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8

# Reducing Social Security PRA Risk at the Individual Level

## Life-Cycle Funds and No-Loss Strategies

James M. Poterba, Joshua Rauh, Steven F. Venti, and David A. Wise

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 because they affect the expenses of investing as well as the risk of low returns. The goal of this chapter 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

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benefit and DC 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 life-cycle 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 DC Social Security system. Poterba et al. (2005), hereafter PRVW (2005), examine how several different portfolio allocation strategies over the life cycle affect retirement wealth.

Previous findings about the level of retirement wealth associated with DC 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 100 percent of his or 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, PRAs, 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 DC 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 "life-cycle 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 chapter, we consider the effect of such life-cycle investment strategies on the distribution of retirement wealth.

Our previous research on life-cycle asset allocation patterns, PRVW (2005), considered how life-cycle 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 chapter builds on our earlier methodology in several ways. First, we model the asset allocation trajectories implied by the life-cycle 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 life-cycle strategies to derive the optimal strategy within a given class of strategies. We then compare the returns from typical life-cycle 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 overestimate the riskiness of PRA investments.

We find that 100 percent 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 life-cycle 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, life-cycle 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 chapter is divided into five sections. The first section summarizes theoretical research on the optimal pattern of age-related asset allocation. It then describes the life-cycle funds that have become increasingly popular in the retirement saving market. Section 8.2 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 8.3 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 life-cycle 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.

## 8.1 Optimal Age-Dependent Asset Allocation Rules and the Rise of Life-Cycle 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 life-cycle 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 (1992) 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 that can be used to study optimal portfolio structure over the life cycle 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 nontradable labor income and borrowing constraints. They find that a life-cycle 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. Jagganathan 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 life-cycle 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 life cycle. 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 life-cycle funds. These funds are usually designed for an investor with a target retirement date. Life-cycle funds were available from Fidelity Investments as early as 1988, and there were at least 250 target-year life-cycle 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 life-cycle 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 8.1 shows the rapid growth in life-cycle fund assets during the last eleven years. The figure indicates that life-cycle 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 percent of all 401(k) plans offer life-cycle funds. At a time when Clements (2005) reports that the proliferation of investment options 401(k) plans has come under fire, life-cycle 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. Life-cycle funds are sometimes suggested as a natural choice for the default investment option in automatic enrollment 401(k) programs.

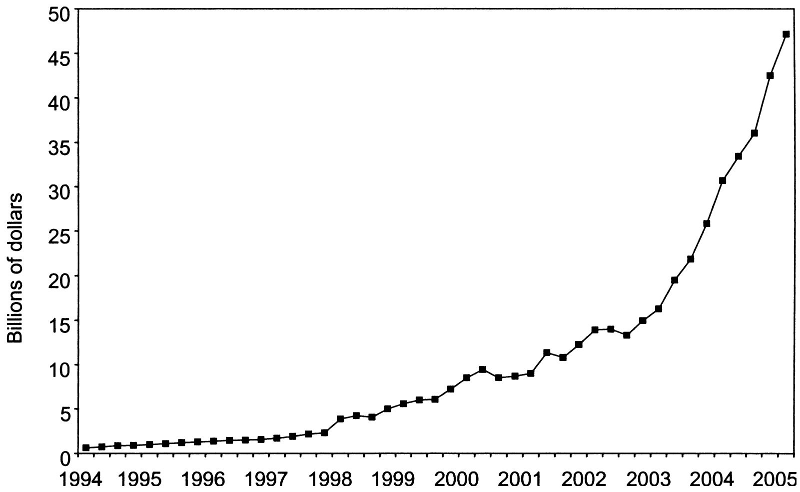


**Fig. 8.1 Aggregate net assets of target-year life-cycle funds, March 1994–March 2005**

*Notes:* This figure shows quarterly net assets of all mutual funds categorized by Morningstar as retirement or life-cycle funds that 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 life-cycle funds were assembled from fund reports and data provided by Morningstar.

