headed by men aged 63-72 in 2000 for which Social Security earnings histories are available. Table 2 shows the effects of conditioning the sample on married couples in this age range. There are 3,833 HRS households with Social Security earnings histories. The restriction to couples eliminates approximately 44 percent of that sample, and the age restriction removes an additional 19 percent, leaving a sample of 1,400 households. The age restriction removes couples with heads between the ages of 59 and 62. Including this group would involve forecasting earnings beyond the time period of the data.

The Social Security earnings records contain truncated information on actual earnings. No earnings above the taxable maximum income level are reported; the data are "top coded." The real value of the taxable maximum earnings level for Social Security has varied over time, and so has the dispersion of earnings, so the fraction of earnings that are not captured on Social Security records varies from year to year. In some years in the early 1970s, particularly for the group with the highest education level, the top-code affects more than half of the sample. Because the payroll tax cap was not indexed for inflation during much of this period, and it changes as a result of legislative action, there are also substantial changes in this threshold during brief periods. The magnitude of the top-coding problem may therefore vary from year to year. We consider replacing the current Social Security system with a PRA system that allows workers to contribute a fixed fraction of their earnings without limit. To describe contributions by high-income workers, we therefore need to estimate earnings above the taxable maximum for workers whose data records are top-coded.

We estimate a cross-sectional tobit equation for each pre-1980 year using the reported Social Security earnings for men in our sample. In the years when a substantial fraction of earnings records are top-coded, we find that the tobit coefficients are sensitive to the set of observations we include in the estimation subsample. In particular, including men with low earnings can lead to "corrected" earnings for those at the payroll tax cap that are substantially higher than the earnings cap, regardless of other individual attributes. The tobit results are more robust when we delete individuals with very

low earnings levels from our sample. We therefore exclude anyone earning less than \$2500 (in \$2000) when we estimate the tobit equations.

Each of Figures 2 through 4 shows a different part of the distribution of age-earnings profile for three different education sub-groups: less than high school, high school and some college, and college and beyond, after we correct for top-coding. The median earnings path, displayed in Figure 3, shows an unusual “bump” in early middle age. This appears to be due to the top-coding adjustment for years in which an especially high fraction of workers were affected by the taxable earnings cap. However, this unusual pattern does not appear at the 25<sup>th</sup> or 75<sup>th</sup> percentiles, nor does it occur when we plot the means of the adjusted earnings histories. We suspect that this is because there is less variation over time in the fraction of workers affected by the tax cap at these percentiles than at the median. These figures show only the husband’s earnings trajectory. We perform the same procedure for their spouses and use the imputed value of total household earnings in our simulations.

Our approach to addressing top-coding is only one of several possible approaches. Scholz, Seshadri, and Khitatrakun (2006) develop an alternative algorithm that exploits the intertemporal dependence of earnings as well as distributional assumptions to adjust top-coded earnings records. They estimate cross-sectional wage equations using IRS W-2 wage reports as well as SSA earnings records, and then they back-cast the residual from the years with W-2 data to adjust the SSA earnings data for earlier years. Because HRS respondents fall in a relatively narrow age range, however, this procedure essentially uses the serial correlation structure from earnings in a later period of life, the period covered by W-2 earnings, to describe the serial correlation structure earlier in life. It is difficult to evaluate the accuracy of this assumption.

We consider our sample households as reaching retirement age when the husband is 63 years old. When we turn to the HRS data, however, we assume that both 63 and 64 year olds in a given survey wave represent the “retiring” cohort because the HRS is carried out every other year. We need to determine non-PRA wealth at retirement age, and the way we do this depends on the household’s age. First, we consider wealth measurement for the nearly three-quarters of the sample with a

household head who was either 63 or 64 in 1996, 1998 or 2000. For these households, a breakdown of non-pension wealth is available on a consistent basis in HRS waves 3, 4, and 5. We scale all household non-PRA asset values to the 2000 base year, so that for each household we have an estimate of what their non-PRA wealth would have been had they turned age 63 in either 1999 or 2000. We implement this scaling by replacing the nominal returns on asset holdings for the two years prior to the year in which the head of household was either 63 or 64, i.e. 1994-1995 for the 1996 households and 1996-1997 for the 1998 households, with nominal returns on assets in 1998 and 1999. We calibrate our simulations using a measure of background wealth that includes only financial wealth, which is assumed to grow at a composite rate based on the national average allocation of tax-deferred financial assets between stocks, bonds, and deposits, as reported in the 2001 Survey of Consumer Finances.

Second, we consider wealth measurement for the one-quarter of the sample that reached the age 64 prior to 1996. We do not use the earlier waves of the HRS because the wealth questionnaire for waves 1 and 2 was different from that for later waves. Wealth values for these HRS households are imputed for each asset class based on the median measured asset growth for households between the ages of 63 and 65, or 63 and 67, in the same educational category in later waves of the HRS.

Table 3 presents summary statistics on our estimates of household balance sheets normalized to age 63-64. We report seven categories of wealth: the present discounted value (PDV) of Social Security payments, the PDV of defined benefit pensions, the PDV of other annuities, the current value of retirement accounts, the value of all other financial wealth net of debt, housing equity net of debt, and all other wealth. The top panel in Table 3 shows medians while the bottom panel shows means. The restriction to couples clearly raises the mean and median of the distribution. The restriction to households in the age range 63-72, with full earnings histories to age 63, lowers the wealth distribution somewhat by removing a group that has not yet begun to spend down their assets. The final sample of couples aged 63-72 has median wealth of \$536,800 and mean wealth of \$783,400. The median high-school educated household has 44 percent more total wealth than the median household with less than a high-school education, and the median college educated household has 61 percent more total wealth

than the median high-school educated household. The differences in means are even more dramatic. In this table, to estimate defined benefit and defined contribution pension wealth for HRS households we use HRS pension wealth imputations, version 1.0, March 2005. For Social Security wealth (SSW) we follow the procedure from PRVW (2005), using cohort mortality tables and the Social Security Administration's intermediate-cost scenario discount rates to calculate the present discounted value of the current or projected Social Security benefits when the husband is age 63-64. We normalize the value of the wife's Social Security to be the value when the husband is aged 63-64, assuming that Social Security payments start for the wife at age 62 if they have not started already. The present value of Social Security is determined as a joint survivor annuity.

When we calibrate our simulations with households' non-PRA wealth, we focus on the total of annuity wealth and other (i.e. non-retirement) financial wealth. We exclude housing wealth, because it is not clear whether it should be viewed as a source of retirement wealth for elderly households. Venti and Wise (2001) report that elderly households rarely draw down their housing wealth, which argues against including this wealth as a source of retirement income. We also exclude defined benefit pension wealth, 401(k) wealth, and Social Security wealth as we are assuming that the PRA system we are simulating would replace those systems entirely. We view our simulations as delivering the value of defined-contribution assets that households accumulate by their retirement date. If we attributed existing 401(k) assets to these households, the amount of DC wealth that households would accumulate would be much greater than the amount that we report in our simulations.

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 PRA retirement balances, we are implicitly assuming that changes in PRA wealth values do not affect other components of wealth. We hope to extend our analysis to allow for correlation between the returns on assets in PRA accounts and the returns on other household assets.

Table 4 disaggregates the household balance sheet aggregates by education level. The table underscores the substantial differences across households both within education categories and across

these categories. The difference at most percentiles between the total wealth of a household that did not complete high school and one that completed college is a factor of at least two. The difference in annuities and other wealth, which we use as our primary measure of non-PRA background wealth, is substantially larger, because this aggregate does not consider wealth from the current progressive Social Security system. At the 60<sup>th</sup> percentile, a household with less than high school education has \$6,400 in annuity and other financial wealth, whereas a household with a college or postgraduate education has \$183,000.

We assume that the three primary assets that households may hold in a PRA are corporate stock, nominal long-term government bonds, and inflation-indexed long-term bonds (TIPS). Calibrating the returns on these investment alternatives is a critical step in our simulation algorithm. We assume that PRA investors hold corporate stocks through portfolios of large capitalization U.S. stocks. We do not address the possibility of poorly diversified portfolios, for example with concentrated holdings in a single stock, as described in Munnell and Sunden (2004) and Poterba (2003). We assume that the return distribution for each asset class is given by Ibbotson Associates' (2003) empirical distribution of returns during the 1926 to 2003 period. The average annual arithmetic real return on large capitalization U.S. equities during this period was 9.2 percent, and the annual standard deviation of the real return was 20.5 percent. Long-term U.S. government bonds had a real return of 2.8 percent, on average, over this period, and a standard deviation of 10.5 percent.

