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DEFINED CONTRIBUTION PLANS, DEFINED BENEFIT PLANS, AND THE ACCUMULATION OF RETIREMENT WEALTH

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ABSTRACT

The private pension structure in the United States was once dominated by defined benefit (DB) plans, but it is currently divided between DB and defined contribution (DC) plans. Wealth accumulation in DC plans depends on financial market returns, while accumulation in a DB pension is very sensitive to an individual's labor market experience. This paper examines how the expansion of DC plans affects the average level of private retirement wealth and the variation in retirement wealth across households. It considers the stochastic contributions of asset returns, earnings histories, and retirement plan characteristics using data from the Health and Retirement Study (HRS). The analysis simulates retirement wealth accumulation under DC and DB plans. For DC plans, the analysis matches individuals to randomly-selected DC plans and draws asset returns from historical distributions. It allows for various asset allocation strategies and expense ratios. For DB plans, the analysis draws earnings histories from the HRS, and randomly assigns a pension plan to each job the individual holds. These procedures generate a distribution of potential DC and potential DB accruals that reflect the structure of DB and DC plans, the stochastic structure of earnings over the lifecycle, and the random contribution of asset returns to retirement wealth. The results provide a measure of the dispersion in prospective retirement wealth under both DB and DC regimes. This information is combined with assumptions about household risk tolerance to develop estimates of the certainty-equivalent wealth associated with both DB and DC pension structures.

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Private retirement arrangements in the United States were once predominantly defined benefit (DB) pension plans. There has been a shift in the last two decades toward defined contribution (DC) arrangements. Very few firms have created new DB plans, while many firms have closed their existing plans or moved toward greater reliance on DC plans, particularly for new workers. The growth of DC plans has given individuals responsibility for managing retirement assets and made retirement wealth accumulation a function of individuals' asset allocation decisions and of the financial market returns they experience.

Many analysts have suggested that the growth of DC plans has eroded retirement income security and increased the riskiness of retirement wealth. Relatively few studies, however, have compared the risks of DB and DC plans either using calibrated simulations or in a fully-specified lifecycle framework. Balcer and Sahin (1979) made an early comparison of DB and DC plans over the entire working life, recognizing that earnings uncertainty and job transitions have an important effect on DB plan participants. Bodie, Marcus, and Merton (1988) pointed out that DB and DC plans entail different risks from the standpoint of participants. More recently, Samwick and Skinner (2004) and Schrager (2005) have used data on earnings trajectories, employment transitions, and pension plans to evaluate the expected value of pension accumulations under both DB and DC plans, along with the variability of these accumulations. The risk of accumulating retirement wealth in DC plans has attracted more attention, particularly in the context of private accounts Social Security reforms. Recent work includes Shiller's (2005) analysis of different asset allocation strategies in such a Social Security system, and Poterba, Rauh, Venti, and Wise's (2005a), hereafter PRVW's (2005a), analysis of lifecycle investment strategies. This work demonstrates that the distribution of retirement wealth in DC plans depends on the net-of-expense asset returns experienced during the working life of the DC plan participant, on the participant's asset allocation strategy, and on the participant's contribution rate. There is no comparison with accumulation profiles under alternative retirement income systems.

This paper uses data on lifetime earnings histories from the Health and Retirement Study to simulate both DC and DB plan accruals. We use historical asset returns to estimate the distribution of financial outcomes for DC plan participants. We capture the heterogeneity in individual earnings experiences as well as the variation in DC and DB plans that individuals face. We summarize the value of retirement assets by computing the expected present discounted value of future DB plan payouts at age 63, and the value of assets in a DC plan at the same age. Given the complex nature of retirement plans and the difficulties of estimating the value of a stream of retirement payouts, our estimates are likely to be subject to error, but they provide some guidance on the generosity and risk of DC and DB pension arrangements.

The paper is divided into six sections. The first summarizes the ongoing shift from DB to DC plans and presents both aggregate information on participation in these plans as well as cohort-specific data on participation rates in DC and DB plans. Section two describes the sample of HRS households that we use to evaluate retirement wealth accumulation under DC and DB plans. It also provides information on the DC plans that these households participate in, in particular on the share of salary that employers and employees contribute to the retirement plan. The third section describes the algorithm that we use to simulate the distribution of DC retirement plan assets under different asset allocation rules during the accumulation period. This discussion draws heavily on PRVW (2005a, 2005b). Section four presents a parallel discussion of our algorithm for computing wealth accumulation in DB plans. This requires assumptions about the timing of job transitions for individual HRS respondents as well as the vesting rules associated with DB plans. The fifth section presents our results on the value of DC and DB plan accumulations. We present averages, which aggregate over workers with different earnings trajectories and plans with different design characteristics, as well as information on the distribution of potential outcomes. We also aggregate the information in these distributions by computing a certainty equivalent measure of the value of participation in both DC and DB plans. There is a brief conclusion.

1. Participant Risks in Defined Contribution (DC) and Defined Benefit (DB) Plans

The DC pension sector in the United States has expanded rapidly in the last twenty years while the DB sector has stabilized or contracted. Workers covered by DB plans are increasingly concentrated in the public sector. In this section we describe the expansion of the DC sector, discuss the relative risks in DB and DC plans from the standpoint of the participant, and review previous work on the comparison of different types of pension arrangements.

1.1 The Evolution of DB and DC Plans

Table 1 presents summary information on the number of vested participants in DB and DC plans from 1990 to 2003 calculated using data from Department of Labor Form 5500 filings. These data apply only to the private sector, where the shift to DC plans has been more pronounced than in the public sector. Buessing and Soto (2006), who tabulated the data in Table 1, adjust the raw 5500 data for the possibility of non-vested and non-participating employees. They also correct for double-counting of employees who may be enrolled in both DC and DB plans at the same firm. The data show a decline in the number of individuals who participate only in a private sector DB plan, from 9.6 million in 1990 to 6.6 million in 2003. The number of individuals with both types of plans is roughly constant over this time period, at nearly 14 million. The number of private sector individuals with DC coverage only has risen dramatically from 11.5 million to 30.1 million since 1990. After the end of the sample period, it is likely that the number of DB plan participants continued to decline. Munnell, Golub-Sass, Soto, and Vitagliano (2006), for example, describe the recent shift toward "freezing" DB plans at financially healthy firms.

Most public sector pension plans in the U.S. are still DB plans. The U.S. Census Bureau (2006) reports 2,659 federal, state, and local pension systems in the U.S., covering 17.9 million workers. Although the Census does not collect detailed data on plan type, some information can be obtained from the Pensions and Investments survey of the 1000 largest pension plans. In 2004, 224 of these plans were public sector plans, and DB assets represented 89.3 percent of total public pension assets. Among public sector plans, 62 percent reported zero DC assets, and 89 percent reported DC assets of less than one fifth of combined DB and DC assets. These figures are almost identical to those from the 1997 survey, the first year when Pensions and Investments profiled the 1000 largest pension plans. In 1997, there were 217 public sector plans and DB assets also represented 89.3 percent of total public pension assets.

Among public sector plans, 64 percent reported zero DC assets, and 89 percent reported that less than one fifth of their assets were in DC plans.

An alternative way to document shifting DB coverage relies on data from the Survey of Income and Program Participation (SIPP) for the years 1984, 1987, 1991, 1993, 1995, 1998, and 2003. Our procedure for analyzing these data involves grouping households by birth cohort. Figure 1 shows the DB participation rate for selected cohorts. The DB participation rate of employed persons is higher among older than younger cohorts. For example, the DB participation rate of 45-year-olds in 1984 was about 51 percent, compared with 31 percent for the age-45 cohort in 2002. Similar comparisons at other ages show similar differences.

Figure 1 shows that there is a cohort effect, with younger cohorts having a successively lower participation rate at all ages, as well as a within-cohort decline in the DB participation rate with age. The within-cohort decline for older cohorts is attributable in part to DB plan participants retiring. Because DB participants tend to retire earlier, all else equal, than DC participants, because of the retirement incentives in DB plans, the share of the employed population enrolled in DC plans may rise at older ages. Even for younger cohorts, however, there is typically a within-cohort decline in DB participation rates after 1987 or 1989, which reflects the movement away from these plans in the private sector.

Figure 2 shows cohort participation rates in DC plans. It shows that younger cohorts have higher age-specific DC participation rates than older cohorts. For example, 45-year olds in 1984 had only an 8 percent participation rate, compared with 45 percent for 45-year-olds in 2002. Furthermore, within cohorts, DC participation rates rise sharply with age, at least until individuals begin to retire and cash out of these plans. The cohort that was 27 in 1984 had only a 4 percent DC participation rate in 1984 compared to 45 percent participation rate in 2002. The cohort that was 45 in 1984 had an 8 percent participation rate in 1984, but its participation rate increased to 38 percent by the time cohort members were 59 in 1998. By age 64, however, this cohort's participation rate had declined to 33 percent, reflecting the cash-out behavior described above. The information in Figures 1 and 2 suggest that a growing fraction of the workforce is accumulating retirement wealth through DC plans, while the fraction with DB coverage is declining in the private sector, and at best stable in the public sector.

1.2 Previous Research on Participant Risk in DC and DB Plans

DC plan participants face asset market risk, because the value of their retirement assets depends on the trajectory of asset returns. Participants in DB plans are not exposed to asset market risk per se, because benefit payments are a liability of the sponsoring firm and they are not affected by the rate of return on plan assets except when the plan faces a risk of being closed or the firm may go bankrupt because of prospective liabilities. Nevertheless DB plan benefits are far from certain when viewed from the perspective of a worker early in her career. Shocks to earnings, job changes, and early retirement can all affect the value of the DB plan accruals. Moreover, even if the worker participates in a DB plan in each of her employed years, there is still uncertainty about the nature of the DB plan that will cover her. Some plans are more generous than others, which creates further DB plan uncertainty.

The complex interaction between pension plan accruals in DB and DC plans, financial market returns, and worker employment experience makes it difficult to compare the relative risks of these plans in a systematic fashion. Two recent studies have taken important steps to address this issue. The first, Samwick and Skinner (2004), uses data from the 1983 and 1989 Survey of Consumer Finances and Pension Provider Supplement (PPS) to summarize the set of DC and DB plans in the workplace. They find that for many workers the accumulation of assets in DC plans is likely to exceed the actuarial present value of the benefit entitlements that they would accrue in a DB plan. The findings in this study are very suggestive of the differences between DB and DC plans. However, the underlying data were collected early in the expansion of the DC sector, so they may no longer represent pension offerings. Moreover, the SCF lacks information on individual earnings histories, so Samwick and Skinner (2004) generate synthetic earnings histories and evaluate DB payouts and DC asset accumulation for each such earnings history. They assume that the logarithm of earnings follows a random walk with an age-related drift component. This approach is unlikely to capture the subtle stochastic properties of actual earnings histories, or to reflect the discrete risk of job loss or job change at various ages.

