Optimal Savings: Would We Know It If We Saw It?

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Abstract

There appears to be a growing consensus that the country is facing a savings crisis. The low rate of aggregate savings, the aging of the Baby Boom, and the reported demise of defined benefit pension plans are often cited as evidence of the crisis. However, recent academic papers using household level data (Engen, Gale, and Uccello, 2004; Hurd and Rohwedder, 2006; Scholz, Seshadri, and Surachai, 2006) conclude that most pre-retirees are well prepared for retirement. This paper examines the apparent disconnect between this recent research and the growing policy consensus. This disconnect may be caused by disagreement over the definition of "enough." Indeed, defining optimal savings requires assumptions about individual preferences and accurate measures of current wealth and past and future earnings. Instead of attempting to define optimal savings, this paper takes a different approach. I calculate the amount of financial assets that can be accumulated using savings behavior that *a priori* seems reasonable, and then ask, "Would this behavior result in adequate resources for retirement?" Specifically, I construct representative households and simulate income replacement rates in retirement under various scenarios, including simulating a full range of investment returns and alternative payout methods. I account for Social Security benefits, taxes before and after retirement, and the presence of owner-occupied housing. This paper illustrates that moderate 401(k) contribution rates can lead to adequate income replacement rates in retirement for many workers; that adequate asset accumulation can be achieved using only a 401(k) plan; and that these results do not rely on earning an investment premium on risky assets. In light of the simulation results, I reexamine the empirical evidence and find that household level data on asset accumulation are roughly consistent with the savings behavior assumptions used in the simulations.

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In 1964, Justice Potter Stewart tried to explain ... what is obscene, by saying, "I shall not today attempt further to define the kinds of material I understand to be embraced . . . [b]ut I know it when I see it . . . "

(From: “Movie Day at the Supreme Court ‘I Know It When I See It’: A History of the Definition of Obscenity,” by Judith Silver of Coollawyer.com)

1. Introduction

In the policy community, there appears to be a growing consensus that the country is facing a savings crisis. In support of this consensus, the low rate of personal and national savings as calculated in the National Income and Product Accounts (NIPA), the demographic strain placed on the Social Security system by the aging of the Baby Boom generation, and the widely reported demise of defined benefit pension plans are often cited. These facts and other analysis lead many to conclude that most Americans are poorly prepared to finance their consumption in retirement (see, for example, Munnell, Webb, and Delorme, 2006). Indeed, underlying the many behavioral economics studies that seek to devise plans to increase participation rates and contribution rates in employer-provided savings plans (see, for example, Bernartzi and Thaler, 2004) is the implicit or explicit assumption that most Americans are currently not saving enough to finance their retirement. However, many of the recent academic papers using household-level data (Engen, Gale, and Uccello, 2004; Hurd and Rohwedder, 2006; Scholz, Seshadri, and Surachai, 2006) conclude that most pre-retirees are well prepared for retirement. This paper examines the apparent disconnect between this line of academic research and the growing policy consensus by examining the question of how much savings is enough. That is, what would an optimal savings path look like?

One issue that may explain the disconnect may be the definition of the crisis. The academic papers cited above conclude that most pre-retiree households are adequately prepared for retirement. Evidence cited to support the notion that the country faces a savings crisis – particularly the low aggregate savings rate and the aging of the baby boom – may be notable developments and may, in fact, be problematic developments, but these facts have little direct relevance to the question of whether or not individual households are adequately prepared for retirement. For example, low aggregate national savings rates may lead to lower rates of long-term economic growth or may lead to more of the income generated by future economic growth to flow to creditors from foreign countries. The demographic shock of the Baby Boom generation will likely put a strain on the financing of the pay-as-you-go Social Security system.[2] However, it is possible that households can accumulate adequate resources to finance retirement expenditures even if aggregate savings as measured by NIPA is low[3] and even if demographic changes are straining government finances.[4]

However, even when addressing the specific question of retirement preparedness, there still appears to be a disconnect between the academic research and the growing public policy consensus. For example, writing in *Business Week*, Laura D' Andrea Tyson stated that, "There is a mounting retirement savings crisis in America," (*Business Week*, June 6, 2005). A report by the Securities Industry Association stated that, "Nearly half of American Households are not saving at all; and two thirds are not saving enough to retire adequately." (Securities Industry Association, 2006) And, a recent article discussing 401(k) plans was entitled, "401(k)s OK, if you like dog food," (*Denver Post*, November 10, 2006).