We assume that TIPS offer a certain real return of 2 percent per year, approximately the current TIPS yield. Index bonds deliver a net-of-inflation certain return only if the investor holds the bonds to maturity, and selling the bonds before maturity exposes the investors to asset price risk. We nevertheless treat these bonds as riskless long-term investment vehicles. In our simulations, when we draw returns from the stock and bond return distributions for a given iteration, we draw returns for the same year from both distributions. This preserves the historical contemporary correlation structure between stock and bond returns in our simulations.

Several analysts suggest that the last several decades, or even the last century, correspond to a particularly favorable time period for equities, and argue that these returns should not be extrapolated to the future. The academic literature on the equity premium puzzle, summarized for example in Mehra and Prescott (2002), raises the possibility that *ex post* returns exceeded *ex ante* expected returns over this period. To allow for such a possibility, we perform some simulations in which the distribution of returns from which we draw is the actual distribution except that equity returns are reduced by 300 basis points in each year. Comparing these simulations with those in our baseline indicates the sensitivity of our findings to the future pattern of equity returns.

Each iteration of our simulation algorithm involves drawing a sequence of 35 real stock and bond 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 under the different asset allocation strategies. For each of the 1,400 households in our sample, we simulate the PRA balance at age 63 5,000 times. We then summarize these 5,000 outcomes either with a distribution of wealth values at retirement, or by calculating the expected utility associated with this distribution of outcomes. We found in PRVW (2005) that roughly this number of iterations was needed to obtain robust findings, particularly at lower percentiles of the retirement wealth distribution.

#### 4. Discussion of Results

We simulate eight primary asset allocation strategies for the household's PRA account. The first three involve investing in only one asset: (i) a portfolio that is fully invested in TIPS; (ii) a portfolio that is fully invested in long-term government bonds, and (iii) a portfolio that is fully invested in corporate stock. The next two portfolios are "heuristic portfolios" that use simple rules for lifecycle asset allocation. Portfolio (iv) holds  $(110 - \text{age of household head})$  percent of the portfolio in stock, with the remaining balance in TIPS. Portfolio (v) is similar to (iv) except that nominal government bonds replace TIPS for the component of the portfolio that is not held in equity. Both of

these portfolios are rebalanced at the end of each period. The next two are lifecycle portfolios consisting of stocks and TIPS, and stocks and government bonds, respectively. The equity weight for each of these funds is computed based on the average of the age-specific allocations in the lifecycle funds at Fidelity, Vanguard, T. Rowe Price, TIAA-CREF, Principal, Barclays, and Wells Fargo. The lifecycle funds from these fund families are weighted equally in this calculation, and the resulting equity allocation is similar to that in Table 1. Portfolio (vi) invests the lifecycle fund average in equities and the balance in TIPS, while fund (vii) holds equities and nominal government bonds in the lifecycle mix.

The final primary investment strategy we consider, strategy (viii), is the “No Lose” strategy that Feldstein (2005) proposes in his analysis of individual account Social Security reforms. At each age, we calculate the share of the household’s PRA contribution that would have to be invested in TIPS to guarantee at least the contributed amount in nominal terms at retirement age. The required TIPS investment is  $(1+R_{TIPS})^{-(63-a)}$ , where 63-a is the number of years to retirement. This strategy is fundamentally different from the other lifecycle strategies because it does not involve portfolio rebalancing at each age. Instead, the equity share of the portfolio depends on the historical pattern of TIPS yields, which in turn determine the amount available for stock investment in past years, and on the historical returns on equity assets.

In addition to these eight strategies, we also consider optimized portfolio strategies that are each derived from running multiple simulations of a given form and then selecting the optimal investment strategies from among them for a given level of risk aversion, asset class, and asset return assumption. The first of these is an optimal fixed portfolio strategy, in which we examine the outcome of investing X% in stocks and 1-X% in TIPS at 5% intervals. The second is an optimal “linear” lifecycle strategy, in which we consider strategies that begin at X% at age 28 and end at 1-X% at age 63. This is of course a restricted class of lifecycle portfolios but serves as a useful point of comparison for the commercially available products. The optimization is performed separately for each level of risk aversion, asset class, and asset return assumption. We describe this in greater detail below.

We assume that the returns on PRA investments equal the pretax returns on the various asset classes we consider, less the expense charge for investment management. For most of the asset classes we consider, we use two assumptions: a baseline assumption and a high-expense assumption. Our baseline assumption for equity mutual funds is a 32 basis point expense ratio, the weighted mean expense ratio on S&P 500 index funds reported in Hortaçsu and Syverson (2004). Given that government bond funds tend to have similar expense ratios to stock index funds, we assume 32 basis points as the expense ratio for government bond funds. For TIPS, we use an expense ratio of 40 basis points, on the grounds that these funds may be twenty percent more expensive than typical stock or bond index funds. Our high-expense assumption is 100 basis points for stock and bond funds. Expense ratios this high are not uncommon.

For the cost of investing in lifecycle products, we consider three possibilities. The baseline assumption we make is that the lifecycle product carries an expense ratio of 40 basis points, with investors paying a relatively small cost (8 basis points) for the automatic rebalancing. Based on the expense ratios in Table 1, however, this baseline assumption is probably too low relative to what individuals investing in this market actually pay. We therefore also run simulations with the asset-weighted average expense ratio from Table 1 of 74 basis points, and for a high-expense scenario of 120 basis points.

#### *4.1 The Distribution of Retirement Wealth*

Table 5 shows the distribution of PRA balances in thousands of year 2000 dollars averaged across the 1400 households in our sample, for each of the first eight strategies and assuming the baseline expense ratios. In the left-most panel, the simulations use the historical distribution of returns. The panel on the right reduces equity returns by 300 basis points. Households are stratified by education group within each panel. The table reports the mean wealth at retirement for each strategy, as well as four points in the distribution of returns. Since our interest is the comparison of wealth outcomes across different strategies, most of our discussion below focuses on a single

education group, households headed by someone with a high school degree but not a college degree.

The relative ranking of different strategies is similar for other education groups.

The first row of Table 5 provides a point of reference for all of the subsequent calculations. It shows the certain wealth at retirement associated with strategy (i), holding only TIPS. For those with a high school degree and/or some college, this leads to a retirement balance of \$236,700. The next panels show the results from strategy (ii), holding on nominal government bonds, and strategy (iii), holding only corporate stocks. Both of these strategies, as well as all of the subsequent strategies that we consider, involve risk so we report information on the distribution of outcomes.

The second panel shows that for a household with a high school degree and/or some college, holding only government bonds leads to a higher average retirement wealth, \$283,200, than holding TIPS. The average wealth at retirement is nearly twenty percent greater than the value with TIPS, but the median wealth of \$265,100 is less than ten percent above the TIPS outcome. Moreover, there are many outcomes with retirement wealth values below the TIPS case. The tenth percentile outcome is \$160,500, and the first percentile is \$76,400.

When the PRA is invested in corporate stock, the average retirement balance is much higher than that with either TIPS or nominal government bonds: \$1,169,300. This value is roughly four times greater than the outcome with nominal government bonds. Because the mean return on stocks is so much higher than that on either nominal or inflation-indexed bonds, even the low outcomes are often above the mean outcomes with bonds. The 10<sup>th</sup> percentile retirement wealth value with the all-stocks portfolio is not far below average outcome with a nominal government bond portfolio. The first percentile outcome, however, \$44,300, is below the correspondingly low outcomes for the nominal bonds strategy.

The next two portfolios, (iv) and (v), are “heuristic” lifecycle investment strategies with a mix of stocks and TIPS, or stocks and long-term nominal government bonds. In both cases the average value of retirement wealth falls between the value with an all-stock investment and that with an all-bond portfolio. When the nominal government bond share of the portfolio is  $(age + 10)$  percent, the

average value of retirement wealth using historical equity returns is \$488,900 for a household with a high school education. The proportional dispersion in the retirement wealth value is smaller than that for an all equity portfolio, and greater than that for the bond portfolio. The difference between the 90<sup>th</sup> percentile and the 10<sup>th</sup> percentile retirement wealth value with an all-stock strategy is 1.87 times the mean value, and the corresponding measure for the all-bond portfolio is 0.97. With the nominal bond-stock heuristic lifecycle portfolio, the 90-10 spread is 1.14 times the mean outcome. The first percentile outcomes with the two heuristic lifecycle portfolios are \$113,600 and \$87,700, both larger than first percentile outcomes with either the all-stock or all-bond portfolios.

The next two portfolios, (vi) and (vii), are the lifecycle portfolios that correspond to the average of the portfolios from various mutual fund complexes. While the age-specific equity allocation is somewhat different from the foregoing heuristic portfolios, the distribution of PRA wealth at retirement is similar. In particular, the mean value of retirement wealth is \$532,200 when we combine TIPS and stocks, and \$574,500 when we combine nominal long-term government bonds and stocks. The difference is due to TIPS offering a lower real yield than the historical average real return on nominal bonds during our sample period. The first percentile outcome when we combine TIPS with stocks is lower than that of the heuristic strategy with TIPS and stocks. Similarly, the first percentile outcome of the bonds-stocks mutual fund product is lower than that of the heuristics strategy with TIPS and bonds. The empirical lifecycle products are therefore higher mean but also somewhat riskier than the heuristic strategies.