The second study, Schrager (2005), examines the same set of issues using data on earnings and job change patterns from the Panel Survey of Income Dynamics. This study makes the important point that job turnover increased in the 1990s relative to earlier decades, which made DC plans became more attractive relative to DB plans for many workers. It corroborates the Samwick-Skinner (2004) conclusion that DC plans may offer greater opportunities for retirement wealth accumulation for many workers. One of the strengths of this paper is the integration of optimal consumption planning with the presence of pension arrangements. This makes it possible to investigate household responses to presence of a DC rather than a DB plan. However, solving the lifecycle planning problem requires parameterizing the uncertainty in the earnings process and the job change process, which again means that some of the richness evident in actual earnings histories and job trajectories may be lost.

The present paper uses actual individual earning histories along with data on DB and DC plans in the 1990s to evaluate retirement wealth accumulation under each type of plan. Using actual earnings histories makes it difficult to find optimal lifetime consumption paths for individuals. Nevertheless, this approach may capture elements of DC and DB pension risk that are lost with simpler earnings processes.

2. Selecting a Sample of HRS Households for Analyzing DC and DB Plan Risks

We use the HRS to study the accumulation of retirement wealth under both DB and DC plans. We focus on married couples because they are financially more homogeneous than non-married individuals in the near-retirement cohort. Some individuals in the latter group have never married, while others have lost a spouse, and the two groups are often in quite different financial condition. Roughly seventy percent of retirement-age individuals are in married couples. A variety of other sample selection criteria, including usable data for several key data items, further restrict our sample.

Table 2 presents information on the sample selection criteria that we employ and their impact on our sample size. Our sample includes all HRS couples headed by men aged 63-72 in 2000 for whom the HRS datafiles include Social Security earnings histories. 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 younger than 62 and older than 73. Including those younger than 62 would require extrapolating earnings histories for the latter part of the working career, and including those over 73 would entail difficulty in calibrating at retirement age. We focus on the earnings experience and the pension benefits for the husband in each married couple because they have fewer interruptions to their earnings histories, and it is therefore easier to track their job experience. There is some danger that our restriction to a sample of married couples leads to a non-representative sample of earnings histories and job changes. This is an issue we plan to explore in future work.

2.1 Measuring Earnings Histories

The HRS includes different earnings measures in different years for each respondent. Together, these measures provide information on earnings for a period beginning as early as 1951. In the years since 1991, the HRS includes self-reported total earnings for each member of each HRS household. For the years between 1980 and 1990, W-2 earnings records from the income tax rolls have been linked to the survey responses for HRS participants. These earnings records may exclude some components of income, such as self-employment, but they are likely to dominate the Social Security earnings data that are also available for these years. Finally, for the period before 1980, the HRS attaches Social Security earnings records to each respondent's data record. These data show exact earnings only for those with earnings below the Social Security payroll tax threshold. For those with higher earnings, the data simply show the threshold amount. This top-coding problem undermines the usefulness of the SSA data.

The taxable maximum earnings level for Social Security has varied over time, and so has the dispersion of earnings, so the fraction of earnings that are not captured on Social Security records varies from year to year. For some subsets of workers, however, such as those with a college education, the earnings cap is a substantial impediment to measuring lifetime contributions to a DC plan or the value of benefit-generating earnings in a DB plan. Table 3 shows the fraction of sample participants, stratified by various characteristics, who are affected by the earnings cap in years between 1951 and 1979. The data show that in some years in the early 1970s, particularly for the group with the highest education level, the top-code affects more than half of the sample. Because the payroll tax cap was not indexed for inflation during much of this period, and it changes as a result of legislative action, there are also substantial changes in this threshold during brief periods. The magnitude of the top-coding problem may therefore vary from year to year..

To address the top-coding problem, 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 individuals are affected by the top-code, we found that the estimated tobit coefficients were sensitive to the set of observations we included in the estimation subsample. In particular, including men with low earnings often led to corrected earnings for those at the payroll tax cap that were substantially higher than the earnings cap, regardless of other individual attributes. The tobit results were more robust when we deleted individuals with very low earnings levels from our sample. We therefore exclude anyone earning less than $2500 (in $2000) when we estimate the tobit equations.

Figures 2a through 2c show the mean age-earnings profile for three different education sub-groups: less than high school, high school and some college, and college and beyond, after we correct for top-coding. The median earnings path, displayed in Figure 2b, shows an unusual "bump" in early middle age. This appears to be due to the top-coding adjustment for years in which an especially high fraction of workers were affected by the taxable earnings cap. However, this unusual pattern does not appear at the 25^{th} or 75^{th} 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.

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

2.2 Retiree Wealth for HRS Households

The HRS provides detail on the actual value of respondents' DC and DB wealth. Before simulating the wealth of retires who work for their entire career under particular sets of DB or DC rules, we summarize the pension wealth imputations provided by version 1.0 of the HRS pension wealth calculator. For DB wealth at age 63 or 64, depending on which age occurs in an HRS sample year, we use the imputed present discounted value of pension wealth assuming retirement at age 62, grossed up by one year at a three percent real interest rate. This three percent value is the real interest rate assumed in the intermediate scenario of the Social Security Administration. For Social Security wealth (SSW), we use cohort mortality tables and the SSA's intermediate-cost scenario discount rates to calculate the present discounted value of current or projected Social Security benefits when the husband is aged 63 or 64. We normalize the value of the wife's Social Security to be the value when the husband is aged 63-64, assuming that Social Security payments start for the wife at age 62 if they have not started already. We value Social Security as a joint survivor annuity.

In addition to pension wealth, we also examine the non-retirement wealth of HRS households. We determine non-retirement wealth at age 63 using a procedure that varies depending on the household's age. For households headed by a husband who was either 63 or 64 in 1996, 1998 or 2000, there is a breakdown of non-pension wealth in HRS waves 3, 4, and 5. We scale all household wealth holdings to the 2000 base year, so that for each household we have an estimate of what their non-pension wealth would have been had they turned 63 in 2000. We implement this scaling by replacing the nominal returns on asset holdings in three categories – financial wealth, housing equity, and other wealth – for the two years prior to the year in which the head of household was 63, with nominal returns on assets in these years in 1998 and 1999. As an example, this implies that we increase the value of non-retirement financial asset holdings for those who reached age 63-64 in 1996, because these individuals did not experience the strong and favorable asset market returns just before age 63 that were experienced by those who turned 63 in 1999 or 2000. This procedure is described in more detail in PRVW (2005a). For HRS households in which the head reached the ages of 63 or 64 prior to 1996, we impute wealth values for each asset class based on the median measured asset growth for households between the ages of 63 and 65, or 63 and 67, in the same educational category in later waves of the HRS. We estimate various components of the household balance sheet normalized to age 63-64. We distinguish housing wealth, because it is not clear whether it should be viewed as a source of retirement wealth for elderly households. Venti and Wise (2001) report that elderly households rarely draw down their housing wealth, which argues against including this wealth as a source of retirement income.

Table 4 shows mean, median, and various percentiles of the wealth distribution for the households associated with the married men in our sample. The mean total wealth for those in our sample, shown in the last row, is $783,400. There is substantial variation by education groups, with a mean of $1,324,500 for those with at least a college education, and $468,100 for those with less than a high-school degree. The tabulations show that there are substantial differences in wealth accumulation across households both within and across education categories. At most percentiles, the average wealth of a household that did not complete high school is no more than half that of a household that completed college. These differences are of the same magnitude as the differences between the 20th and 60th percentiles of the distribution for a given education level. The 80th percentile of the distribution for all three education levels has wealth holdings that are at close to three times as great as those of households in the 20th percentile for the same education level.

The mean household net wealth is the sum of the means of the constituent parts; the quantiles do not satisfy this property. For the group with less than a high school education, the present discounted value of Social Security benefits represent roughly half of household net worth, with net housing equity and other wealth in durables and related items accounting for nearly one fifth. On average, current DB and DC wealth values account for less than one tenth of household net worth for this group. For those in the college and beyond group, SSW accounts for less than a quarter of net worth, and other financial assets are the single most important component of net worth. DC wealth is substantially more important the DB wealth on average, with the mean value of DC accumulation, $330,900, roughly five times greater than the mean DB wealth.

Mean wealth statistics are straightforward to analyze, but they often fail to capture the circumstances of households in much of the wealth distribution. The third panel of Table 4 shows that for the household at the median of the wealth distribution, net worth including Social Security wealth equals $536,800. Nearly half of this amount takes the form of the present discounted value of expected Social Security payments and another twenty percent is accounted for by housing equity. The role of housing and Social Security wealth diminishes as we move to higher percentiles of the wealth distribution, or to households with more education, while other financial wealth becomes more significant. There is greater disparity in "other financial wealth" than in any other component of the household balance sheet. This wealth component is negligible at the 20th percentile of the distribution, but by the 80th percentile its value is $215,200. The value of Social Security and annuity wealth varies least across percentiles of the distribution, reflecting the role of upper limits on benefit payments as well as minimum benefit payments.

For more than half of all sample participants, DB pension wealth is zero. At the 80th percentile, individuals with high school and some college have $12,000 in DB wealth and individuals with college or postgraduate degrees have DB wealth of $65,100. These are the estimates provided by the HRS pension calculator. Mean DB wealth accumulation for the entire sample is $47,700. This is a comparison point we can use when examining the value of DB and DC plan assets that emerge in our simulations.

3. Retirement Wealth Accumulation in DC Plans

We model DC plan accumulation by simulating the path of plan contributions and investment returns over an individual's working life. We use actual lifetime earnings trajectories along with the historical distribution of returns on financial assets and realistic assumptions about the expenses charged by financial institutions that manage assets in defined contribution retirement plans to calculate the resulting asset balance at age 63.

3.1 Contribution Behavior

We assume that an individual contributes a fixed percentage of his earnings to a DC plan each year during his working life, which we assume to start at age 28. The contribution rate is determined by drawing from a distribution of possible rates corresponding to the distribution of employer plus employee contribution rates to DC plans for the 1991 HRS. We assume that this rate remains constant throughout an individual's career, so even when job changes occur, they involve a move to a new employer with the same contribution percentage. It would be straightforward to allow random draws of the contribution at each job. This would result in a less disperse distribution of retirement wealth outcomes than the one we report, but would have very little impact on the mean of wealth accumulation.