The life-cycle funds offered at different fund families follow different age-phased asset allocation rules. Table 8.1 reports summary information on the life-cycle 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

**Table 8.1 Target-year life-cycle mutual fund characteristics (March 2005)**

| Retirement year | Years to retirement | Net assets ($ billion) | Weighted average expense ratio (%) | No. of fund families | No. 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 |

*Notes:* Funds used in this analysis consist of all mutual funds categorized by Morningstar as retirement or life-cycle funds that also have a target-year rebalancing feature. Net assets for these funds as of March 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 subfund 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.

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 life-cycle funds in which the rebalancing happens automatically.

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

## 8.2 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 nonmarried individuals, some of whom never married and others of whom have lost a spouse. About 70 percent of the individuals reaching retirement age are in married couples.

We assume that 9 percent of the household's earnings are contributed to a DC plan each year. We further assume that the couple begins to participate in a PRA plan when the husband is twenty-eight and that they contribute in every year in which the household has Social Security earnings until the husband is sixty-three. 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 sixty-three 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 $C_i(a) = .09 \cdot E_i(a)$ 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 percent. 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 percent of all wage and salary earnings.

To find the PRA balance for the couple at age sixty-three ($a = 63$), 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 sixty-three is then given by:

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

$R_i(a)$ 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 $R_i(a) = (1 - \theta_{\text{stock}}) \cdot R_{\text{stock}}(a)$, where $\theta_{\text{stock}}$ is the assumed annual expense ratio on an equity fund. If the couple holds all bonds, $R_i(a) = (1 - \theta_{\text{bond}}) \cdot R_{\text{bond}}(a)$. A mixture of the two is of course possible. If the couple invests in a life-cycle mutual fund, the asset return at age $a$ will be $(1 - \theta_{\text{bond}}) \cdot R_{\text{lifecycle}}(a)$, which corresponds to the return on the mix of bonds and stocks that will be held by the life-cycle 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

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

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 equation (2) to recognize this wealth:

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

Because 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 sixty-three, $W_{\text{PRA},h}$, and a corresponding utility level, $U_h$, where

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

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:

$$Z_{\text{SP500}} = [EU_{\text{SP500}}(1-\alpha)]^{1/(1-\alpha)} - W_{\text{non-PRA}}. \tag{5}$$

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 DC 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 following table represents an average over the outcomes for many individuals. Our strategy can be thought of as drawing an HRS household at age twenty-seven 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.

## 8.3 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 sixty-three to seventy-two in 2000 for which Social Security earnings histories are available. Table 8.2 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 fifty-nine and sixty-two. 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 dis-

**Table 8.2** **Sample composition, Health and Retirement Survey (HRS) households**

| | All households, head 59–72 | Households 59–72, with Social Security earnings | Couples 59–72, with Social Security earnings | Couples 63–72, with Social Security earnings |
|---|---|---|---|---|
| | *Household head education less than high school* | | | |
| Survey households | 1,579 | 1,086 | 540 | 374 |
| Population counterpart | 3,769.3 | 2,653.4 | 1,324.2 | 938.3 |
| | *Household head high school education and/or some college* | | | |
| Survey households | 2,793 | 1,954 | 1,076 | 689 |
| Population counterpart | 7,669.2 | 5,453.6 | 3,013.2 | 1,949.3 |
| | *Household head at least college degree* | | | |
| Survey households | 1,132 | 793 | 526 | 337 |
| Population counterpart | 3,411.6 | 2,390.6 | 1,611.8 | 1,013.6 |
| | *Total* | | | |
| Survey households | 5,504 | 3,833 | 2,142 | 1,400 |
| Population counterpart | 14,850.1 | 10,497.6 | 5,949.2 | 3,901.1 |

*Source:* Authors' tabulations based on the 2000 wave of the HRS and the Social Security earnings histories available for a subsample of HRS respondents. Population counterparts are calculated using the household weights provided in the HRS.

persion 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 topcode 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, ex-