The eighth and last strategy in this table is the Feldstein (2005) “no lose” plan. This strategy offers a mean return that is broadly similar to the mean returns on the lifecycle strategies. The mean retirement wealth for a high school educated household is \$607,800, which is between the mean wealth values with a lifecycle fund that holds TIPS and one that holds nominal government bonds. The important difference among this strategy and the lifecycle strategies and the all-stocks and all-nominal bonds strategies is found in the lower tail of the wealth outcomes. Because the “no lose”

strategy holds TIPS, the first percentile wealth value is \$174,600, greater than any of the strategies other than investing 100% in TIPS.

The assumption that the equity return is drawn from its historical distribution is important for the absolute level of retirement wealth under most of the strategies that we consider, and also for the magnitude of the differences across strategies. The fourth, fifth, and sixth columns in Table 5 present results assuming that equity returns are reduced by 300 basis points. The all-stock strategy is the one that is most affected by this change. The average wealth at retirement for this strategy falls from \$1,169,300 to \$585,500. The tenth percentile wealth value drops from \$265,100 to \$143,700 in this case, and the first percentile value drops to \$44,300 from \$27,200. This very low outcome emphasizes the risk associated with holding stocks: a very small chance of a very poor outcome. The average retirement wealth values for the various heuristic and empirical lifecycle funds decline when we reduce the value of the mean equity return. The mean wealth value for the “no lose” strategy falls relative to the lifecycle strategies, because the no-lose strategy has relatively more equity exposure than any of the lifecycle plans.

The distribution of retirement balances shown in Table 5 is conceptually similar to the distribution reported in Shiller’s (2005) analysis of personal accounts Social Security reform, although there are differences in the simulation procedure that affect the results. The most important difference is that Shiller (2005) uses data on stock and bond returns from a longer time period than we consider. This means that he assumes a distribution of equity returns with a lower mean value than the mean of the distribution we consider. Our results when the average return on stocks is set at 300 basis points below the historical mean in our sample are closer to those in Shiller (2005) than our results that assume that returns are drawn from the actual return distribution for 1926-2002.

Table 6 shows the distributions of outcomes from Table 5 but under the higher expense ratio scenario (100 basis points for stocks and bonds, 120 basis points for the lifecycle products). This table demonstrates the detrimental effects of high expense ratios on retirement wealth accumulation. The outcomes are 7 to 15% lower than under the baseline expense ratio scenario.

#### 4.2 Expected Utility of Retirement Wealth

Results like those in Tables 5 and 6 do not provide any information on the household utility associated with a particular retirement wealth outcome. To address this issue, we evaluate the expected utility associated with various wealth outcomes from our simulation runs, using the procedure described in (5) above. We focus in this analysis on constant relative risk aversion (CRRA) parameters of 2 and 4.

We first calculate for each education category (less than high school, high school and/or some college, college and/or post graduate), risk aversion (2 and 4), return assumption (empirical and 300 basis points reduced), and non-PRA wealth assumption (none and annuity plus other financial wealth) an “optimal” fixed proportions strategy and “optimal” linear lifecycle strategy. This is done by searching over grids at 5% intervals. For example, in finding the optimal fixed proportions we start with 100% stocks and 0% TIPS, then simulate 95% stocks and 5% TIPS, and so on until we get to 5% stocks and 95% TIPS. In finding the optimal linear lifecycle portfolio we start with a strategy that begins 100% in stocks and declines linearly to 0% in stocks with the rest of the allocation going to TIPS. We then simulate a strategy that begins 95% in stocks and declines linearly to 5%, and so on, until we get to 55% stocks declining to 45% stocks. We calculate these using the baseline expense ratios, and we assume that individuals pay the baseline expense ratios for the stock and TIPS funds (32 and 40 basis points respectively).

Table 7 shows the strategies that yield the highest expected utility for each set of characteristics. When there is no other wealth, risk aversion of 2, and historical empirical stock returns, the optimal fixed proportions strategy is 100% stocks and 0% TIPS for all education categories. Under the lower returns assumption, the optimal fixed proportion is 65% stocks and 35% TIPS for the lower two education categories, and 70% stocks and 30% TIPS for the college or more category. With risk aversion of 4, the optimal fixed proportion declines to 55 to 60% in stocks under the historical empirical distribution and 35% in stocks under the reduced return assumption. When there is other wealth of annuities and other financial assets, the optimal fixed proportion allocation

varies from 40% to 100% depending on the education level, return assumption and risk aversion. Lower optimal equity shares are associated with the lower return assumption, the lower levels of education, and the higher levels of risk aversion. The education patterns reflect the fact that lower-education households typically have much less non-PRA wealth than higher-education households. If alpha is 0 or 1 (not shown in the table), the optimal fixed proportion is always 100% stocks.

The optimal linear lifecycle strategy among the class of strategies we simulate is in many cases the one with the flattest profile. However, a profile that begins 60-65% in stocks and declines linearly to 40-35% in stocks is optimal among the class of linear lifecycle portfolios for couples with risk aversion of 4, no other wealth, and facing the historical distribution of equity returns. A more downward-sloping profile that begins 80% in stocks and declines linearly to 20% in stocks is optimal for households with risk aversion of 4, no other wealth, and facing the reduced equity returns. In general, lower returns and higher risk aversion are correlated with a greater shift from stocks towards TIPS as the individual ages.

Table 8 shows the expected utility generated by the distribution of retirement resources for each of the eight primary portfolio strategies, as well as the two derived optimal strategies, using a certainty equivalent wealth measure to value the potential outcomes. In this table we assume that the PRA balance is the household's only wealth. The values in the upper half of Table 8 are based on risk aversion of 2. This panel shows that under the empirical stock return scenario, the 100% stocks strategy is the best among all of the strategies that we simulated for households with this level of risk aversion. The amount by which this strategy outperforms the other strategies is rather considerable in the empirical return scenario. It is roughly 20% greater than the empirical lifecycle strategies, assuming that investors can obtain the empirical lifecycle for 40 basis points. It is roughly 30% greater than the empirical lifecycle strategies under the average expense ratio of 74 basis points. The certainty equivalent for 100% stocks is at least 40% greater than the heuristic strategies, and it is more than 120% better than the all bonds strategies. When expense ratios are raised, the 100% stock

allocation is still optimal (as the higher expense ratio scenario also involves higher expense ratios for bonds and TIPS) but the household is 13-14% worse off.

When returns are reduced by 300 basis points, the 100% stock strategy is no longer optimal. The empirical lifecycle strategy under the baseline expense assumption (40 basis points) yields the best outcome. For example, for a household with a high school education, the certainty equivalent of the empirical lifecycle fund is \$319,000, compared to \$294,500 from investing entirely in stocks and \$236,700 from investing entirely in bonds. Note that the amount by which the best strategy outperforms the next best alternative is smaller in both percentage terms and dollar terms than the amount by which the stocks strategy outperformed in the empirical stock returns scenario. In particular, the best fixed proportions strategy, which Table 7 found to be 65% stocks for the lower two education categories and 70% stocks for the highest category, falls below the best strategy by less than \$2000. The broad magnitudes of all of the strategies that involve some equity investment are not far from the optimal strategy. Obtaining reasonably low expense ratios is critical, however, as the average and high expense ratio simulations show that the household loses substantial value relative to the baseline expense ratio certainty equivalents. Certainty equivalents under the higher expense ratios are 10 to 15% lower than those under the baseline expense ratios. Furthermore, the empirical lifecycle products are much less competitive when we consider the premiums that investors generally pay in terms of expense ratios.

The lower panel of Table 8 shows a similar analysis to the upper panel but with a risk aversion of 4. Under the historical empirical distribution of equity returns and baseline expense ratios, the empirical lifecycle consisting of stocks and TIPS generates the highest certainty equivalents relative to the other strategies. However, this assumes that investors will not pay a large premium in expenses for the lifecycle fund. The average expense ratio lifecycle fund (74 basis points) performs worse than the optimal linear lifecycle or optimal fixed proportions strategies since these are achieved at lower cost (32 basis points when in stocks, 40 basis points when in TIPS). Under the reduced equity return assumptions, the optimal linear lifecycle strategy beats the other strategies assuming the baseline

expense ratios. When expense ratios are high, the Feldstein “no lose” plan generates higher certainty equivalents than the other strategies considered.