Table 5 shows the distribution of contribution percentages across firms for firms that employ HRS participants. The mean contribution rate is 10.3 percent, but the table displays substantial dispersion. The 25th percentile value of the contribution rate is less than 6 percent, the median is approximately 10 percent, and the 75th percentile value is greater than 14 percent. Ten percent of the individuals in DC plans have combined employer and employee contribution rates of at least 18 percent of salary, and ten percent have contribution rates of no more than three percent. We assume that each individual in our sample participates in the DC plan in every year in which he has Social Security earnings until age 63. Contributions are set to zero when the household is unemployed or retired. We assume that there are no contributions after age 63.

We denote each individual by subscript i, and denote his DC contribution at age a by $C_i(a) = c_i.*E_i(a)$ for $E_i(a)$ the individual's earnings at age a and c_i the combined employer and employee contribution to the DC plan, as a percentage of earnings. We express this contribution in year 2000 dollars. To find the DC balance for an individual at age 63 (a = 63), we need to cumulate contributions over the course of the working life, with appropriate allowance for asset returns. Let $R_i(a)$ denote the net-of-expense return earned on DC assets that were held at the beginning of the year when the participant attained age a. The value of the individual's DC assets at age 63 is then given by:

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

$R_i(a)$ depends on the year-specific returns on stocks and bonds, and on the mix of stocks and bonds that the individual owned at age a. If he holds an all-stock portfolio, then $R_i(a) = R_{stock}(a)$.

3.2 Asset Allocation and Rate of Return Assumptions

We assume that the three primary assets that individuals hold in their DC plans are corporate stock, nominal long-term government bonds, and inflation-indexed long-term bonds (TIPS). Calibrating the returns on these investment alternatives is a critical step in our simulation algorithm. We assume that DC plan investors hold corporate stocks through mutual funds that invest in portfolios of large capitalization U.S. stocks. We do not address the possibility of poorly diversified portfolios or holdings of company stock, which are discussed in Munnell and Sunden (2004) and Poterba (2003). We assume that the distribution of returns on each of these asset classes is given by Ibbotson Associates' (2004) 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.

Some suspect that the period covered by our data sample was particularly favorable for equity markets. They caution against extrapolating these returns to the future. To allow for such a possibility, we perform some simulations in which all equity returns are reduced by 300 basis points relative to their level in the actual historical distribution. Comparing these simulations with those in our baseline indicate the sensitivity of our findings to the future pattern of equity returns.

Each time we simulate a retirement wealth outcome, we draw a sequence of 35 real stock and bond returns from the empirical return distribution. The draws are done with replacement and we assume that there is no serial correlation in returns. We then use this return sequence to calculate the real value of each individual's retirement account balance at age 63 under the different asset allocation strategies. For each of the 1,400 workers in our sample, we simulate the DC balance at age 63 50,000 times. For each individual we therefore obtain a distribution of wealth values at retirement. We can present information on various percentiles and other summary measures of this distribution, and we can also use the distribution to compute the expected utility of retirement wealth. We can present summary information for all individuals, and we can stratify the outcomes by various education levels.

We simulate seven different asset allocation strategies for each individual's DC account. The first three involve investing in only one asset: (i) TIPS; (ii) long-term government bonds, and (iii) corporate stock. The next two portfolios are blended portfolios. Portfolio (iv) is an age-invariant 50-50 mix of stocks and TIPS, while portfolio (v) is a 50-50 mix of stocks and nominal government bonds. Portfolios (vi) and (vii) are lifecycle portfolios that combine stocks and TIPS, and stocks and nominal bonds, in a mixture that is based on the empirical holdings of stocks and bonds in current lifecycle mutual funds. Lifecycle funds have recently been introduced in many DC plans to address the desire of many investors to avoid having to rebalance their DC accounts. The age-specific equity weight in our simulations is the average of the age-specific allocations in the lifecycle funds at Fidelity, Vanguard, T. Rowe Price, TIAA-CREF, Principal, Barclays, and Wells Fargo. The lifecycle funds from these fund families are weighted equally in this calculation. Marquez (2005) reports that Hewitt Associates estimates that 38 percent of all 401(k) plans offer lifecycle funds. The lifecycle funds offered at different fund families follow different age-phased asset allocation rules. PRVW (2005a) describe these funds in detail and report summary information on the lifecycle funds offered at leading mutual fund companies.

We assume that the returns on DC plan investments equal the pretax returns on the various asset classes we consider, less an expense charge for investment management. Based on the expense ratio tabulations in PRVW (2005a), we assume a 74 basis point cost on investing in the lifecycle products. This is a weighted average of expenses on several funds, with each fund weighted by assets under management. We assume a 32 basis point expense ratio on equity mutual funds, the weighted mean expense ratio on S&P 500 index funds reported in Hortaçsu and Syverson (2004). Given that government bond funds tend to have similar expense ratios to stock index funds, we assume 32 basis points as the expense ratio for government bond funds. For TIPS, we use an expense ratio of 40 basis points, on the grounds that these funds may be twenty percent more expensive than typical stock or bond index funds.

3.3 Summarizing the Distribution of DC Retirement Balances

Our simulations yield a distribution of $W_i(63)$ for each individual for various asset allocation strategies. By comparing the distributions of retirement assets under each of these strategies, we can learn how they affect retirement resources. The distribution of outcomes is of substantial interest, but it does not capture the individual's valuation of different levels of retirement resources. In particular, while reporting the distribution of outcomes enables us to display wider dispersion with some investment strategies than with others, we need a metric for comparing a distribution with a lower mean but less dispersion with one with a higher mean and greater dispersion. We use a utility-of-terminal wealth approach. We assume that individuals have identical preferences over wealth at retirement, and that these preferences are described by a constant relative risk aversion (CRRA) utility function

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

where α is the individual's coefficient of relative risk aversion. Since individuals have wealth both in retirement plans and in other accounts when they reach retirement, we modify (2) accordingly:

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

The effect of DC wealth on an individual's utility depends on the individual's other wealth holdings, so we consider other assets on the individual's balance sheet in our empirical analysis. In practice, we allocate all of the household's balance sheet to each individual when we carry out this analysis.

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

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

We evaluate the expected utility of each portfolio strategy by the probability-weighted average of the utility outcomes associated with that strategy. 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 a utility level equal to the expected utility of the retirement wealth distribution. The certainty equivalent of an all-equity portfolio, for example, denoted by the subscript *SP500*, is given by:

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

When individual DC participants have wealth outside a DC plan, the certainty equivalent of the DC wealth is the amount of DC wealth that is needed, in addition to the other wealth, to achieve a given utility level. We treat non-DC wealth as nonstochastic throughout our analysis. We apply the same procedure to examine the certainty-equivalent value of wealth in DB plans.

4. Computation of Defined Benefit (DB) Retirement Wealth

The DB plans that cover HRS respondents are described in detail in a supplementary file of Summary Plan Documents (SPDs). Plan provisions have also been codified in a pension benefit calculator that makes it possible to estimate the prospective DB pension payouts for each HRS respondent who is covered by a DB plan, or for other individuals with well-specified earnings and job tenure histories. The HRS Pension Estimation Program (PEP) is described in Peticolas and Stolyarova (2003). This software contains coding for the pension SPDs that the HRS collected from employers in 1993 and 1999, for plan years 1992 and 1998 respectively. The HRS uses this calculator, described in conjunction with Table 4, to impute DB pension wealth for each survey respondent in a DB plan.

We use the PEP to estimate the counterfactual expected present discounted value of DB pension wealth for all sample participants assuming that they are assigned to a randomly selected DB plan for each of their jobs. The PEP takes as input an earnings history and a particular pension plan in the sample, and it generates a stream of retirement income payouts for an individual with the given earnings history if they were employed at a firm with the specified plan. Estimated DB pension payouts can be combined with information on mortality rates to estimate the expected present discounted value of these payouts. The PEP can be used to estimate a given individual's DB pension wealth under different DB plans, thereby illustrating the risk associated with uncertainty of what DB plan a firm in the DB sector will offer, and it can be used to evaluate the payouts under a given DB plan for individuals with different earnings histories, thereby indicating the earnings risk associated with a particular plan. Both plan risk and earnings risk contribute to the overall risk of participating in a DB plan, and our calculations provide information on this combined risk.

To analyze DB accruals for a given individual, we need to separate the individual's earnings history into its constituent employment spells at various employers. The data requirements for such a separation are greater than those associated with measuring the stream of potential contributions to a DC plan, where we assumed that whatever earnings an individual had could provide the basis for a plan contribution. We also need to identify a sample of DB plans for analysis. We consider each of these data issues in turn.

4.1 Construction of Job Histories for HRS Respondents

We construct job histories for each individual in our sample based on both their reported earnings histories between the ages of 28 and 63 and their responses to various HRS questions about job tenure.

The survey includes questions about the number of years the respondent has worked at his or her current or longest-tenure job. When we tried to use these questions to create job histories, however, we found that many responses were inconsistent across HRS waves, and that the resulting job histories matched poorly with the reported earnings histories. We therefore chose not to rely exclusively on the self-reported job tenure information, but instead combined information from these questions with data from earnings histories. We infer the beginning and the end of a job from the HRS earnings history by assuming that zeros in the earnings record reflect job interruptions. Furthermore, in keeping with the assumptions used above in the top coding corrections, observations with less than $2500 in real (year 2000) earnings are assumed to reflect part-year or part-time work and therefore defined as a work interruption. This assumption may cause us to underestimate the length of some jobs for HRS respondents. Finally, given the typical characteristics of DB plans in our sample, we assume that a job did not generate any DB pension benefits unless it lasted for at least five years. Thus a given year of earnings generates credit toward a DB plan payout only if it occurs between ages 28 and 63, is greater than $2500 in real dollars, and is part of a string of at least five consecutive years of earnings above this threshold. We further assume that no one in our sample has more than three DB-eligible jobs during their work career. This is consistent with empirical evidence suggesting that very few individuals DB pension benefits from more than three jobs.

Tables 6 and 7 present information on the pattern of job histories that emerges from our procedure for dividing earnings records into jobs. Table 6 shows the number of individuals, divided by educational attainment, who are assigned 0, 1, 2, and 3 jobs. Among the 1400 individuals in our sample, 77.2 percent (1081) are assumed to have a single DB-eligible job during their lifetimes, while 18.4 percent are assumed to have two such jobs. The remaining 3.4 percent of the sample is divided equally between those who have no job that lasts more than five years and those who have three jobs. The distribution of number of jobs is stable across sub-samples with different levels of educational attainment.

Table 7 reports another summary measure on job histories, namely the distribution of job lengths. In this case we are considering each job separately, not each individual separately, so when we report that the median job for a person with less than a high school education lasted 25 years, this is the median of the 286*1 + 65*2 + 9*3 = 443 jobs that we observe for individuals in this education category. Table 7 shows that most jobs are long-lasting. The 25th percentile value for job length for all three education sub-samples is either 11 or 12 years, and the median job length is between 24 and 27 years. One quarter of all jobs last at least 33 years. These data indicate that a substantial subgroup of workers had, during the decades ending in the 1990s, the long-term jobs that are consistent with substantial DB plan accumulation. A significant subgroup of workers, however, worked at several different jobs, and this group might experience limited DB accumulation at any particular job. The simulation results that we present below indicate how important the risk of short jobs is for the accumulation of DB plan resources.