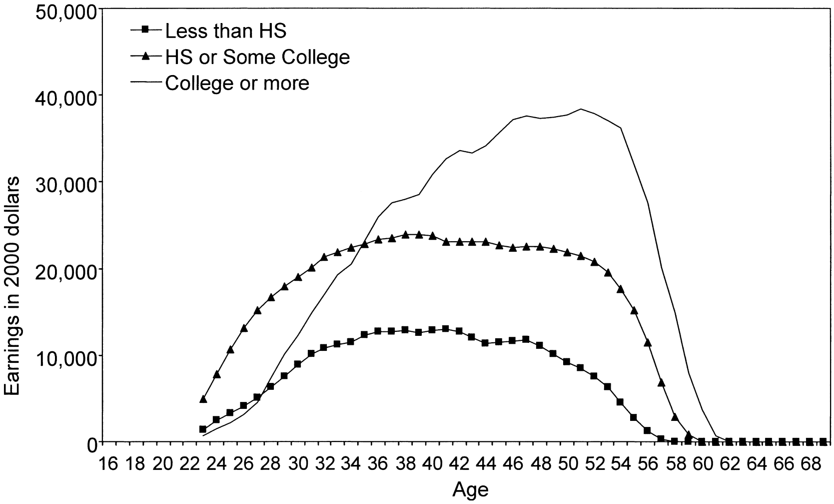


**Fig. 8.2 25th percentile earnings, after top-coding correction, HRS husbands**

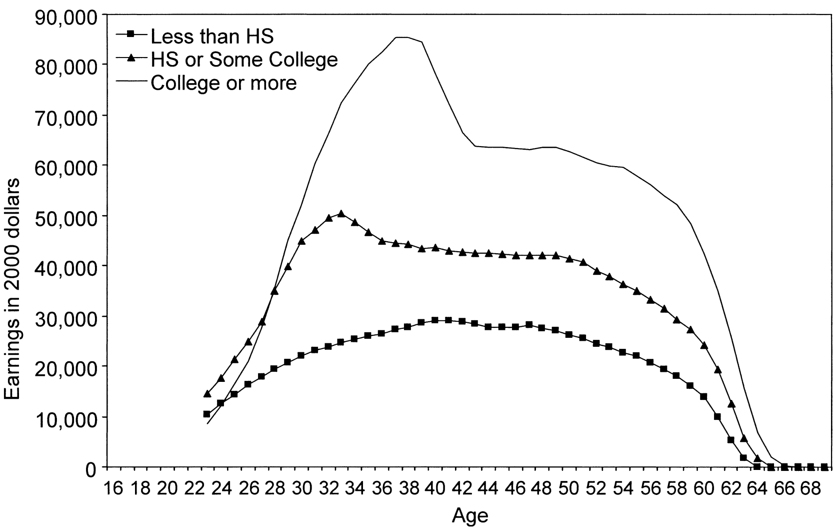


**Fig. 8.3 50th percentile earnings, after top-coding correction, HRS husbands**

clude anyone earning less than $2,500 (in $2000) when we estimate the tobit equations.

Each of figures 8.2 through 8.4 shows a different part of the distribution of age-earnings profile for three different education subgroups: 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

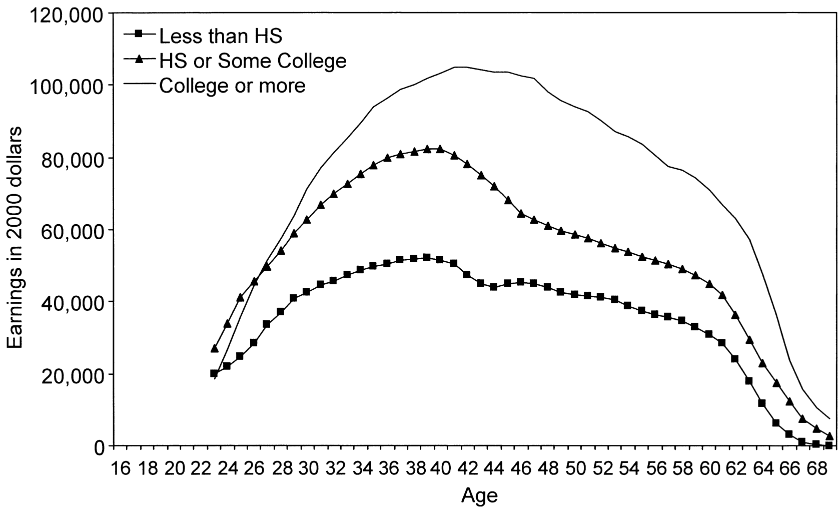


**Fig. 8.4 75th percentile earnings, after top-coding correction, HRS husbands**

8.3, 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 25th or 75th 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 Internal Revenue Service (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 sixty-three years old. When we turn to the HRS data, however, we assume that both sixty-three- and sixty-four-year-olds in a given survey wave represent the "retiring" cohort because the HRS is carried out ever 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 sixty-three or sixty-four in 1996, 1998, or 2000. For these households, a breakdown of nonpension 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 sixty-three 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 sixty-three or sixty-four, that is, 1994 to 1995 for the 1996 households and 1996 to 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 sixty-four 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 sixty-three and sixty-five, or sixty-three and sixty-seven, in the same educational category in later waves of the HRS.