Although not shown here, we also conducted simulations with risk aversion of 0 (linear utility) and risk aversion of 1 (log utility). In both of these cases, 100% equity is always the optimal strategy. Risk aversion of 0 is equivalent to considering the mean returns from Tables 5 and 6. The log level of risk aversion reduces the certainty equivalent value of the all-stock portfolio strategy relative to other strategies, but this strategy continues to generate the highest expected utility for all education groups. This outcome obtains when the expected stock return is set equal to its historical average, and when it is reduced by 300 basis points.

Table 8 considers the certainty equivalent of different investment strategies when retirement wealth from a PRA plan is the only source of wealth at retirement. By assuming that the household is solely dependent on PRA wealth, these calculations exaggerate the level of retirement income risk faced by the household. Holding constant the household’s relative risk coefficient, when the household has other sources of wealth, it will behave as though it were less risk averse.

Table 9 presents results with the alternative assumptions about non-PRA wealth at retirement, namely that it equals annuity and other financial wealth. The households in this case are less averse to holding high fractions of their wealth in stocks. For a relative risk aversion of two, for example, the certainty equivalent value of contributing to a PRA that is invested in the empirical lifecycle fund at average expense ratios with stocks and TIPS is \$425,300 when households with a high-school education have no wealth at retirement other than their retirement wealth. This value can be found in Table 8. When other financial wealth is combined with retirement account wealth in determining the utility of retirement wealth, the certainty equivalent of the same strategy rises to \$442,100. These values represent the certainty equivalent of just the PRA account balance. This is the amount in addition to other wealth that would be needed to generate the expected utility associated with the uncertain retirement wealth distribution.

Allowing for non-retirement account wealth raises the attractiveness of riskier strategies relative to other investment options. Under the empirical returns scenario, the 100% stocks investment dominates when alpha is 2, under both the baseline expense and higher expense ratio scenarios. When returns are reduced, the optimal fixed strategy generates the highest certainty equivalent for the lower two education categories. As shown in Table 7, this strategy requires 80% and 85% in stocks respectively for households with less than high school education and households with a high school education. For the top education category, the 100% equity strategy dominates. This is also the optimal fixed-proportions strategy.

When alpha is 4, the situation with baseline and average expense ratios is similar to that when the household has no other wealth, in that the empirical lifecycle portfolio is a good choice when it can be obtained at a low cost. There are some differences, however. Now the optimal fixed proportions strategy does slightly better than the empirical lifecycle portfolio for the higher two education categories under baseline expense ratios and historical equity returns. A 100% stocks strategy actually dominates for these education groups under the high expense ratio scenario, as their background wealth makes them effectively less risk averse, while the lifecycle funds here cost 120 basis points compared to the equity fund's 100 basis points.

The pattern of results when the household has non-PRA wealth is quite similar to the pattern when it has no other wealth. There is often an optimal fixed proportions and optimal linear lifecycle portfolio that generates certainty equivalents at least as high as those from the empirical lifecycle funds, especially when we consider the higher average expense ratios that investors actually pay in empirical lifecycle funds.

## 5. Conclusions

This paper presents evidence on the distribution of balances in PRA retirement saving accounts under various assumptions about the asset allocation strategies that investors choose. In addition to a range of age-invariant strategies, such as an all-bond and an all-stock strategy, we

consider several different “lifecycle funds” that automatically alter the investor’s mix of assets as he or she ages. These funds offer investors a higher portfolio allocation to stocks at the beginning of a working career than as they approach retirement, but in many cases charge higher expense ratios. We also consider a “no lose” allocation strategy for retirement saving, in which households purchase enough riskless bonds at each age to ensure that they will have no less than their nominal contribution when they reach retirement age, and then invest the balance in corporate stock. This strategy combines a riskless floor for retirement income with some upside investment potential.

Our results suggest several conclusions about the effect of investment strategy on retirement wealth. The expected utility associated with different PRA asset allocation strategies, and the ranking of these strategies, is very sensitive to four assumptions: the expected return on corporate stock, the relative risk aversion of the investing household, the amount of non-PRA wealth that the household will have available at retirement, and the expenses associated with the given investment strategies. At modest levels of risk aversion, or when the household has access to substantial non-PRA wealth at retirement, the historical pattern of stock and bond returns implies that the expected utility of an all-stock investment allocation rule is greater than that from any of the more conservative strategies.

When we reduce the expected return on stocks by 300 basis points relative to historical values, however, other strategies dominate the all-equity allocation for investors with high levels of relative risk aversion. For a risk aversion parameter of 2, the expected utility associated with investing in an optimally chosen mix of stocks and TIPS, or in an inexpensive lifecycle product, is highest. For a risk aversion parameter of 4, the expected utility associated with an optimally chosen fixed portfolio of stocks and TIPS or an optimally chosen linear lifecycle product is highest and is substantially higher than investing 100% in stocks. The actual lifecycle products available to investors often generate lower certainty equivalents than our derived optima, but this is partly related to the expense ratios charged by those products.

When households are calibrated to have non-PRA wealth, 100% stocks is optimal for a risk aversion parameter of 2, and is not far from optimal even when equity returns are reduced by 300 basis

points. For a risk aversion parameter of 4, an optimally chosen fixed portfolio of stocks and TIPS, or an lifecycle product obtained at low cost, performs the best.

The analysis underscores the fact that avoiding high expense ratios is critical for households saving for retirement in a PRA. Many of the available lifecycle products have higher expense ratios than could be achieved by the household simply holding a stock index fund and some TIPS (or bonds) and either holding them in fixed proportions throughout their lifetime or rebalancing towards TIPS (or bonds) as they get older. Households who are unable to do this on their own will not do terribly in lifecycle funds but they will lose money relative to what they could get if they executed very simple investing strategies on their own.

Our analysis of lifecycle funds suggests three issues that warrant future research. First, it is possible that lifecycle funds should be different for single individuals than for married couples. The focus in these funds so far has been on accumulating wealth for retirement, and the conceptual justification for age-phased equity exposure would be age-related variation in household risk aversion. Single individuals may have fewer opportunities to respond to an adverse economic shock than married couples, so their tolerance of equity market risk in their retirement accounts may be different from that for married couples.

Second, we have focused on only a limited set of outcome measures associated with different asset allocation strategies. While we consider various percentiles of the retirement wealth distribution, as well as the mean value of wealth at retirement, and the expected utility associated with this wealth value, other metrics may also deserve consideration. One possibility is the risk of shortfall associated with one strategy relative to another. The Feldstein (2005) “no lose” strategy eliminates the shortfall risk associated with a DC investment strategy relative to investing all contributions to a DC plan in a zero-yield cash account. Shortfall risk measures could be computed for a range of other strategies.

Third, we have not introduced any of the market imperfections or elements of behavioral economics that might affect the estimated benefits of lifecycle funds. For example, we have not allowed retirement ages to vary as a function of the household’s accumulated PRA balance. Allowing

for additional years of work when returns are unfavorable would reduce the cost of low accumulation values. We have also assumed that when we assign households to fixed proportions strategies, they successfully rebalance their portfolio so that they maintain the designated proportions. If households fail to do so, strategies such as lifecycle investing that automate such portfolio decisions may affect expected utility in ways that we have not captured.

### References

Ameriks, John, and Stephen Zeldes, 2004, "Do Household Portfolio Shares Vary with Age?," mimeo, Columbia University Graduate School of Business.

Bodie, Zvi, Robert C. Merton, and William Samuelson, 1991, "Labor Supply Flexibility and Portfolio Choice in a Lifecycle Model," Journal of Economic Dynamics and Control 16, 427-449.

Campbell, John Y. and Luis M. Viceira, 2002, Strategic Asset Allocation: Portfolio Choices for Long Term Investors (New York: Oxford University Press).

Campbell, John Y., Joao Cocco, Francisco Gomes, and Pascal Maenhout, 2001, "Investing Retirement Wealth: A Life-Cycle Model," in John Y. Campbell and Martin Feldstein (eds), Risk Aspects of Investment-Based Social Security Reform (Chicago: University of Chicago Press).

Clements, Jonathan, 2005, "Plan Paralysis: Why a Wealth of Choices in 401(k)s May Not Make Investors Rich," Wall Street Journal May 4, page C1.

Cocco, Joao, Francisco Gomes, and Pascal Maenhout, 2005, "Consumption and Portfolio Choice over the Life Cycle," Review of Financial Studies, 18(2), 491-533.

Gomes, Francisco and Alexander Michaelides, 2005, "Optimal Life Cycle Asset Allocation: Understanding the Empirical Evidence," Journal of Finance 60, 869-904.

Feldstein, Martin, 2005, "Reducing the Risk of Investment-Based Social Security Reform," NBER Working Paper 11084.

Gollier, Christian, 2001, The Economics of Risk and Time (Cambridge: MIT Press).

Gollier, Christian and Richard J. Zeckhauser, 2002, "Horizon Length and Portfolio Risk," Journal of Risk and Uncertainty 24, 195-212.