4.2 Selecting a Sample of DB Plans

To select a set of DB plans for analysis, we begin with all plans in the 1998 HRS sample. The 1998 sample has better coverage than the comparable samples in earlier years. We tabulate the number of HRS respondents who are covered by each DB plan and select the 25 public DB pension plans and the 25 private DB pension plans with the largest number of HRS respondents. All of the plans are associated with large employers. In most cases the private sector employers are large national firms. The public sector pension plans are often connected with state-managed programs for public sector employees, so in some cases employees at many different localities may be covered by the same state-wide pension plan.

While confidentiality issues preclude reporting of individual DB plan attributes, the range of plans in our sample display wide diversity in plan provisions. This diversity suggests the limitation of any analysis of DB and DC plan risk that is based on only a stylized example of a DB plan. In the private sector, there are some similarities across plans, but important differences. Virtually all of the plans use five-year cliff vesting, which is consistent with our focus on five year jobs as the starting length for DB accruals. Most plans also use 65 as a normal retirement age. There is substantial divergence, however, in the early retirement provisions of different plans, and in the earnings measure that is used to determine benefits. Social Security integration provisions also vary, with eleven plans offering no integration and the remaining 14 choosing a variety of integration strategies.

Among public sector plans, there are also some margins of similarity, and others of divergence, but they are often different from what we observe in the private sector. There is more variation in both the vesting rules for the public sector plans and in the normal retirement ages embodied in these plans than in the comparable large private-sector plans. The public sector plans vary relatively little in their type of benefit: most provide a "highest average" benefit calculation, and they are also homogenous with respect to Social Security integration. Only two plans of the 25 in our sample are integrated with Social Security. There is substantial heterogeneity among public sector plans with regard to early retirement provisions, as there is with private sector plans. Our summary of the provisions of the DB plans focuses on the standard provisions of each DB plan, not to special "window" provisions that are sometimes used to encourage early retirement or retirement more generally. The periodic presence of such plans adds further variability to the DB sector.

4.3 Calculating the PDV of DB Wealth

In our simulations, we assign an individual with a given earnings and job history to a particular DB plan, and calculate the present discounted value of DB pension wealth. In this calculation, we use a five percent nominal discount rate, a two percent real discount rate, and a real wage growth rate of one percent per year. For plans that are integrated with Social Security, we assume the historical growth rate of Social Security benefits for past years and a zero real benefit growth rate prospectively. We specify the calculation of a 50 percent joint-and-survivor annuity, given that the sample comprises married men, and we use the PEP to estimate the presented discount value of benefits for retirement at age 63. We modify mortality rates before age 63 to assume that the individual lives at least until age 63. This means that we have suppressed the risk of DB plans that is associated with unexpectedly early death. While a DC plan participant can bequeath assets in this scenario, a DB plan participant loses the value of his accumulated retirement wealth.

To transform the distribution of accumulated DB wealth under different DB plans into an expected present discounted value of DB wealth, we construct the average wealth value over the various simulation outcomes. We construct separate averages for public sector and private sector plans, since the public sector plans tend to be more generous than their private sector counterparts. Our algorithm assumes that each time an individual takes a job at a firm with a DB plan, the plan is drawn randomly from the 25 public sector, or 25 private sector, plans in our sample. We repeat the randomization for each job in the individual's career, so for an individual with three jobs, there are 25^3 possible combinations of public sector DB plans and the same number of possible private sector DB plan combinations. Our algorithm does not allow for migration between the public and the private sector; an individual who works in one sector is restricted to remain in that sector throughout his working life.

The present discounted value of DB annuity payouts is a wealth aggregate comparable to the DC wealth values we computed above. Just as we did for the DC wealth outcomes, we can use the distribution of DB wealth values to compute certainty equivalent measures of DB wealth. The utility associated with a given DB plan outcome is

$$U(W_{DB}, W_{non-DB}) = \frac{\left(W_{DB} + W_{non-DB}\right)^{1-\alpha}}{1-\alpha}. \tag{6}$$

This expression can be solved for the certainty equivalent of a given distribution of DB wealth outcomes.

5. Comparison of DC and DB Wealth Distributions

In reporting our simulations of DC and DB wealth accumulation, we begin with information on DC balances at age 63, then present the analogous measure of DB wealth at the same age. We report both summary measures of the retirement wealth distributions, as well as certainty equivalents, in each case.

5.1 DC Plan Balances at Retirement

Table 8 shows the distribution of DC plan balances in thousands of year 2000 dollars averaged across the 1400 individuals in our sample. The simulations in the left panel use the historical distribution of returns, while those in the right panel use modified returns in which the average yield on equities is 300 basis points below its historical average. Individuals are stratified by education group within each panel. The table reports the mean wealth at retirement for each strategy, as well as four points in the distribution of returns. Since we are interested in the dispersion of DC wealth accumulation for individuals of different types, and in the effect of different asset allocation strategies on wealth accumulation, most of the discussion below focuses on a single education group, namely individuals with a high school degree but not a college degree. The relative ranking of different strategies is similar for other education groups.

The first rows in Table 8 show the wealth at retirement associated with holding only TIPS in the defined contribution account. The investment returns from this strategy are riskless, but the fact that the contribution rate is randomly drawn for each job generates a distribution of retirement wealth outcomes even under this strategy. The mean result of the TIPS simulation, \$228,200, provides a useful benchmark for the discussion that follows. The risk associated with DC plan contribution rates yields a 1st percentile outcome of \$30,100, a 10th percentile outcome of \$64,400 and a 90th percentile outcome of \$406,000 for this group.

The second panel shows that holding only government bonds leads to higher average retirement wealth, \$275,300, than we found in the case of TIPS. The average wealth at retirement is over twenty percent greater than the value with TIPS, but the median wealth of \$234,300 is less than ten percent above the TIPS outcome. This reflects a higher average real return on nominal government bonds than on TIPS in our simulations. Moreover, there is a greater spread of outcomes with nominal government bonds than with inflation indexed bonds. The tenth percentile outcome is \$59,400 with nominal bonds, compared with \$64,400 for TIPS, and the 90th percentile outcome is \$531,400, compared with \$406,600. The 1st percentile outcome is \$13,300 for this strategy, compared with \$30,100 under the TIPS strategy. The variation in outcomes from holding TIPS is due only to variation in contribution rates, while the variation for the nominal government bond strategy includes variation from real returns as well.

When the DC balance is invested in corporate stock, the average retirement balance is much higher than that with either TIPS or nominal government bonds: \$1,183,700. 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 exceeds the average outcome with a nominal government bond portfolio. At lower percentiles that are not reported in the table, however, the outcome with the all-stocks portfolio allocation falls below the correspondingly low outcomes for the TIPS and nominal bonds strategies.

The next two rows in each panel consider the two “50-50” portfolios constructed using either stocks and TIPS or stocks and nominal government bonds. At the mean and across most quantiles of the distribution, these investment strategies result in significantly lower levels of retirement wealth than stocks alone. The mean outcome of a 100 percent portfolio of stocks is 2.3 times as large as the mean outcome of a mix of 50 percent TIPS and 50 percent stocks, and 2.1 times as large as the mean outcome of a mix of 50 percent government bonds and 50 percent stocks. Even at the 10^{th} percentile, a portfolio of 100 percent stocks outperforms a portfolio of 50 percent stocks and 50 percent TIPS by 30 percent. The mixed portfolio yields a larger DC wealth accumulation than the all-stock portfolio only at the lowest percentiles of the distribution.

The last two horizontal subpanels of Table 8 consider portfolios that are allocated to lifecycle funds that are a mix of either stocks and TIPS or stocks and government bonds. Even though the expense ratios of these funds are higher than those of the “pure” stock and bond funds, the lifecycle funds yield slightly higher average values of DC wealth accumulation. However, due largely to their higher expenses, they do not protect investors particularly well against very low retirement wealth outcomes. The bottom percentile of the stocks-TIPS lifecycle fund is lower than the bottom percentile of the 50-50 stocks and TIPS strategy.

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 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 $1,183,700 to $583,000. The tenth percentile wealth value drops from $137,900 to $71,800 in this case. The first percentile wealth value drops from $13,300 to $7,400. With the all-stock portfolio, and to lesser degree with other portfolios that have some equity exposure, there is a small chance of a very poor outcome. The average retirement wealth values for the various heuristic and empirical lifecycle funds decline when we reduce the value of the mean equity return. Furthermore, the stocks-TIPS (stocks-bonds) lifecycle fund outperforms the 50-50 stocks-TIPS (stocks-bonds) portfolio at the mean.

Table 9 repeats the exercise in Table 8 but assumes that all individuals participate in a DC plan for which the annual contribution percentage is the mean of the combined employer plus employee contribution for the DC plans in our sample. This provides a way of understanding how much of the dispersion in DC plan outcomes is due to "plan risk" and how much is due to asset market risk. The mean of any given investment strategy in Table 9 is therefore the same as in Table 8, except for small differences that are below the numerical precision of our simulation algorithm. These differences are generally smaller than \$100, while retirement wealth in our analysis is several hundred thousand dollars. The 100 percent TIPS strategy in Table 9 is riskless, however, while that in Table 8 is risky because of uncertainty about DC plan parameters. When we compare outcomes within education-asset allocation strategy cells in Tables 8 and 9, the lower percentile outcomes are worse in Table 8 than in Table 9 due to the contribution risk. However, a comparison of the results at the 90th percentile shows that the outcomes at the top of the distribution are better with the randomized contribution rates in Table 8 than they are in Table 9. These outcomes are not surprising: the randomness in contribution patterns in the simulations described in Table 8 provide DC plan participants with a chance of a very high contribution rate plan, but also expose them to the risk of working at an employer with a low contribution rate. These risks are not present in the simulations reported in Table 9.

To summarize the value of different wealth distributions for individuals who are risk averse, we compute the expected utility associated with DC wealth distributions that we described in Table 8, and then find the certainty equivalent that generates the same expected utility value. Table 10 shows the certainty equivalent associated with the distribution of retirement resources for each portfolio strategy. The calculations in this table assume that in addition to DC plan wealth, each individual also has whatever household financial wealth the HRS reports outside retirement accounts, and that the individual has Social Security wealth and any other annuity wealth shown on the survey. We constrain this other wealth to be non-negative for the purposes of the calculations; this entails adjustment to relatively few households. The entries reported in Table 10 are based on a smaller number of simulation runs than the corresponding entries in Tables 8 and 9, so they are likely to be less precise than the results in those tables. Results based on a more extensive set of simulations will be available shortly in an updated version of this paper.