Table 8.3 presents summary statistics on our estimates of household balance sheets normalized to age sixty-three to sixty-four. 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 8.3 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 sixty-three to seventy-two, with full earnings histories to age sixty-three, 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 sixty-three to seventy-two 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

**Table 8.3** **Summary statistics on household balance sheet at age 63/64, Health and Retirement Survey (HRS) households**

| | All HRS households | | | | HRS couples with husband aged 63–72 | | | |
|---|---|---|---|---|---|---|---|---|
| | Household head aged 59–72 | Household head aged 59–72 and with SS earnings | Couples aged 59–72, with SS earnings | Couples aged 63–72, with SS earnings | All | Less than high school degree | High school and/or some college | College and/or postgraduate |
| *Medians* | | | | | | | | |
| 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 |
| *Means* | | | | | | | | |
| 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 |

(*continued*)

**Table 8.3** (continued)

| | All HRS households | | | | HRS couples with husband aged 63–72 | | | |
|---|---|---|---|---|---|---|---|---|
| | Household head aged 59–72 | Household head aged 59–72 and with SS earnings | Couples aged 59–72, with SS earnings | Couples aged 63–72, with SS earnings | All | Less than high school degree | High school and/or some college | College and/or postgraduate |
| 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 |
| No. of households | 5,504 | 3,833 | 2,142 | 1,400 | 1,400 | 374 | 689 | 337 |
| Weighted size ('000s) | 14,850 | 10,498 | 5,949 | 3,901 | 3,901 | 938 | 1,949 | 1,013 |

*Source:* Authors' tabulations based on the 2000 HRS. All entries are normalized to calendar year 2000. To estimate defined benefit (DB) and defined contribution (DC) pension wealth for HRS households, we use the pension wealth imputations from the HRS (March 2005 version). Social Security wealth is calculated as in PRVW (2005).

*Notes:* 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.

IRA = individual retirement account.

and DC 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 PDV of the current or projected Social Security benefits when the husband is aged sixty-three to sixty-four. We normalize the value of the wife's Social Security to be the value when the husband is aged sixty-three to sixty-four, assuming that Social Security payments start for the wife at age sixty-two 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., nonretirement) 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 (2004) 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 DC 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 nonrandom 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 8.4 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 60th 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

**Table 8.4** **Distribution of household balance sheet for Household and Retirement Survey (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 |
|---|---|---|---|---|
| *20th percentile* | | | | |
| Total | 302.0 | 220.9 | 315.1 | 448.1 |
| Total excluding retirement accounts | 292.2 | 216.8 | 312.2 | 387.8 |
| SS + DB + Annuity | 189.8 | 169.4 | 198.8 | 204.6 |
| Annuities and other financial wealth | 1.0 | 0.0 | 1.7 | 30.0 |
| *40th percentile* | | | | |
| Total | 450.1 | 323.2 | 450.4 | 707.9 |
| Total excluding retirement accounts | 419.1 | 314.1 | 423.6 | 607.8 |
| SS + DB + Annuity | 257.0 | 230.7 | 257.3 | 281.2 |
| Annuities and other financial wealth | 29.7 | 2.0 | 30.0 | 113.0 |
| *60th percentile* | | | | |
| Total | 637.4 | 441.3 | 622.1 | 1051.1 |
| Total excluding retirement accounts | 575.3 | 413.6 | 549.8 | 878.6 |
| SS + DB + Annuity | 295.6 | 265.7 | 296.1 | 338.0 |
| Annuities and other financial wealth | 62.3 | 6.4 | 58.7 | 183.0 |
| *80th percentile* | | | | |
| Total | 994.5 | 644.1 | 866.4 | 1598.6 |
| Total excluding retirement accounts | 830.4 | 575.4 | 745.2 | 1229.6 |
| 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. Defined benefit (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).

inflation-indexed long-term bonds (Treasury inflation-protected securities [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 thirty-five 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 sixty-three under the different asset allocation strategies. For each of the 1,400 households in our sample, we simulate the PRA balance at age sixty-three 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.