Hortaçsu, Ali and Chad Syverson, 2004, "Search Costs, Product Differentiation, and Welfare Effects of Entry: A Case Study of S&P 500 Index Funds," Quarterly Journal of Economics 119(4), 403-456.

Ibbotson Associates, 2003, Stocks, Bonds, Bills, and Inflation: 2003 Yearbook: Market Results for 1926-2002. (Chicago: Ibbotson Associates).

Jaggaonathan, Ravi, and Narayana Kocherlakota, 1996, "Why Should Older People Invest Less in Stocks than Younger People?" Federal Reserve Bank of Minneapolis Quarterly Review 20(3), 11-23.

Marquez, Jessica, 2005, "Lifecycle Funds Can Help Companies Mitigate Risk and Boost Employee Savings," Workforce Management, April, 65-67.

Mehra, Rajneesh and Edward Prescott, 2002, "The Equity Premium Puzzle in Retrospect," in G. Constantinides, M. Harris, and R. Stulz, eds., Handbook of Economics of Finance (Amsterdam: North Holland).

Merton, Robert C., 1969, "Lifetime Portfolio Selection under Uncertainty: The Continuous Time Case," Review of Economics and Statistics 51, 247-257.

Munnell, Alicia and Annika Sunden, 2004, Coming Up Short: The Challenge of 401(k) Plans (Washington: Brookings Institution).

Poterba, James, 2003, "Employer Stock and 401(k) Plans," American Economic Review 93 (May), 398-404.

Poterba, James, Joshua Rauh, Steven Venti and David Wise, 2005, "Utility Evaluation of Risk in Retirement Savings Accounts," in David Wise (ed), Analyses in the Economics of Aging, Volume 10, University of Chicago Press.

Poterba, James, and Andrew Samwick, 2001, "Household Portfolio Allocations Over the Lifecycle," in S. Ogura, T. Tachibanaki, and D. Wise, ed., Aging Issues in the U.S. and Japan (Chicago: University of Chicago Press), 65-103.

Samuelson, Paul, 1963, "Risk and Uncertainty: the Fallacy of the Law of Large Numbers," Scientia 98, 108-113.

Samuelson, Paul, 1969, "Lifetime Portfolio Selection by Dynamic Stochastic Programming," Review of Economics and Statistics 51, 239-246.

Samuelson, Paul, 1989, "The Judgement of Economic Science on Rational Portfolio Management: Indexing, Timing, and Long-Horizon Effects," Journal of Portfolio Management, Fall, 3-12.

Samuelson, William, and Richard J. Zeckhauser, 1988, "Status Quo Bias in Decision Making," Journal of Risk and Uncertainty 1, 7-59.

Samwick, Andrew, and Jonathan Skinner, 2004, "How Will 401(k) Plans Affect Retirement Income?," American Economic Review 94, 329-343.

Scholz, J. Karl, Ananth Seshadri, and Surachrai Khitatrakun, 2006, "Are Americans Saving Optimally for Retirement?," Journal of Political Economy 114, 607-643.

Shiller, Robert, 2005, "The Life Cycle Personal Accounts Proposal for Social Security: A Review," NBER Working Paper 11300.

Venti, Steven F. and David A. Wise, 2001, "Aging and Housing Equity: Another Look," in David A. Wise (ed.) Analyses in the Economics of Aging, Volume 9, University of Chicago Press.

**Table 1: Target-Year Lifecycle Mutual Fund Characteristics, March 2005**

Retirement Year	Years to Retirement	Net Assets (\$ billion)	Weighted Average Expense Ratio	Number of Fund Families	Number of Funds	2005Q1 Weighted Average Asset Allocation		
						Stocks	Bonds	Cash
2005	0	4.1	0.6%	10	40	30.0%	42.0%	28.0%
2010	5	11.2	0.8%	13	45	49.4%	35.4%	15.3%
2015	10	2.9	0.6%	8	22	58.2%	35.7%	6.1%
2020	15	14.5	0.8%	13	45	69.7%	24.6%	5.7%
2025	20	1.9	0.6%	8	22	79.2%	17.2%	3.6%
2030	25	8.3	0.8%	12	39	81.7%	13.8%	4.5%
2035	30	0.6	0.8%	6	15	85.2%	10.4%	4.4%
2040	35	3.3	0.8%	11	38	88.0%	8.4%	3.5%

Funds used in this analysis consist of all mutual funds categorized by Morningstar as retirement or lifecycle funds which also have a target-year rebalancing feature. Net assets for these funds as of 3/31/2005 were collected from fund reports and from Morningstar.com. The number of funds differs from the number of fund families for a given retirement year because funds have multiple classes of shares and “number of funds” counts each share class as a separate fund. The weighted average expense ratio is the average expense ratio including sub-fund expenses weighted by fund net asset value. Asset allocations are also averaged with fund net asset value weighting. One fund family also offers funds with retirement years 2011, 2012, 2013, 2014, 2045, and 2050. The information on these funds is not used in constructing this table.

**Table 2: Sample Composition, HRS Households**

	All Households, Head 59-72	Households 59-72, with SS Earnings	Couples 59-72, with SS Earnings	Couples 63-72, with SS Earnings
<b>Household Head Education Less Than High School</b>				
Survey Households	1579	1086	540	374
Population Counterpart	3769.3	2653.4	1324.2	938.3
<b>Household Head High School Education and/or Some College</b>				
Survey Households	2793	1954	1076	689
Population Counterpart	7669.2	5453.6	3013.2	1949.3
<b>Household Head at least College Degree</b>				
Survey Households	1132	793	526	337
Population Counterpart	3411.6	2390.6	1611.8	1013.6
<b>Total</b>				
Survey Households	5504	3833	2142	1400
Population Counterpart	14850.1	10497.6	5949.2	3901.1

Source: Authors’ tabulations based on the 2000 wave of the HRS and the social security earnings histories available for a sub-sample of HRS respondents. Population counterparts are calculated using the household weights provided in the HRS.

**Table 3: Summary Statistics on Household Balance Sheet at Age 63/64, HRS Households**

	All HRS Households				HRS Couples with Husband Aged 63-72			
	Househol d Head 59-72	Household Head 59-72 and with SS Earnings	Couples 59-72, with SS Earnings	Couples 63-72, with SS Earnings	All	Less Than High School Degree	High School and/or Some College	College and/or Post- graduate
<b>Medians</b>								
Social Security	176.1	167.2	258.0	262.5	262.5	247.4	260.9	285.5
DB pension	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Annuity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retirement Accounts	15.0	15.0	35.7	22.7	22.7	0.0	20.4	81.7
IRA	8.1	8.4	22.0	12.0	12.0	0.0	11.5	49.6
DC pension	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Financial Wealth	34.6	35.2	69.6	58.0	58.0	6.4	55.7	170.5
Housing Equity	76.2	72.0	90.9	92.6	92.6	60.2	90.9	125.0
Other Wealth	11.5	11.0	17.7	18.1	18.1	11.0	20.0	21.9
SS + DB + Annuity	204.6	203.5	280.3	276.9	276.9	250.5	277.2	301.8
Total Excluding Retirement Accounts	399.9	397.3	526.7	489.4	489.4	360.3	484.0	749.7
Total	439.1	435.6	587.5	536.8	536.8	370.1	531.1	856.3
<b>Means</b>								
Social Security	179.9	181.9	235.9	246.5	246.5	229.1	243.6	268.1
DB pension	62.4	63.1	85.2	47.7	47.7	33.9	44.4	66.6
Other Annuity	4.9	5.0	5.2	5.0	5.0	0.8	7.3	4.6
Retirement Accounts	107.8	113.2	154.7	136.4	136.4	36.8	83.1	330.9
IRA	73.2	72.8	95.2	77.3	77.3	29.4	67.4	140.6
DC pension	32.4	37.0	55.7	59.0	59.0	7.4	15.7	190.3
Other Financial Wealth	177.4	179.3	223.1	199.7	199.7	69.6	138.7	437.3
Housing Equity	113.2	103.1	125.3	115.3	115.3	78.7	106.6	165.7
Other Wealth	26.2	26.5	32.8	33.0	33.0	19.2	30.1	51.3
SS + DB + Annuity	247.2	250.0	326.3	299.2	299.2	263.8	295.3	339.3
Total Excluding Retirement Accounts	587.3	583.8	727.3	647.0	647.0	431.3	570.6	993.6
Total	694.2	695.8	881.5	783.4	783.4	468.1	653.7	1324.5
Sample Size								
Number of Households	5504	3833	2142	1400	1400	374	689	337
Weighted Size ('000s)	14850	10498	5949	3901	3901	938	1949	1013

Source: Authors' tabulations based on the 2000 HRS. All entries are normalized to calendar year 2000. To estimate DB and DC pension wealth for HRS households we use the pension wealth imputations from the HRS (March 2005 version). Other financial wealth includes stocks, equity mutual funds, bonds, fixed income mutual funds, checking and saving accounts, money market mutual funds and certificates of deposit held outside of retirement accounts. Social security wealth is calculated as in PRVW (2005).