The values in the first horizontal panel in Table 10 are based on linear utility (α=0) and thus are the expected values of each investment choice. These results are identical to the average individual retirement wealth calculations in Table 8, since a risk-neutral individual cares only about the expected value of retirement wealth. A risk neutral individual would find the all-stock strategy the most attractive investment rule, since it offers the highest mean value of DC wealth. This is true both with the actual historical distribution of stock returns and with the distribution that reduces the mean return by 300 basis points. It is also true for all education groups.

The next horizontal panel in Table 10 presents results for individuals whose utility of retirement wealth is logarithmic. This 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. Of the various mixed strategies and lifecycle approaches, the empirical lifecycle strategy with stocks and bonds generates the best outcomes under the stock return draws from the unadjusted empirical distribution, and the 50-50 stocks-bonds strategy generates the highest certainty equivalent value under the reduced stock returns scenario.

The third and fourth horizontal panels in Table 10 consider individuals whose relative risk aversion coefficients are two and four, respectively. Even at these higher levels of risk aversion, the all-stock portfolio strategy dominates the other strategies in certainty equivalent terms, and this continues to be the case even when stock returns are reduced by 300 basis points. The table shows that among the mixed strategies, the 50-50 stocks-bonds strategy is generally the best for individuals with constant relative risk aversion of two and consistently the best for individuals with constant relative risk aversion of four, regardless of the returns distribution assumption.

We have computed, but do not present, certainty equivalent calculations that correspond to the sample average DC plan parameter scenarios considered in Table 9. The certainty equivalent values in these cases display the same patterns as in the cases with uncertainty about DC plan attributes, but they are generally higher than the values reported in Table 10. This is because the lower tail of the distribution, corresponding to adverse outcomes with a low DC contribution rate and a poor set of asset returns, is eliminated in this case. The risk of poor asset returns remains, but it is not compounded by the risk of being allocated to a DC plan with a low contribution rate.

All of the certainty equivalent calculations assume that the individual contemplating the value of a distribution of DC plan wealth has other wealth consisting of Social Security benefits, which are nearly universal, any other annuity income, which is rare, and other non-retirement financial assets. These are modest except at the highest levels of the wealth distribution. The presence of these other assets, however, and in particular the recognition of Social Security wealth, raises the certainty equivalent of equity-based allocation rules relative to other investment strategies. The cost of holding equities from the standpoint of a risk-averse individual is the risk of a very low payout associated with very poor returns over many periods. When individuals have a fallback level of consumption assured by their Social Security benefits, they are effectively more willing to bear risk. PRVW (2005a) compare the certainty equivalents of different asset allocation strategies under the assumption that individuals have no outside wealth, and under the assumption that they have the some other wealth to support their retirement consumption. In some cases the relative ranking of equity-based strategies and other strategies changes, depending on the assumption we make about other wealth holdings.

5.2 DB Balances at Retirement and Certainty Equivalent Measures

We now present DB plan results paralleling those for DC plans in Tables 8 and 10. In this case there are fewer results to present, because we do not need to consider the range of asset allocation strategies that we examined in the DC environment. We do consider two cases, corresponding to drawing the DB plan from the private and the public sector plan distributions. Table 11 shows the distribution of DB plan balances in thousands of year 2000 dollars averaged across the 1400 individuals in our sample.

The entries indicate the present discounted value of DB plan benefits from the perspective of an individual at age 63. Once again, individuals are stratified by education group within each panel. The table reports the mean wealth at retirement as well as four points in the distribution of returns. To make our discussion consistent with that for DC plans, we again focus primarily on the intermediate education group, the group with a high school degree but not a college degree, in our analysis.

The results in Table 11 suggest several conclusions about retirement wealth accumulation through DB plans. First, they highlight the substantial differences between the benefit accruals for private-sector and public-sector plans. For the high school educated group, the mean value of DB plan accumulations at age 63 is $156,000 for the sample of private sector plans, compared with $316,800 for public sector plans. The proportional differences are larger for those in other education categories. Note that these results represent averages across individuals with various earnings histories, and that they average across various DB plans in each sector. One strength of the HRS data is its capacity to address the relative payouts of different types of pension plans, and to do so with much more information on individual plans than in other datasets.

Second, the mean level of DB wealth accumulation in private sector plans is substantially lower than the mean level corresponding to a DC plan, even under the conservative investment assumption of a portfolio invested only in riskless government inflation-indexed bonds. For a high-school educated worker, the mean (median) value of the DB pension accrual at retirement is $156,000 ($150,600), compared with $228,200 ($229,700) for a TIPS-invested DC plan. If the DC plan is invested partly in corporate equities, so that the expected return is higher, then the disparity between the means in the DB and the DC plans is even greater. The comparison between private sector DC plans and public sector DB plans is more subtle. Public sector DB plans are more generous than private sector plans by enough for the mean and median level of benefits accrued in these plans to exceed the mean and median for conservatively-invested DC plans. The median public sector DB plan accumulation, $326,800 for an individual with a high school education, is nearly fifty percent greater than the median DC plan accrual for a comparable individual who invests only in taxable government bonds ($234,300). The DB plan accruals are not as large as those from working under a DC plan and pursuing an investment strategy of 50-50 stocks and TIPS, or 50-50 stocks and bonds. These strategies yield medians of $425,100 and $443,200 respectively.

The comparison between public sector DB plans and private sector DC plans becomes more favorable for the former when we consider the scenario in which equity returns are reduced by 300 basis points relative to their historical average. Recall from Table 8 that the mean value of DC wealth accumulation for a high school-educated individual is between $360,000 and $400,000 for all of the lifecycle and 50-50 strategies that we consider, while the DB accumulation averages $316,800. The DB and DC values are much closer in this case then when the equity returns are drawn from the actual historical distribution. The DB accumulation is also substantially greater than the DC accumulation when the asset allocation strategy involves holding either TIPS or nominal long-term government bonds.

Table 12 reports the certainty equivalents corresponding to the distribution of DB wealth values in Table 11. Once again we consider individuals in four different risk aversion categories. The reduction in the certainty equivalent of the DB plan distributions is modest as we increase the relative risk aversion coefficient for the individual pensioner. For private sector DB plans, raising this parameter from zero, which denotes risk neutrality, to four, which implies substantial risk aversion, translates into a ten percent decline in the certainty equivalent value of the DB plan accrual in the private sector for a high-school educated worker. The effects are more pronounced for college-educated workers, because while the mean accrual is significantly higher, there remains significant probability of an interrupted work career that results in only modest benefit accruals. In the public sector, the decline in the certainty equivalent is even more pronounced. This also probably reflects a higher level of benefits in most cases, but a residual risk of some low-benefit outcomes.

5.3 Comparing Certainty Equivalent Outcomes

The question that motivates this paper is the relative riskiness of DB and DC plans. The results in Tables 10 and 12 provide an answer to this question, subject to the various assumptions that we have made in calculating certainty equivalence, and our assumption on the level of non-pension wealth available to the individuals in our sample. For a risk neutral individual, there are no scenarios under which drawing a DB plan randomly from the distribution of private sector plans leads to a certainty equivalent that is higher than that associated with drawing a DC plan from the plan population and computing retirement wealth through it. In other words, a risk neutral individual, given the choice of selecting either a random private sector DB plan or a random DC plan, would choose the DC plan risk. For example, if the individual had high school and/or some college education, his certainty equivalent in a randomly-chosen private sector DB plan would be $156,000. This is below the range of certainty equivalents of DC plans for this risk aversion and education category, which is from $228,200 to $1,183,700. A similar result holds for individuals with risk aversion of 1, 2, or 4. In all of these cases, the certainty equivalent of the private sector DB plan is worse than all of the certainty equivalents of the DC plan investment strategies we consider.

For a risk neutral individual, there some scenarios under which a public sector DB plan generates a higher certainty equivalent than a DC simulation, but there is always at least one DC investment strategy that dominates even the public sector DB option. This is true regardless of our assumption about equity returns. For example, the highest certainty-equivalent DB simulation for the risk neutral individual is $544,700 for an individual with a college or post-graduate degree in a public sector pension plan. This is greater than the $323,000 that the individual would have gotten in a DC plan invested entirely in TIPS, or the $384,400 that the individual would have gotten in a DC plan invested entirely in bonds. It is also greater than the $494,500 that the individual would have gotten in a DC plan invested 50 percent in reduced-return stocks and 50 percent in TIPS, as well as the $487,100 that he would have gotten in a DC plan invested in a stocks-TIPS lifecycle fund under the reduced return scenario. However, a DC plan with an all-stock strategy dominates this DB plan, regardless of whether we assume equity returns are 300 basis points lower than their historical values. Similarly, a risk averse individual with a high school degree and/or some college in a public sector DB plan would have a certainty equivalent of $316,800. He would do better than if he had a DC plan invested entirely in TIPS ($228,200) or government bonds ($275,300), but he would do worse than if he had invested in any of the other strategies we examine.

For a risk averse individual, the relative performance of DC versus public DB plans is highly dependent on the equity return assumptions for the DC plan. In general, if equity returns follow their historical empirical distribution, an individual can achieve higher certainty equivalent outcomes in a DC plan, in most cases, using any of the investment strategies that we consider and that involve some equity investment. However, if equity returns are 300 basis points lower than their historical empirical distribution, sufficiently risk averse individuals achieve higher certainty equivalents in public sector DB plans. This turns out to be especially the case for higher education individuals, who may have more stable earnings histories that generate less DB plan risk.

To see the out-performance of DC plans when stock returns follow their historical empirical distribution, consider an individual with a high school and/or some college education. A public sector DB plan generates certainty equivalents that are higher than the certainty equivalents of DC plans invested 100% in TIPS or government bonds, but lower than the certainty equivalents of DC plans that contain any stocks as part of their investment strategies. For example, when the coefficient of relative risk aversion is unity, an individual with this level of education has a public sector DB certainty equivalent of $307,400, a DC certainty equivalent of at most $244,600 for 100 percent fixed income investment strategies, and a DC certainty equivalent of at least $431,300 for investment strategies that include some equities. A similar pattern holds for risk aversion levels of 2 and 4, and for lower levels of education with risk aversion levels of 1,2, or 4. One exception to this pattern is that for an individual with a college or post-graduate degree and risk aversion of 4, the public sector DB certainty equivalent of $417,000 is actually better than the certainty equivalents of most DC investment strategies. Yet still an all-stocks investment strategy generates a $506,000 certainty equivalent, which dominates the public sector DB certainty equivalent.