## 8.4 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: (1) a portfolio that is fully invested in TIPS; (2) a portfolio that is fully invested in long-term government bonds, and (3) a portfolio that is fully invested in corporate stock. The next two portfolios are "heuristic portfolios" that use simple rules for life-cycle asset allocation. Portfolio (4) holds (110—age of household head) percent of the portfolio in stock, with the remaining balance in TIPS. Portfolio (5) is similar to (4) 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 life-cycle 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 life-cycle funds at Fidelity, Vanguard, T. Rowe Price, Teachers Insurance and Annuity Association-College Retirement Equities Fund (TIAA-CREF); Principal, Barclays, and Wells Fargo. The life-cycle funds from these fund families are weighted equally in this calculation, and the resulting equity allocation is similar to that in table 8.1. Portfolio (6) invests the life-cycle fund average in equities and the balance in TIPS, while fund (7) holds equities and nominal government bonds in the life-cycle mix.

The final primary investment strategy we consider, strategy (8), 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 $(1 + R_{\text{TIPS}})^{-(63-a)}$, where $63 - a$ is the number of years to retirement. This strategy is fundamentally different from the other life-cycle 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 $X$ percent in stocks and $1 - X$ percent in TIPS at 5 percent intervals. The second is an optimal "linear" life-cycle strategy, in which we consider strategies that begin at $X$ percent at age twenty-eight and end at $1 - X$ percent at age sixty-three. This is, of course, a restricted class of life-cycle 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 in the following.

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 20 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 life-cycle products, we consider three possibilities. The baseline assumption we make is that the life-cycle 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 8.1, 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 8.1 of 74 basis points and for a high-expense scenario of 120 basis points.

### 8.4.1 The Distribution of Retirement Wealth

Table 8.5 shows the distribution of PRA balances in thousands of year 2000 dollars averaged across the 1,400 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 4 points in the distribution of returns. Because our interest is the comparison of wealth outcomes across different strategies, most of our following discussion 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 8.5 provides a point of reference for all of the subsequent calculations. It shows the certain wealth at retirement associated with strategy (1), 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 (2), holding on nominal government bonds, and strategy (3), 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 or some college, holding only government bonds leads to a higher average

**Table 8.5** **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 | 1,699.7 | 2,446.7 | 3,039.1 | 845.0 | 1,205.7 | 1,546.7 |
| Mean | 813.1 | 1,169.3 | 1,470.4 | 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 | 1,041.2 | 431.8 | 612.6 | 809.1 |
| Mean | 344.3 | 488.9 | 646.60 | 266.0 | 377.2 | 505.1 |
| | | | *Empirical life cycle, 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 | 1,114.7 | 409.9 | 584.0 | 761.7 |
| Mean | 372.4 | 532.2 | 690.0 | 254.7 | 362.0 | 481.7 |
| | | | *Empirical life cycle, 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 | 1,000.8 | 1,270.2 | 467.6 | 666.7 | 867.2 |
| Mean | 401.8 | 574.5 | 742.5 | 274.1 | 389.7 | 516.8 |

**Table 8.5** (continued)

| | Empirical stock returns | | | Empirical returns reduced 300 basis points | | |
|---|---|---|---|---|---|---|
| Investment strategy/ percentile | 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 |
| | | | *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 | 1,120.6 | 1,379.3 | 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.
*Note:* TIPS = Treasury inflation-protected securities.

retirement wealth, $283,200, than holding TIPS. The average wealth at retirement is nearly 20 percent greater than the value with TIPS, but the median wealth of $265,100 is less than 10 percent above the TIPS outcome. Moreover, there are many outcomes with retirement wealth values below the TIPS case. The 10th percentile outcome is $160,500, and the 1st 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 10th percentile retirement wealth value with the all-stocks portfolio is not far below average outcome with a nominal government bond portfolio. The 1st percentile outcome, however, $44,300, is below the correspondingly low outcomes for the nominal bonds strategy.