**Table 4: Distribution of Household Balance Sheet for HRS Couples with Husbands Aged 63-72, Normalized to Age 63/64 in Year 2000**

Net Worth Concept	All Education Levels	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate
<i>20th percentile</i>				
Total	302.0	220.9	315.1	448.1
Total Excluding Retirement	292.2	216.8	312.2	387.8
Accounts				
SS + DB + Annuity	189.8	169.4	198.8	204.6
Annuities and Other Financial Wealth	1.0	0.0	1.7	30.0
<i>40th percentile</i>				
Total	450.1	323.2	450.4	707.9
Total Excluding Retirement	419.1	314.1	423.6	607.8
Accounts				
SS + DB + Annuity	257.0	230.7	257.3	281.2
Annuities and Other Financial Wealth	29.7	2.0	30.0	113.0
<i>60th percentile</i>				
Total	637.4	441.3	622.1	1051.1
Total Excluding Retirement	575.3	413.6	549.8	878.6
Accounts				
SS + DB + Annuity	295.6	265.7	296.1	338.0
Annuities and Other Financial Wealth	62.3	6.4	58.7	183.0
<i>80th percentile</i>				
Total	994.5	644.1	866.4	1598.6
Total Excluding Retirement	830.4	575.4	745.2	1229.6
Accounts				
SS + DB + Annuity	362.8	313.7	354.3	449.3
Annuities and Other Financial Wealth	273.5	121.0	235.5	600.0

Source: Authors' tabulations from the 2000 HRS. DB pension wealth was calculated from the pension wealth imputations from the HRS (March 2005 version). Social security and annuity wealth were computed as in PRVW (2005).

**Table 5: Simulated Distribution of 401(k) Balances at Retirement (\$2000), Baseline Expense Ratios**

Investment Strategy/ Percentile	Empirical Stock Returns			Empirical Returns Reduced 300 Basis Points		
	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate
100% TIPS	167.4	236.7	325.5	167.4	236.7	325.5
100% Government Bonds						
1	53.8	76.4	110.0	53.8	76.4	110.0
10	113.6	160.5	224.5	113.6	160.5	224.5
50	182.3	258.0	352.9	182.3	258.0	352.9
90	307.6	435.6	582.9	307.6	435.6	582.9
Mean	200.1	283.2	385.0	200.1	283.2	385.0
100% Stocks						
1	30.9	44.3	62.4	19.0	27.2	40.1
10	186.3	265.1	355.0	101.5	143.7	200.2
50	553.5	790.4	1016.5	285.4	404.7	539.8
90	1699.7	2446.7	3039.1	845.0	1205.7	1546.7
Mean	813.1	1169.3	1470.4	410.5	585.5	761.7
(110 - Age)% Stocks, (Age + 10)% TIPS						
1	80.0	113.6	156.9	63.0	89.4	125.3
10	183.4	259.9	352.1	142.8	202.2	277.6
50	289.5	410.3	548.4	224.6	317.8	430.3
90	454.7	645.0	851.6	351.7	498.0	665.4
Mean	307.7	436.2	581.3	238.5	337.7	455.7
(110 - Age)% Stocks, (Age + 10)% Bonds						
1	62.4	87.7	122.7	49.6	69.8	99.1
10	171.1	242.6	329.9	133.5	189.1	260.7
50	308.0	436.8	581.7	238.5	337.7	455.4
90	561.2	797.7	1041.2	431.8	612.6	809.1
Mean	344.3	488.9	646.6	266.0	377.2	505.1
Empirical Lifecycle, Stocks and TIPS						
1	70.7	101.0	142.5	53.6	76.4	110.5
10	184.2	261.3	353.8	131.4	185.9	258.2
50	329.8	469.8	615.6	227.7	322.8	434.3
90	611.0	876.3	1114.7	409.9	584.0	761.7
Mean	372.4	532.2	690.0	254.7	362.0	481.7
Empirical Lifecycle, Stocks and Bonds						
1	58.6	82.6	116.1	44.4	62.7	90.4
10	174.4	247.7	335.2	124.3	176.0	244.4
50	342.3	487.9	638.7	236.1	334.8	449.8
90	697.6	1000.8	1270.2	467.6	666.7	867.2
Mean	401.8	574.5	742.5	274.1	389.7	516.8
Feldstein (2005) "No Lose" Plan						
1	123.6	174.6	245.5	120.3	169.7	239.4
10	175.5	248.9	339.0	145.1	204.9	285.0
50	314.0	448.9	581.6	209.8	297.6	400.4
90	774.2	1120.6	1379.3	424.0	607.4	776.1
Mean	421.9	607.8	768.0	260.0	370.9	487.8

Source: Authors' tabulations of simulation results. See text for further details.

**Table 6: Simulated Distribution of 401(k) Balances at Retirement (\$2000), Higher Expense Ratios**

Investment Strategy/ Percentile	Empirical Stock Returns			Empirical Returns Reduced 300 Basis Points		
	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate
100% TIPS	148.9	210.3	291.6	148.9	210.3	291.6
100% Government Bonds						
1	48.1	68.2	99.1	48.1	68.2	99.1
10	100.0	141.2	199.3	100.0	141.2	199.3
50	159.3	225.3	310.9	159.3	225.3	310.9
90	267.1	377.7	509.9	267.1	377.7	509.9
Mean	174.5	246.8	338.5	174.5	246.8	338.5
100% Stocks						
1	27.5	39.5	56.1	17.1	24.6	36.5
10	161.5	229.5	310.1	89.2	126.2	177.4
50	474.4	676.4	876.9	247.2	350.2	471.2
90	1446.5	2078.4	2599.4	724.5	1031.8	1333.3
Mean	694.3	996.5	1262.2	353.5	503.4	660.3
(110 - Age)% Stocks, (Age + 10)% TIPS						
1	70.8	100.6	140.0	56.0	79.5	112.4
10	161.2	228.3	311.8	126.0	178.3	246.9
50	253.8	359.2	484.0	197.5	279.2	381.2
90	397.7	563.3	749.4	308.4	436.2	587.5
Mean	269.6	381.7	512.7	209.6	296.5	403.3
(110 - Age)% Stocks, (Age + 10)% Bonds						
1	55.1	77.5	109.5	44.0	62.0	88.8
10	149.2	211.3	290.0	117.0	165.5	230.2
50	267.0	378.2	507.9	207.5	293.5	399.3
90	484.2	687.0	904.0	373.6	529.3	704.9
Mean	298.0	422.5	563.6	231.1	327.2	442.0
Empirical Lifecycle, Stocks and TIPS						
1	64.8	92.5	131.5	49.5	70.5	102.6
10	166.4	235.9	321.4	119.5	169.0	236.2
50	295.6	420.6	554.7	205.4	290.8	393.9
90	544.2	779.3	997.2	366.9	522.1	685.3
Mean	333.1	475.4	620.3	229.1	325.3	435.8
Empirical Lifecycle, Stocks and Bonds						
1	53.7	75.8	107.2	41.0	57.9	84.0
10	157.5	223.5	304.4	113.0	159.9	223.5
50	306.8	436.7	575.2	212.8	301.5	407.7
90	621.2	890.0	1136.1	418.5	595.9	779.9
Mean	359.2	513.0	667.1	246.4	350.0	467.2
Feldstein (2005) "No Lose" Plan						
1	110.8	156.4	221.7	108.0	152.3	216.5
10	154.6	219.0	300.9	129.0	182.1	255.4
50	271.0	386.7	505.5	183.7	260.2	353.2
90	657.5	949.9	1177.6	364.1	520.6	670.7
Mean	361.6	520.0	662.5	225.9	321.7	427.0

Source: Authors' tabulations of simulation results. See text for further details.