If equity returns are reduced by 300 basis points, it is still the case for most levels of risk aversion and education categories, a properly chosen investment strategy can lead to a certainty equivalent that surpasses that of the DB case. For example, for an individual with high school and/or some college and an alpha of 2, the public sector DB certainty equivalent of $264,700 is greater than that of a number of the

DC investment strategies, but is smaller than the 100% stocks DC certainty equivalent of $327,300. A similar pattern holds for an individual with less than a high school degree.

However, if risk aversion is high enough under the reduced equity return scenario, the public sector DB certainty equivalent will dominate. For the high school and/or some college education category, this happens at a coefficient of relative risk aversion of four, where the public sector DB generates a certainty equivalent of $264,700 and the best DC plan generates a certainty equivalent of $229,300. For the college or post-graduate group, the dominance of the public sector DB plans actually happens when the coefficient of relative risk aversion is as low as two, where the public sector DB generates a certainty equivalent of $524,100 compared to the best DC certainty equivalent of $461,300.

6. Conclusions

This paper presents new evidence on the expected value of retirement wealth accruals under defined benefit (DB) and defined contribution (DC) retirement plans. These plans are drawn from the actual retirement plans covering participants in the Health and Retirement Study. The value of retirement benefits in each type of plan is computed using the actual earnings and employment history of HRS participants. This enables us to compare not only the average value of retirement wealth, but also its dispersion, recognizing three types of uncertainty: (i) uncertainty about which plan the individual's employer will offer; (ii) uncertainty about the individual's employment history and earnings trajectory; and (iii) uncertainty of both the plan that an individual has access to and the individual's employment history. We are able to compare, in a similar framework, the asset market risk facing participants in DC plans and the employment history risk facing DB plan participants. The asset market risk for DC plan participants is sensitive to the asset allocation choices they make. Our results build on the findings of Samwick and Skinner (2004) and Schrager (2005), bringing more recent data on pension arrangements and particularly rich information on the structure of lifetime earnings histories to bear on these issues.

Our findings on retirement wealth accumulations highlight the important heterogeneity across different plans. We distinguish, for example, DB plans in the public sector from those in the private sector. Because the former are substantially more generous, on average, than the latter, workers covered by public sector DB plans accumulate substantially greater retirement resources than workers in the private sector DB system. Similarly, there is substantial heterogeneity across defined contribution plans within the private sector, measured by the share compensation that employers and employees together contribute to the plan.

When we compare the average level of wealth accumulation in DB and DC plans, the results depend on assumptions that we make about how the DC plan participant allocates assets across different investment options and on whether the DB plan participant is in the public or the private sector. Private sector DB plans are almost always dominated by DC plans, at least under the parameterizations we study. The comparison of public sector DB plans to DC plan outcomes is particularly sensitive to assumptions. In general, if equity returns follow their historical empirical distribution, an individual can achieve higher certainty equivalent outcomes in a DC plan, and can in most cases do so under any investment strategy that includes some equities. If equity returns are 300 basis points lower than their historical empirical distribution, individuals with relatively low levels of risk aversion and/or high risk of job fragmentation will still achieve higher certainty equivalents with a carefully chosen DC plan. However, sufficiently risk averse individuals achieve higher certainty equivalents in public sector DB plans. This turns out to be especially the case for higher education individuals, who may have more stable earnings histories that generate less DB plan risk.

We present expected utility calculations to measure the impact of risk aversion on consumer valuation of DB and DC plan outcomes. These results are sensitive, as we show, to assumptions about the coefficient of relative risk aversion. Previous work suggests that they are also sensitive to assumptions about the non-retirement wealth available to individuals. There are unresolved conceptual issues associated with the measurement of such wealth. Consider the case of housing net worth. If one views housing wealth as a source of retirement income support and includes this wealth component in the “other wealth” that we consider, then the certainty equivalents we report above are too low value of the retirement wealth that we consider will be greater than the values we report. Alternatively, if we replaced our assumption of non-stochastic non-retirement wealth and instead allowed for covariance between stock market and bond returns that affect DC plan accumulations, and the wealth that individuals accumulate outside their retirement accounts, then the certainty equivalence of these retirement plan accumulations would decline.

Our findings represent a first step toward comparing the relative risks of DB and DC plans using actual earnings histories rather than parametric forms for the earnings and job change process. We have not yet studied the distribution of actual DB and DC wealth in the HRS with the distributions that emerge from our simulations. Since we are using the actual earnings histories of HRS respondents, if respondents are matched randomly to pension plans, as we assume, then the observed distribution should be similar to the one generated by our simulations. Comparing these distributions, which we plan to do, can offer some insight on the validity of our matching assumption and it may suggest further directions for improving our analysis.

Even without the input from such a distributional comparison, we are aware that there are many ways in which our algorithm for computing retirement wealth could be extended and improved. For example, we do not allow for lump sum distributions from DC plans, even though Engelhardt (2002) and Poterba, Venti, and Wise (1998) suggest that these distributions exert a potentially important drag on retirement wealth accumulation. We have not allowed for differences in asset allocation patterns as a function of individual characteristics, such as education, even though past research such as Ameriks and Zeldes (2004) suggests that there are such differences. We have not considered the role of uncertain inflation, and the impact that may have on the retirement wealth of DB and DC plan participants. We do not allow earnings trajectories or the length of the work life to respond to the structure of pension arrangements, even though Friedberg and Webb (2005a) suggest that DC plan participants work longer than their DB counterparts, at least potentially because of the retirement incentives that are incorporated in many DB plans. We also treat the non-retirement financial resources of the household as given, and we do not allow for changes in asset allocation in non-retirement portfolios as a result of differential exposure to retirement risk. Friedberg and Webb (2005b) suggest that DC participants are more likely to hold corporate equities outside their pension account than are comparable households without DC coverage. This may be consistent with a "learning about equities" model, rather than a model of risk substitution which might be a more standard approach to this question. Issues of behavioral response may be easier to address in a parametric model of lifecycle utility maximization, such as that developed by Schrager (2005), than in our less structured framework, but our approach can be used to explore the sensitivity of the findings to alternative assumptions about retirement ages.

Finally, our analysis has treated the individual's wage profile as unaffected by the presence or absence of various pension arrangements. Standard models of wage determination in the presence of employer-provided benefits, however, suggest that all else equal, workers with more generous pension benefits should receive lower wages. Thus in our simulations, when we draw a DC plan with substantial employer contributions or a DB plan with generous provisions, the argument would suggest modifying the time path of earnings to reflect the generous retirement benefits provided on this job. Allowing for potential earnings responses would raise a complex set of issues about household wealth accumulation outside the pension account, and how it is affected by the lifetime pattern of wage income. It also links to recent discussions of the extent to which individuals make forward-looking decisions, and the value they place on generous but future DB benefits. This is an important topic for future analysis.

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Table 1: Number of Workers in Private Sector DB and DC Plans (thousands, 1990–2003)

	DB Only	DC Only	Both
1990	9,611	11,541	13,659
1991	9,326	12,124	14,571
1992	8,456	13,154	14,865
1993	7,895	14,199	15,220
1994	8,189	15,064	14,464
1995	7,555	17,542	14,445
1996	7,436	18,897	14,533
1997	7,266	22,776	14,559
1998	7,783	24,091	14,448
1999	7,123	24,902	14,282
2000	6,259	27,792	13,944
2001	6,200	29,112	13,649
2002	6,696	29,338	14,276
2003	6,579	30,061	14,943

Source: Buessing and Soto (2006) based on IRS 5500 data with corrections for non-vesting and non-participating employees, and elimination of double counting.

Table 2: Sample Composition, HRS Households

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

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

Table 3: Number of Households with Top-Coded Earnings, HRS 1951-1979

Year	Total	Less than HS Education	HS or Some College	College and Beyond
1951	7.5%	7.7%	7.8%	6.6%
1952	10.1	11.3	10.6	7.4
1953	14.5	17.7	14.4	10.6
1954	17.3	18.9	18.4	12.8
1955	14.5	14.9	15.3	12.2
1956	18.3	16.8	20.4	15.6
1957	21.5	19.1	24.4	17.9
1958	24.0	20.7	25.8	23.7
1959	22.6	18.1	24.7	23.2
1960	27.6	20.2	30.3	30.1
1961	31.9	23.9	33.3	37.9
1962	39.3	28.6	41.8	45.9
1963	46.2	32.8	48.9	56.0
1964	52.4	36.7	56.0	63.0
1965	60.0	42.3	63.8	71.5
1966	46.9	29.7	48.7	63.5
1967	53.0	32.0	56.5	70.4
1968	46.7	26.7	48.0	67.6
1969	54.4	33.7	56.4	75.2
1970	57.8	37.2	60.4	77.3
1971	61.9	41.0	65.3	79.8
1972	59.6	40.3	62.2	77.1
1973	52.7	32.6	54.3	73.4
1974	42.5	22.4	42.6	66.5
1975	41.4	21.2	40.8	66.5
1976	42.8	21.6	43.3	66.3
1977	43.4	23.2	44.1	65.6
1978	45.5	25.3	47.7	65.0
1979	31.1	13.7	30.8	52.4

Source: Authors Tabulations using data from SSA Earnings Histories for HRS Respondents.

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

Wealth Component	Full Sample	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate
		20th percentile		
SSW + Annuity	177.3	163.4	188.9	165.7
DB Accumulation	0	0	0	0
DC Accumulation	0	0	0	4.2
Other Financial Assets	0.9	0	1.6	29.6
Net Housing Equity	34.6	6.0	40.4	61.3
Other Wealth	6.0	2.5	7.4	9.6
Net Worth	302.0	220.9	315.1	448.1
		40th percentile		
SSW + Annuity	245.8	228.0	246.8	270.1
DB Accumulation	0	0	0	0
DC Accumulation	8	0	8	45.0
Other Financial Assets	28.0	2.0	28.8	110.0
Net Housing Equity	76.5	45.3	78.8	106.1
Other Wealth	14.0	7.2	15.9	17.5
Net Worth	450.1	323.2	450.4	707.9
		50th percentile - Median		
SSW + Annuity	264.1	247.9	264.1	286.9
DB Accumulation	0	0	0	0
DC Accumulation	22.7	0	20.4	81.7
Other Financial Assets	58.0	6.4	55.7	170.5
Net Housing Equity	92.6	60.2	90.9	125.0
Other Wealth	18.1	11.0	20.0	21.9
Net Worth	536.8	370.1	531.1	856.3
		60th percentile		
SSW + Annuity	264.1	261.4	282.0	309.6
DB Accumulation	0	0	0	0
DC Accumulation	46.5	6.9	40.3	124.6
Other Financial Assets	105.3	18.2	98.0	264.3
Net Housing Equity	109.4	79.6	104.1	153.4
Other Wealth	23.0	15.9	24.1	30.0
Net Worth	637.4	441.3	622.1	1051.3
		80th percentile		
SSW + Annuity	329.5	294.3	321.0	368.0
DB Accumulation	0	0	12.0	65.1
DC Accumulation	148.0	58.2	118.9	349.7
Other Financial Assets	215.2	120.0	223.3	600.0
Net Housing Equity	167.3	113.6	153.1	230.8
Other Wealth	40.0	26.5	39.4	59.3
Net Worth	994.5	644.1	866.4	1598.6
		Sample Mean		
SSW + Annuity	251.5	229.9	250.9	272.7
DB Accumulation	47.7	33.9	44.4	66.6
DC Accumulation	136.4	36.7	83.1	330.9
Other Financial Assets	199.7	69.6	138.7	437.3
Net Housing Equity	115.3	78.7	106.6	165.7
Other Wealth	33.0	19.2	30.1	51.3
Net Worth	783.4	468.1	653.7	1324.5

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

Table 5: Distribution of Combined Employer and Employee Contribution Percentages as a Percentage of Pay

Decile	Within-Decile Mean	Upper Bound
1	1.41	3.00
2	4.42	5.00
3	5.99	6.00
4	7.65	8.40
5	9.70	10.00
6	11.74	12.00
7	12.88	13.00
8	14.75	15.00
9	16.79	18.00
10	21.06	24.50

Source: 1991 wave of the HRS, when this information was collected for all respondents with defined contribution plans. Values over 25 percent, representing 7% of the sample, were discarded as implausible answers.