The next two portfolios, (4) and (5), are "heuristic" life-cycle 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 90th percentile and the 10th 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 life-cycle portfolio, the 90-10 spread is 1.14 times the mean outcome. The 1st percentile outcomes with the two heuristic life-cycle portfolios are $113,600 and $87,700, both larger than 1st percentile outcomes with either the all-stock or all-bond portfolios.

The next two portfolios, (6) and (7), are the life-cycle 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 1st percentile outcome when we combine TIPS with stocks is lower than that of the heuristic strategy with TIPS and stocks. Similarly, the 1st percentile outcome of the bonds-stocks mutual fund product is lower than that of the heuristic strategy with TIPS and bonds. The empirical life-cycle 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 life-cycle strategies. The mean retirement wealth for a high school educated household is $607,800, which is between the mean wealth values with a life-cycle fund that holds TIPS and one that holds nominal government bonds. The important difference among this strategy and the life-cycle 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 1st percentile wealth value is $174,600, greater than any of the strategies other than investing 100 percent 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 8.5 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 10th percentile wealth value drops from $265,100 to $143,700 in this case, and the 1st 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 life-cycle 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 life-cycle strategies because the No Lose strategy has relatively more equity exposure than any of the life-cycle plans.

The distribution of retirement balances shown in table 8.5 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 8.6 shows the distributions of outcomes from table 8.5 but under the higher expense ratio scenario (100 basis points for stocks and bonds, 120 basis points for the life-cycle products). This table demonstrates the detrimental effects of high expense ratios on retirement wealth accumulation. The outcomes are 7 to 15 percent lower than under the baseline expense ratio scenario.

### 8.4.2 Expected Utility of Retirement Wealth

Results like those in table 8.5 and 8.6 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 equation (5). We focus in this analysis on 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 postgraduate), 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 life-cycle strategy. This is done by searching over grids at 5 percent intervals. For example, in finding the optimal fixed proportions we start with 100 percent stocks and 0 percent TIPS, then simulate 95 percent stocks and 5 percent TIPS, and so on until we get to 5 percent stocks and 95 percent TIPS. In finding the optimal linear life-cycle portfolio, we start with a strategy that begins 100 percent in stocks and declines linearly to 0 percent in stocks with the rest of the allocation going to TIPS. We then simulate a strategy that begins 95 percent in stocks and declines linearly to 5 percent, and so on, until we get to 55 percent stocks declining to 45 percent 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 8.6** **Simulated distribution of 401(k) balances at retirement ($2000), higher expense ratios**

| | Empirical stock returns | | | Empirical returns reduced 300 basis points | | |
|---|---|---|---|---|---|---|
| Investment strategy/ percentile | 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 | 1,446.5 | 2,078.4 | 2,599.4 | 724.5 | 1,031.8 | 1,333.3 |
| Mean | 694.3 | 996.5 | 1,262.2 | 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 life cycle, 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 life cycle, 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 | 1,136.1 | 418.5 | 595.9 | 779.9 |
| Mean | 359.2 | 513.0 | 667.1 | 246.4 | 350.0 | 467.2 |

**Table 8.6** (continued)

| | Empirical stock returns | | | Empirical returns reduced 300 basis points | | |
|---|---|---|---|---|---|---|
| Investment strategy/ percentile | 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 |
| | | | *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 | 1,177.6 | 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.
*Note:* TIPS = Treasury inflation-protected securities.

Table 8.7 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 percent stocks and 0 percent TIPS for all education categories. Under the lower returns assumption, the optimal fixed proportion is 65 percent stocks and 35 percent TIPS for the lower two education categories, and 70 percent stocks and 30 percent TIPS for the college or more category. With risk aversion of 4, the optimal fixed proportion declines to 55 to 60 percent in stocks under the historical empirical distribution and 35 percent 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 percent to 100 percent 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 percent stocks.