**Table 7: Optimal Asset Allocations Calculations (5% Grid)**

Empirical Stock Returns			Empirical Stock Returns, Reduced 300 Basis Points		
Less Than High School Degree	High School and/or Some College	College and/or Post- graduate	Less Than High School Degree	High School and/or Some College	College and/or Post- graduate
No Other Wealth					
<i>alpha = 2</i>					
Optimal Fixed Proportions: % Stocks (Rest TIPS)	100%	100%	100%	65%	65%
Optimal Linear Lifecycle: Starting % Stocks	55%	55%	55%	55%	55%
<i>alpha = 4</i>					
Optimal Fixed Proportions: % Stocks (Rest TIPS)	55%	55%	60%	35%	35%
Optimal Linear Lifecycle: Starting % Stocks	65%	65%	60%	80%	80%
Annuities and Other Financial Wealth					
<i>alpha = 2</i>					
Optimal Fixed Proportions: % Stocks (Rest TIPS)	100%	100%	100%	80%	85%
Optimal Linear Lifecycle: Starting % Stocks	55%	55%	55%	55%	55%
<i>alpha = 4</i>					
Optimal Fixed Proportions: % Stocks (Rest TIPS)	70%	75%	90%	40%	45%
Optimal Linear Lifecycle: Starting % Stocks	55%	55%	55%	75%	70%

Table 8: Certainty Equivalent Wealth (\$2000) For Different Asset Allocation Rules and Different Expected Stock Returns, No Other Wealth

Investment Strategy / Risk Aversion <i>alpha</i> = 2	Empirical Stock Returns			Empirical Stock Returns, Reduced 300 Basis Points		
	Less Than High School Degree	High School and/or Some College	College and/or Post- graduate	Less Than High School Degree	High School and/or Some College	College and/or Post- graduate
Baseline Expense Ratios						
100% TIPS	167.4	236.7	325.5			
100% Government Bonds	171.9	242.9	334.3			
100% Stocks	389.1	553.7	731.0	207.9	294.5	403.3
Heuristic: (110 - Age)% Stocks, rest TIPS	271.5	384.8	516.4	210.8	298.4	405.7
Heuristic: (110 - Age)% Stocks, rest Bonds	278.0	393.9	528.7	215.8	305.5	415.3
Empirical Lifecycle, Stocks and TIPS	322.5	458.9	605.5	224.4	317.9	430.2
Empirical Lifecycle, Stocks and Bonds	323.5	460.3	607.9	225.2	319.0	432.1
Feldstein "No Lose" Plan	297.1	423.5	557.5	212.7	301.6	407.8
Optimal Fixed Proportions (Stocks and TIPS)	389.1	553.7	731.0	224.2	317.6	430.8
Optimal Linear Lifecycle	298.4	423.9	562.8	220.1	311.7	421.9
Average Expense Ratios						
Empirical Lifecycle, Stocks and TIPS	299.1	425.3	563.6	209.0	295.8	402.1
Empirical Lifecycle, Stocks and Bonds	300.0	426.6	565.8	209.7	297.0	403.9
High Expense Ratios						
100% TIPS	148.9	210.3	291.6			
100% Government Bonds	150.5	212.7	295.1			
100% Stocks	335.9	477.7	635.1	181.6	257.2	354.7
Empirical Lifecycle, Stocks and TIPS	268.8	381.9	509.0	189.0	267.3	365.5
Empirical Lifecycle, Stocks and Bonds	269.7	383.1	511.0	189.7	268.4	367.2
Feldstein "No Lose" Plan	258.4	367.7	487.8	186.9	264.6	360.7
<i>alpha</i> = 4						
Baseline Expense Ratios						
100% TIPS	167.4	236.7	325.5			
100% Government Bonds	150.0	211.8	294.9			
100% Stocks	204.2	288.3	398.1	116.3	164.2	234.5
Heuristic: (110 - Age)% Stocks, rest TIPS	239.4	339.1	458.3	186.3	263.6	361.0
Heuristic: (110 - Age)% Stocks, rest Bonds	226.2	320.2	435.5	176.6	249.8	344.1
Empirical Lifecycle, Stocks and TIPS	263.1	372.6	501.7	186.8	263.8	363.9
Empirical Lifecycle, Stocks and Bonds	247.5	350.6	473.8	176.5	249.3	345.0
Feldstein "No Lose" Plan	245.8	348.7	468.9	191.2	270.4	370.3
Optimal Fixed Proportions (Stocks and TIPS)	256.3	363.5	490.1	193.8	274.3	374.6
Optimal Linear Lifecycle	256.7	364.1	489.1	197.3	278.9	381.3
Average Expense Ratios						
Empirical Lifecycle, Stocks and TIPS	244.8	346.6	468.6	174.6	246.4	341.3
Empirical Lifecycle, Stocks and Bonds	230.5	326.3	442.8	165.0	233.0	323.9
High Expense Ratios						
100% TIPS	148.9	210.3	291.6			
100% Government Bonds	131.9	186.2	261.3			
100% Stocks	178.3	252.9	351.3	102.9	145.8	209.7
Empirical Lifecycle, Stocks and TIPS	221.0	312.9	425.4	158.6	223.9	311.8
Empirical Lifecycle, Stocks and Bonds	208.2	294.8	402.7	150.0	211.8	296.3
Feldstein "No Lose" Plan	215.5	305.5	413.9	168.9	238.7	329.5

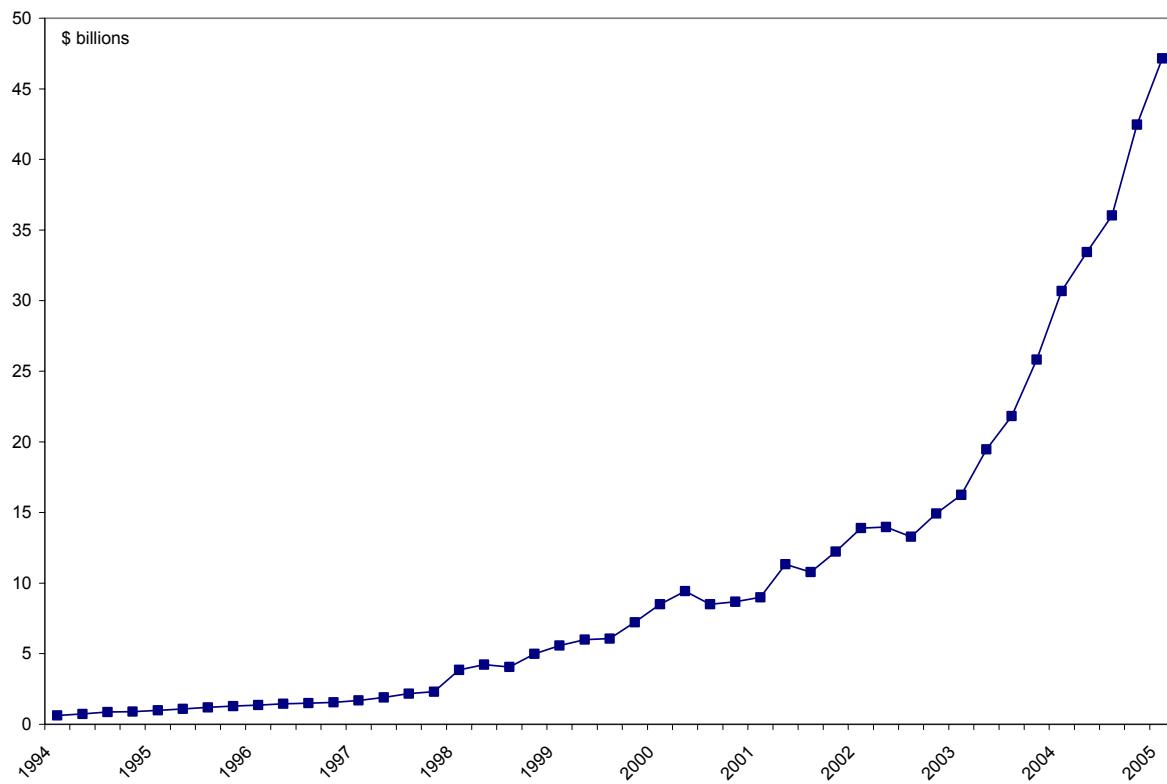
Source: Authors' tabulations from simulation analysis. See text for further discussion.

Table 9: Certainty Equivalent Wealth (\$2000) For Different Asset Allocation Rules and Different Expected Stock Returns, Other Wealth Equal to Annuities (Excluding DB Plans and Social Security) and Non-Retirement Financial Wealth