Table 6: Imputed Number of Jobs by Education Level of Individual

Number of Jobs	All Education Levels	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate
0	31	14	12	5
1	1081	286	533	262
2	257	65	127	65
3	31	9	17	5

Source: Authors' imputations for husbands in HRS couples, using algorithm describe in the text.

Table 7: Distribution of Job Lengths, by Education Level of Individual

	Less Than High School Degree	High School and/or Some College	College and/or Postgraduate
10%	6	6	6
25%	11	12	12
50%	25	27	24
75%	33	34	34
90%	35	35	35
Mean	22.3	22.8	22.4

Source: Authors' imputations using algorithm described in the text.

Table 8: Simulated Distribution of DC Plan Balances at Retirement ($2000) Using Random Matching of Individuals to DC Plan Contribution Rates

	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						
1	21.0	30.1	42.8	21.0	30.1	42.8
10	46.5	64.4	85.2	46.5	64.4	85.2
50	162.8	229.7	325.0	162.8	229.7	325.0
90	285.2	406.6	575.2	285.2	406.6	575.2
Mean	160.2	228.2	323.0	160.2	228.2	323.0
100% Nominal Government Bonds						
1	9.4	13.3	19.7	9.4	13.3	19.7
10	41.7	59.4	83.9	41.7	59.4	83.9
50	164.3	234.3	331.1	164.3	234.3	331.1
90	371.5	531.4	736.1	371.5	531.4	736.1
Mean	192.7	275.3	384.4	192.7	275.3	384.4
100% Stocks						
1	8.9	13.3	18.7	5.1	7.4	11.0
10	96.2	137.9	187.4	50.4	71.8	101.1
50	476.0	686.8	910.3	242.3	346.6	477.8
90	1845.7	2693.2	3442.2	910.0	1314.8	1737.7
Mean	812.7	1183.7	1524.5	404.1	583.0	777.6
50% Stocks, 50% TIPS						
1	14.9	21.8	30.6	11.0	16.1	23.1
10	73.4	105.2	143.0	53.1	75.8	105.1
50	296.2	425.1	577.9	213.8	305.6	424.0
90	683.0	985.1	1315.1	488.5	701.4	954.9
Mean	350.2	504.0	677.9	251.4	360.3	494.5
50% Stocks, 50% Nominal Bonds						
1	13.1	18.8	26.7	9.7	13.9	20.3
10	75.5	108.2	147.3	54.6	77.9	108.3
50	30.8	443.2	600.9	222.3	318.0	440.1
90	783.6	1131.9	1500.5	558.3	802.8	1084.9
Mean	387.1	558.1	746.2	277.1	397.6	542.3
Empirical Lifecycle, Stocks and TIPS						
1	13.7	20.0	28.5	9.9	14.4	21.3
10	74.0	106.1	144.0	51.0	72.7	101.3
50	298.5	429.3	580.3	204.4	292.2	406.2
90	734.8	1065.6	1400.3	491.6	707.8	955.6
Mean	367.9	531.7	706.5	248.4	356.7	487.1
Empirical Lifecycle, Stocks and Nominal Bonds						
1	12.2	17.5	25.1	8.8	12.6	18.7
10	74.4	106.7	145.1	51.3	73.2	102.3
50	306.3	440.7	594.8	209.5	299.5	415.7
90	817.8	1186.5	1554.7	546.1	786.6	1058.2
Mean	397.5	575.1	761.5	267.8	384.9	523.6

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

Table 9: Simulated Distribution of DC Plan Balances at Retirement Using Sample Average Contribution Rate for All Individuals in All Years ($2000)

	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	160.2	228.3	323.1	160.2	228.3	323.1
100% Nominal Government Bonds						
1	42.5	59.9	91.9	42.5	59.9	91.9
10	107.3	152.7	220.4	107.3	152.7	220.4
50	174.9	249.5	351.1	174.9	249.5	351.1
90	298.9	428.1	588.0	298.9	428.1	588.0
Mean	192.7	275.3	384.5	192.7	275.3	384.5
100% Stocks						
1	19.0	26.9	42.5	11.7	16.6	27.5
10	179.7	257.2	355.3	95.6	136.0	196.3
50	546.8	790.2	1042.9	277.0	396.6	544.1
90	1709.2	2497.3	3175.7	838.5	1213.4	1593.3
Mean	812.8	1183.6	1525.1	404.1	583.0	777.9
50% Stocks, 50% TIPS						
1	59.0	83.0	122.6	44.5	62.7	94.9
10	186.5	266.8	370.1	136.1	194.0	274.9
50	319.6	459.2	622.0	230.2	329.3	455.3
90	551.1	795.9	1055.1	392.7	564.5	762.6
Mean	350.2	504.0	678.2	251.4	360.3	494.7
50% Stocks, 50% Nominal Bonds						
1	45.9	64.7	97.0	35.0	49.4	75.8
10	176.5	252.4	350.8	128.9	183.6	260.8
50	337.6	485.3	655.6	242.6	347.3	478.8
90	656.5	949.6	1250.1	466.1	671.0	899.7
Mean	387.1	558.0	746.5	277.1	397.6	542.5
Empirical Lifecycle, Stocks and TIPS						
1	53.7	75.4	114.1	40.6	57.0	88.6
10	177.6	253.7	353.5	124.8	177.5	254.6
50	323.9	466.5	627.3	220.7	315.9	436.8
90	610.0	886.6	1153.6	404.7	584.1	779.7
Mean	367.9	531.7	706.7	248.4	356.7	487.3
Empirical Lifecycle, Stocks and Nominal Bonds						
1	42.5	59.8	91.1	32.2	45.4	71.1
10	168.1	240.3	334.8	118.1	167.9	240.9
50	336.5	484.6	650.9	229.0	327.8	452.6
90	697.2	1013.6	1316.5	462.3	667.4	889.0
Mean	397.5	575.1	761.8	267.8	384.9	523.8

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

Table 10: Certainty Equivalent Wealth ($2000) of DC Plan Accumulation Allowing for Heterogeneity in DC Plan Contribution Rates and Using Non-Retirement Financial Assets, Social Security Wealth and Annuity Income as "Non-DC Wealth"

	Empirical Stock Returns			Empirical Stock Returns, Reduced 300 Basis Points		
Risk Aversion/Investment Strategy	Less Than HS Degree	HS and/or Some College	College or Post-graduate	Less Than HS Degree	HS and/or Some College	College or Post-graduate
α = 0						
100% TIPS	160.2	228.2	323.0			
100% Government Bonds	192.7	275.3	384.4			
100% Stocks	812.7	1183.7	1524.5	404.1	583.0	777.6
50% Stocks, 50% TIPS	350.2	504.0	677.9	251.4	360.3	494.5
50% Stocks, 50% Bonds	387.1	558.1	746.2	277.1	397.6	542.3
Empirical Lifecycle, Stocks and TIPS	367.9	531.7	706.5	248.4	356.7	487.1
Empirical Lifecycle, Stocks and Bonds	397.5	575.1	761.5	267.8	384.9	523.6
α = 1						
100% TIPS	148.9	212.5	302.6			
100% Government Bonds	171.4	244.6	345.4			
100% Stocks	544.3	784.1	1047.0	294.6	421.0	584.0
50% Stocks, 50% TIPS	303.0	431.3	588.0	222.0	315.1	438.0
50% Stocks, 50% Bonds	322.1	462.6	629.1	236.4	338.2	468.5
Empirical Lifecycle, Stocks and TIPS	309.4	445.3	602.1	215.3	308.2	427.6
Empirical Lifecycle, Stocks and Bonds	325.5	468.2	632.7	226.8	324.5	449.6
α = 2						
100% TIPS	138.7	197.6	281.8			
100% Government Bonds	154.1	219.2	311.5			
100% Stocks	394.3	562.9	773.9	235.0	327.3	461.3
50% Stocks, 50% TIPS	259.1	375.0	510.6	194.6	277.4	388.7
50% Stocks, 50% Bonds	271.8	388.2	535.1	204.7	291.6	408.2
Empirical Lifecycle, Stocks and TIPS	263.3	376.9	517.0	189.0	269.4	377.6
Empirical Lifecycle, Stocks and Bonds	271.7	388.5	533.5	195.8	278.7	399.0
α = 4						
100% TIPS	120.3	170.2	243.6			
100% Government Bonds	127.3	179.9	258.3			
100% Stocks	251.4	354.6	506.0	163.0	229.3	332.0
50% Stocks, 50% TIPS	198.2	280.6	394.6	155.6	219.9	312.7
50% Stocks, 50% Bonds	202.7	286.6	404.1	159.8	225.6	321.5
Empirical Lifecycle, Stocks and TIPS	198.6	281.3	395.1	150.4	212.6	303.0
Empirical Lifecycle, Stocks and Bonds	200.8	284.1	400.1	152.8	215.7	308.1

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

Table 11: Distribution of Defined Benefit Pension Values at Retirement ($2000)

	Private Sector Plans			Public Sector Plans		
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
1	51.6	60.4	67.1	35.8	40.1	40.4
10	67.3	86.6	108.3	134.6	186.7	322.5
50	110.1	150.6	260.1	232.0	326.8	563.4
90	185.1	237.4	406.5	303.3	424.8	734.7
Mean	118.0	156.0	255.5	226.7	316.8	544.7