The optimal linear life-cycle strategy among the class of strategies we simulate is in many cases the one with the flattest profile. However, a profile that begins 60 to 65 percent in stocks and declines linearly to 40 to 35 percent in stocks is optimal among the class of linear life-cycle 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 percent in stocks and declines linearly to 20 percent in stocks is

**Table 8.7 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 postgraduate | Less than high school degree | High school and/or some college | College and/or postgraduate |
| | | | *No other wealth* | | | |
| alpha = 2 | | | | | | |
| Optimal fixed proportions: % stocks (rest TIPS) | 100 | 100 | 100 | 65 | 65 | 70 |
| Optimal linear life cycle: starting % stocks | 55 | 55 | 55 | 55 | 55 | 55 |
| alpha = 4 | | | | | | |
| Optimal fixed proportions: % stocks (rest TIPS) | 55 | 55 | 60 | 35 | 35 | 35 |
| Optimal linear life cycle: starting % stocks | 65 | 65 | 60 | 80 | 80 | 80 |
| | | | *Annuities and other financial wealth* | | | |
| alpha = 2 | | | | | | |
| Optimal fixed proportions: % stocks (rest TIPS) | 100 | 100 | 100 | 80 | 85 | 100 |
| Optimal linear life cycle: starting % stocks | 55 | 55 | 55 | 55 | 55 | 55 |
| alpha = 4 | | | | | | |
| Optimal fixed proportions: % stocks (rest TIPS) | 70 | 75 | 90 | 40 | 45 | 55 |
| Optimal linear life cycle: starting % stocks | 55 | 55 | 55 | 75 | 70 | 65 |

*Note:* TIPS = Treasury inflation-protected securities.

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 toward TIPS as the individual ages.

Table 8.8 shows the expected utility generated by the distribution of retirement resources for each of the eight primary portfolio strategies, as well

**Table 8.8** **Certainty equivalent wealth ($2000) for different asset allocation rules and different expected stock returns, no other wealth**

| Investment strategy/risk aversion | Empirical stock returns | | | Empirical stock 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 |
| | | | *alpha* = 2 | | | |
| *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 life cycle, stocks and TIPS | 322.5 | 458.9 | 605.5 | 224.4 | 317.9 | 430.2 |
| Empirical life cycle, 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 life cycle | 298.4 | 423.9 | 562.8 | 220.1 | 311.7 | 421.9 |
| *Average expense ratios* | | | | | | |
| Empirical life cycle, stocks and TIPS | 299.1 | 425.3 | 563.6 | 209.0 | 295.8 | 402.1 |
| Empirical life cycle, 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 life cycle, stocks and TIPS | 268.8 | 381.9 | 509.0 | 189.0 | 267.3 | 365.5 |
| Empirical life cycle, 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 |

(*continued*)

**Table 8.8** (continued)

| Investment strategy/risk aversion | Empirical stock returns | | | Empirical stock 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 |
| | | | *alpha = 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 life cycle, stocks and TIPS | 263.1 | 372.6 | 501.7 | 186.8 | 263.8 | 363.9 |
| Empirical life cycle, 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 | | | | 0 | | |
| and TIPS) | 256.3 | 363.5 | 490.1 | 193.8 | 274.3 | 374.6 |
| Optimal linear life cycle | 256.7 | 364.1 | 489.1 | 197.3 | 278.9 | 381.3 |
| *Average expense ratios* | | | | | | |
| Empirical life cycle, stocks and TIPS | 244.8 | 346.6 | 468.6 | 174.6 | 246.4 | 341.3 |
| Empirical life cycle, 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 life cycle, stocks and TIPS | 221.0 | 312.9 | 425.4 | 158.6 | 223.9 | 311.8 |
| Empirical life cycle, 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.
*Note:* TIPS = Treasury inflation-protected securities.

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 8.8 are based on risk aversion of 2. This panel shows that under the empirical stock return scenario, the 100 percent 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 percent greater than the empirical life-cycle strategies, assuming that investors can obtain the empirical life cycle for 40 basis points. It is roughly 30 percent greater than the empirical life-cycle strategies under the average expense ratio of 74 basis points. The certainty equivalent for 100 percent stocks is at least 40 percent greater than the heuristic strategies, and it is more than 120 percent better than the all bonds strategies. When expense ratios are raised, the 100 percent 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 to 14 percent worse off.