Investment Strategy / Risk Aversion <i>alpha</i> = 2	Empirical Stock Returns			Empirical Stock Returns, Reduced 300 Basis Points		
	Less Than High School Degree	High and/or Some College	College and/or Post- graduate	Less Than High School Degree	High and/or Some College	College and/or Post- graduate
Baseline Expense Ratios						
100% TIPS	167.4	236.7	325.5			
100% Government Bonds	176.1	252.0	351.7			
100% Stocks	419.0	618.9	861.7	229.4	340.5	492.5
Heuristic: (110 - Age)% Stocks, rest TIPS	275.9	394.3	535.4	214.8	306.9	422.2
Heuristic: (110 - Age)% Stocks, rest Bonds	285.5	410.2	560.9	222.5	319.9	443.1
Empirical Lifecycle, Stocks and TIPS	330.4	476.4	639.3	230.7	331.6	456.0
Empirical Lifecycle, Stocks and Bonds	334.2	483.7	653.5	233.8	337.7	467.5
Feldstein"No Lose" Plan	306.2	443.8	597.0	217.3	311.6	426.8
Optimal Fixed Proportions (Stocks and TIPS)	419.0	618.9	861.7	235.4	344.1	492.5
Optimal Linear Lifecycle	304.0	436.1	586.9	224.8	321.9	441.6
Average Expense Ratios						
Empirical Lifecycle, Stocks and TIPS	306.7	442.1	595.8	215.0	309.0	426.6
Empirical Lifecycle, Stocks and Bonds	310.3	449.1	609.3	217.9	314.7	437.6
High Expense Ratios						
100% TIPS	148.9	210.3	291.6			
100% Government Bonds	154.4	221.0	310.9			
100% Stocks	363.7	538.1	755.6	201.4	299.4	436.3
Empirical Lifecycle, Stocks and TIPS	276.0	397.6	539.1	194.6	279.6	388.3
Empirical Lifecycle, Stocks and Bonds	279.3	404.3	551.8	197.3	285.0	398.5
Feldstein"No Lose" Plan	266.8	386.2	523.5	191.0	273.7	377.7
<i>alpha</i> = 4						
Baseline Expense Ratios						
100% TIPS	167.4	236.7	325.5			
100% Government Bonds	157.6	227.9	325.5			
100% Stocks	250.0	387.1	593.0	148.4	232.1	365.9
Heuristic: (110 - Age)% Stocks, rest TIPS	248.1	357.7	495.1	194.0	280.0	392.8
Heuristic: (110 - Age)% Stocks, rest Bonds	240.3	350.2	494.6	189.0	276.0	394.9
Empirical Lifecycle, Stocks and TIPS	277.3	404.0	561.8	198.0	288.2	409.7
Empirical Lifecycle, Stocks and Bonds	266.3	391.4	552.8	191.3	281.3	406.0
Feldstein "No Lose" Plan	257.1	373.6	518.6	197.0	283.2	395.3
Optimal Fixed Proportions (Stocks and TIPS)	275.0	408.0	569.9	199.3	287.4	405.7
Optimal Linear Lifecycle	266.8	386.3	533.3	203.0	291.8	407.0
Average Expense Ratios						
Empirical Lifecycle, Stocks and TIPS	258.5	376.6	525.7	185.3	269.7	384.7
Empirical Lifecycle, Stocks and Bonds	248.4	365.3	518.0	179.2	263.6	381.8
High Expense Ratios						
100% TIPS	148.9	210.3	291.6			
100% Government Bonds	138.8	201.0	289.1			
100% Stocks	220.8	343.7	529.7	132.5	208.0	329.5
Empirical Lifecycle, Stocks and TIPS	233.8	340.9	478.6	168.6	245.5	352.1
Empirical Lifecycle, Stocks and Bonds	225.0	331.4	472.6	163.3	240.4	350.1
Feldstein "No Lose" Plan	225.9	328.3	459.0	174.2	250.3	351.9

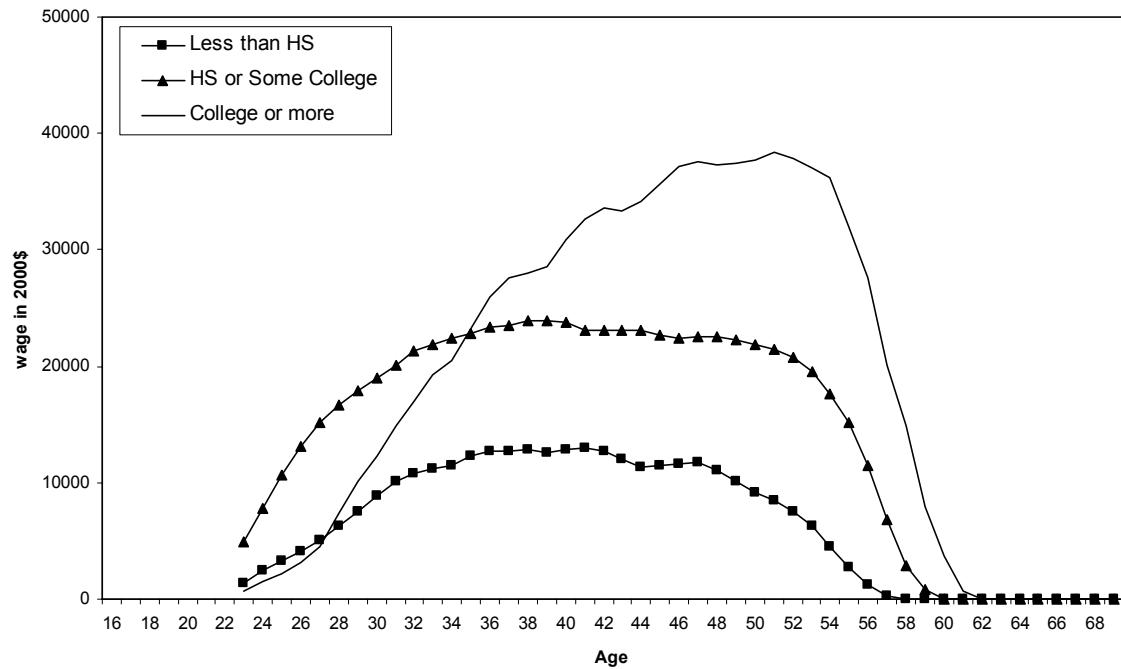
Source: Authors' tabulations from simulation analysis. See text for further discussion.

**Figure 1: Aggregate Net Assets of Target-Year Lifecycle Funds, March 1994-March 2005**

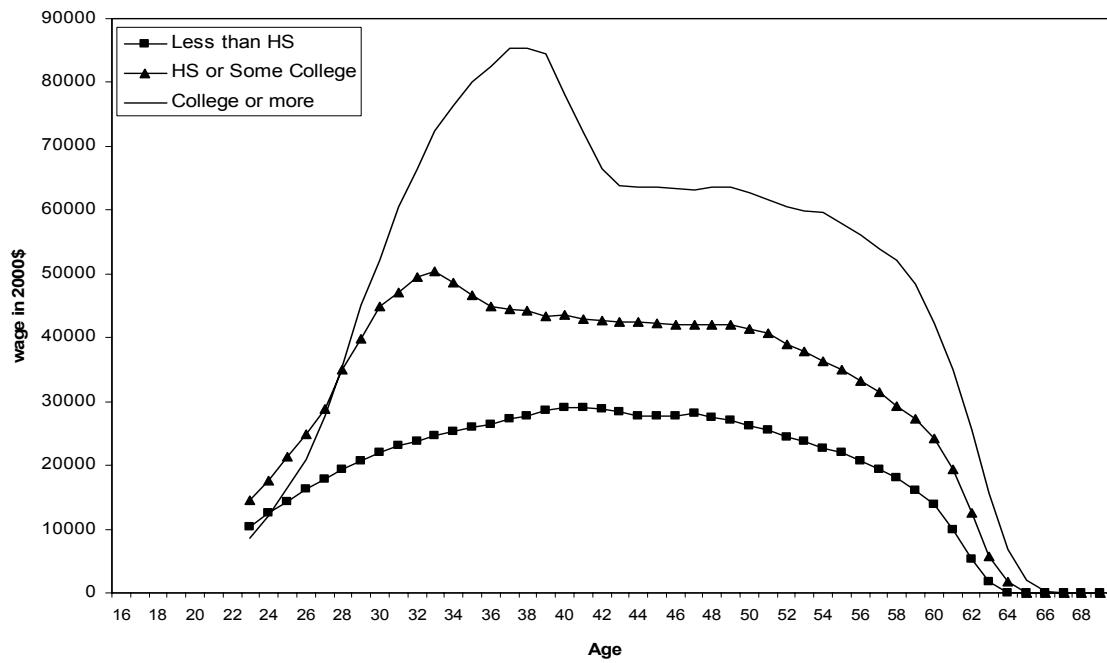


This figure shows quarterly net assets of all mutual funds categorized by Morningstar as retirement or lifecycle funds which also have a target-year rebalancing feature. As of March 2005, the \$47.1 billion represents assets in the following families: Barclays Global Investors LifePath, Fidelity Freedom Funds, Fidelity Advisor Freedom, Intrust Bank NestEgg, MassMutual Select Destination Retire, Principal Investors Lifetime, Putnam Retirement Ready, Scudder Target, State Farm Lifepath, TIAA-CREF Institutional Lifecycle, T. Rowe Price Retirement, Vanguard Target Retirement, Vantagepoint Milestone, and Wells Fargo Outlook. Net assets for lifecycle funds were assembled from fund reports and data provided by Morningstar.

**Figure 2: 25<sup>th</sup> Percentile Earnings, After Top-Coding Correction, HRS Husbands**



**Figure 3: 50<sup>th</sup> Percentile Earnings, After Top-Coding Correction, HRS Husbands**



**Figure 4: 75<sup>th</sup> Percentile Earnings, After Top-Coding Correction, HRS Husbands**