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

Table 12: Certainty Equivalent Wealth ($2000) of DB Plan Accumulation Using Non-Retirement Financial Assets, Social Security Wealth and Annuity Income as "Non-DB Wealth"

	Private Sector Plans			Public Sector Plans		
Risk Aversion	Less Than HS Degree	HS and/or Some College	College or Post-graduate	Less Than HS Degree	HS and/or Some College	College or Post-graduate
α = 0	118.0	156.0	255.5	226.7	316.8	544.7
α = 1	114.8	151.6	242.5	220.5	307.4	524.1
α = 2	111.9	147.6	229.9	212.7	294.7	491.5
α = 4	106.6	140.3	208.6	193.6	264.7	417.0

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

Figure 1: DB Participation Rate in the SIPP, Every Other Cohort

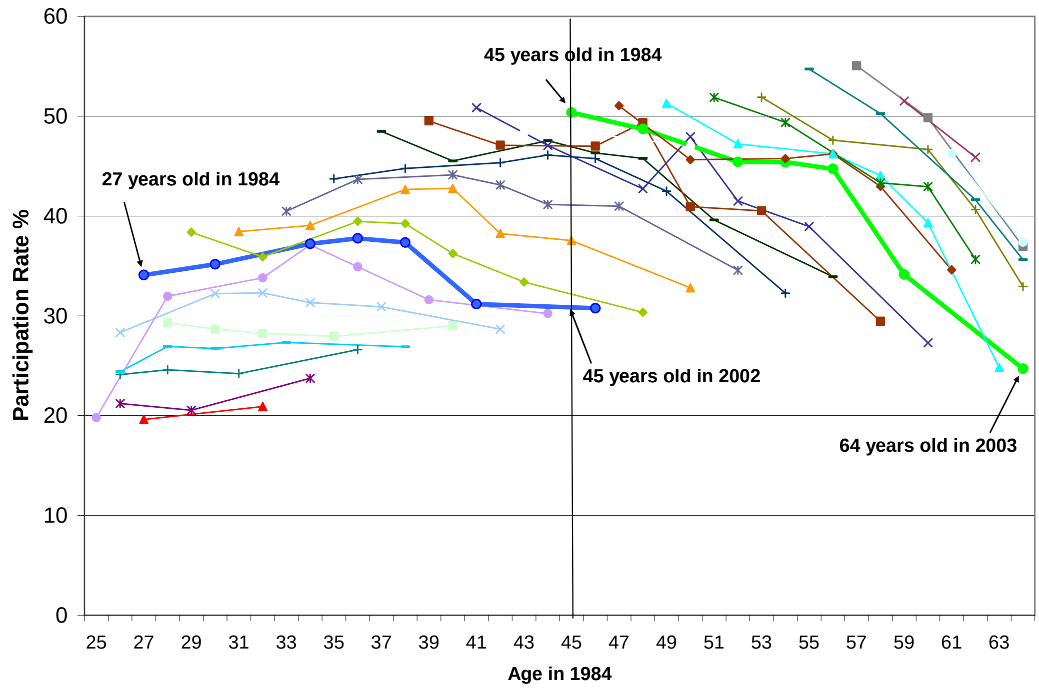

Figure 2: DC Participation Rate in the SIPP, Every Other Cohort

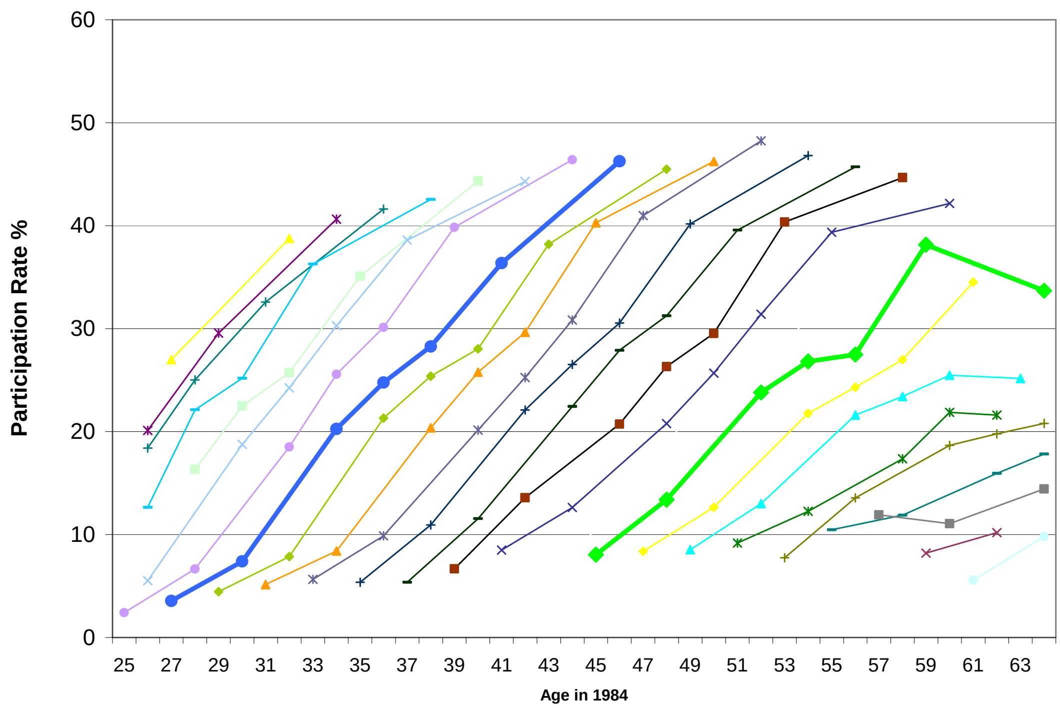

Figure 2a: 25th Percentile Earnings, After Top-Coding Correction, HRS Husbands

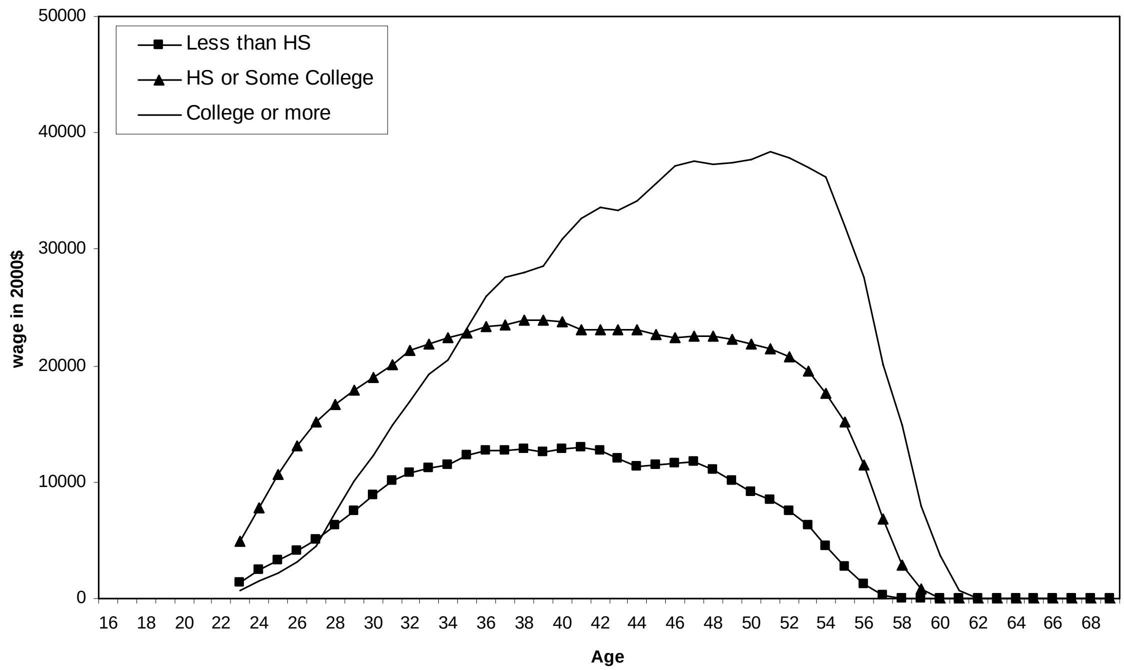

Figure 2b: 50th Percentile Earnings, After Top-Coding Correction, HRS Husbands

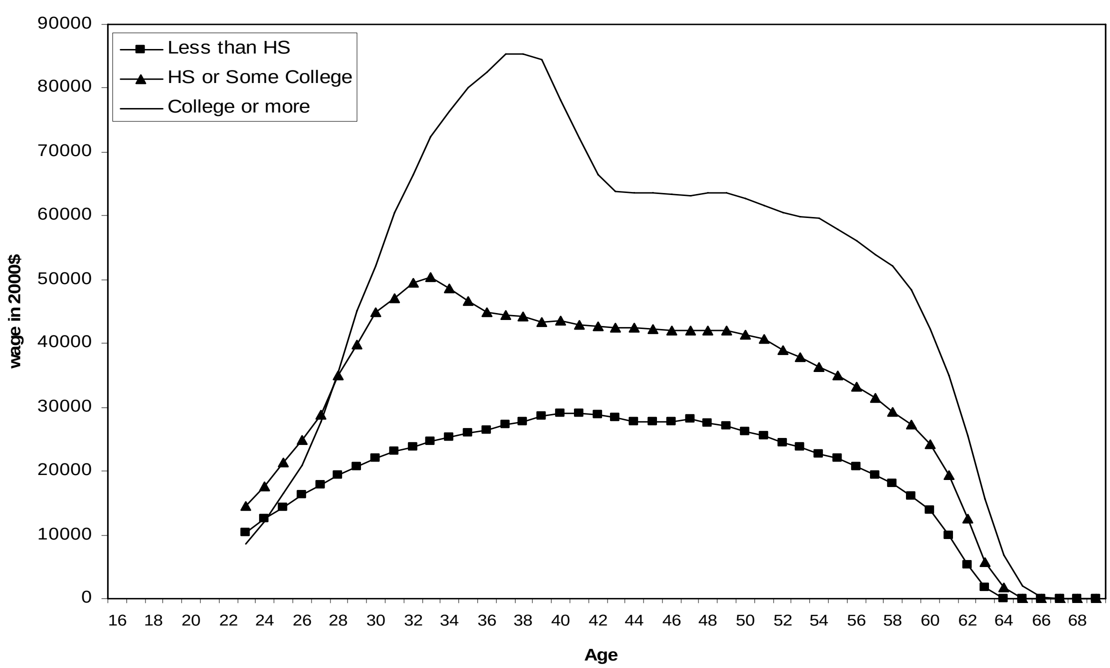

Figure 2c: 75th Percentile Earnings, After Top-Coding Correction, HRS Husbands