When returns are reduced by 300 basis points, the 100 percent stock strategy is no longer optimal. The empirical life-cycle 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 life-cycle 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 8.7 found to be 65 percent stocks for the lower two education categories and 70 percent stocks for the highest category, falls below the best strategy by less than $2,000. 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 percent lower than those under the baseline expense ratios. Furthermore, the empirical life-cycle products are much less competitive when we consider the premiums that investors generally pay in terms of expense ratios.

The lower panel of table 8.8 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 life cycle 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 life-cycle fund. The average expense ratio life-cycle fund (74 basis points) performs worse than the optimal linear life-cycle or optimal fixed proportions strategies because 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 life-cycle 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 percent equity is always the optimal strategy. Risk aversion of 0 is equivalent to considering the mean returns from tables 8.5 and 8.6. 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 8.8 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 8.9 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 life-cycle 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 8.8. 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 nonretirement account wealth raises the attractiveness of riskier strategies relative to other investment options. Under the empirical returns scenario, the 100 percent 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 8.9** **Certainty equivalent wealth ($2000) for different asset allocation rules and different expected stock returns, other wealth equal to annuities (excluding defined benefit [DB] plans and Social Security) and non-retirement financial wealth**

| | Empirical stock returns | | | Empirical stock returns reduced 300 basis points | | |
|---|---|---|---|---|---|---|
| Investment strategy/risk aversion | 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 |
| | | | *alpha* = 2 | | | |
| *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 life cycle, stocks and TIPS | 330.4 | 476.4 | 639.3 | 230.7 | 331.6 | 456.0 |
| Empirical life cycle, 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 life cycle | 304.0 | 436.1 | 586.9 | 224.8 | 321.9 | 441.6 |
| *Average expense ratios* | | | | | | |
| Empirical life cycle, stocks and TIPS | 306.7 | 442.1 | 595.8 | 215.0 | 309.0 | 426.6 |
| Empirical life cycle, 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 life cycle, stocks and TIPS | 276.0 | 397.6 | 539.1 | 194.6 | 279.6 | 388.3 |
| Empirical life cycle, 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 |

(*continued*)

**Table 8.9** **Certainty equivalent wealth ($2000) for different asset allocation rules and different expected stock returns, other wealth equal to annuities (excluding defined benefit [DB] plans and Social Security) and non-retirement financial wealth**

| | Empirical stock returns | | | Empirical stock returns reduced 300 basis points | | |
|---|---|---|---|---|---|---|
| Investment strategy/risk aversion | 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 |
| | | | *alpha* = 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 life cycle, stocks and TIPS | 277.3 | 404.0 | 561.8 | 198.0 | 288.2 | 409.7 |
| Empirical life cycle, 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 life cycle | 266.8 | 386.3 | 533.3 | 203.0 | 291.8 | 407.0 |
| *Average expense ratios* | | | | | | |
| Empirical life cycle, stocks and TIPS | 258.5 | 376.6 | 525.7 | 185.3 | 269.7 | 384.7 |
| Empirical life cycle, 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 life cycle, stocks and TIPS | 233.8 | 340.9 | 478.6 | 168.6 | 245.5 | 352.1 |
| Empirical life cycle, 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.
*Note:* TIPS = Treasury inflation-protected securities.

table 8.7, this strategy requires 80 percent and 85 percent 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 percent 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 life-cycle 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 life-cycle portfolio for the higher two education categories under baseline expense ratios and historical equity returns. A 100 percent 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 life-cycle 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 life-cycle portfolio that generates certainty equivalents at least as high as those from the empirical life-cycle funds, especially when we consider the higher average expense ratios that investors actually pay in empirical life-cycle funds.

## 8.5 Conclusions

This chapter 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 "life-cycle 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 life-cycle 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 life-cycle product is highest and is substantially higher than investing 100 percent in stocks. The actual life-cycle 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 percent 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 a life-cycle 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 life-cycle 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 toward TIPS (or bonds) as they get older. Households who are unable to do this on their own will not do terribly in life-cycle 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 life-cycle funds suggests three issues that warrant future research. First, it is possible that life-cycle 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 life-cycle 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 life-cycle investing that automate such portfolio decisions may affect expected utility in ways that we have not captured.

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## Comment Douglas W. Elmendorf

This chapter by Jim Poterba, Josh Rauh, Steve Venti, and David Wise considers an important practical issue that would be associated with the intro-

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