Beyond the exact definition of the crisis at hand, another reason for the disconnect between the apparent policy community consensus and the academic research may be that some in the public policy community disagree with the definition of "enough" savings that is used in the research. Indeed, it is not a simple task to define optimal savings. To completely define optimal savings, a researcher must know an individual's current wealth, expected future

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[2] Another concern that has been raised is that the aging of the baby boom could upset the financial markets. That is, the risk that when baby-boomer retirees sell off the assets they have accumulated to fund their retirement consumption, prices of financial instruments will decline substantially. A study by the U.S. Government Accountability Office (2006) concluded that the retirement of the baby boom was unlikely to dramatically reduce market returns.

[3] Although a full discussion of the topic would likely be a paper in itself, a particular concern about using the National Income and Product Account (NIPA) aggregate savings rate as a measure of retirement preparedness is that the increase in value of existing assets is, appropriately, not included in the NIPA measure of production or income, and thus is not reflected in the aggregate savings rates. However, the increase in the value of existing assets – that is, accrued or realized capital gains – should be included when analyzing a household's ability to finance their retirement. That is, the typical measure of retirement preparedness is the amount of annual payments that can be financed from a household's accumulation of assets. The problem is not the design of the NIPA savings measure, as it was designed to measure income less consumption (i.e., Y – C) and was never intended to measure retirement preparedness.

[4] As for the importance of private-sector defined benefit pension plans, these plans are not now, and never were, the primary factor determining the overall level of retirement preparedness in the population. Payments from private sector defined benefit pensions represented 7 percent of retirement income for individuals over age 65 in 1977 and represented 9 percent of retirement income in 2004 (Salisbury, 2006). Although the widely reported demise of defined benefit pension plans may be an important development for a portion of the population, the presence of defined benefit pensions in the past did not, in itself, assure retirement security for most Americans, and the potential absence of defined benefit pensions in the future will not, in itself, assure a life of poverty in retirement for most Americans.

bequests, expected lifetime earnings, life expectancy, and must possess a correctly specified utility function that is both the proper functional form and has accurately estimated parameters. It could be that those who believe that there is a looming retirement savings crisis disagree with the authors' choice of utility function, parameter estimates, or believe that the authors' information on wealth and earnings was incomplete. To avoid disagreements regarding the definition of optimal savings, this paper takes an alternative approach. Instead of attempting to define optimal savings, this paper examines savings behavior that *a priori* seems reasonable to the author, and then asks, "Does it look like this savings behavior produces adequate resources to finance retirement consumption?" That is, would we know optimal savings if we saw it?

A third reason for the disconnect between the apparent public policy consensus and the academic research could be that the academic papers cited above look at empirical evidence regarding those currently near retirement. Those concerned about the current level of savings may be worried about the retirement prospects of much younger generations. That is, perhaps those near retirement are adequately prepared, but younger workers – without the benefit of experiencing the recent bull markets for stocks and housing, without defined benefit pension plans, and with lower levels of Social Security benefits – are not saving enough. This paper addresses these issues as well. The simulations presented examine savings behavior over individuals' entire working careers, allow retirement income from only Social Security benefits and assets accumulated through a 401(k) plan, examine adequacy with both current-law Social Security benefits and reduced Social Security benefits, and examine adequacy under a large range of market returns.

This study constructs representative earnings paths that roughly represent median earnings for workers with various levels of education. For a given earnings path, individuals or married couples follow an assumed savings path. Income in retirement consists of Social Security benefits and income derived from accumulated savings. Replacement rates are calculated under various scenarios. It then reexamines the empirical evidence in light of the examples.

2. Literature Review

The literature regarding the broad topics of lifecycle savings, retirement preparedness, and income replacement rates is voluminous. This section does not attempt to provide an exhaustive review of all the literature, but instead focuses on several recent studies.[5] These studies all use the Health and Retirement Study (HRS) and all conclude that most pre-retirees appear to be adequately prepared for retirement. The HRS is a panel data set that follows individuals from age 51 through retirement. The first data were collected in 1992 targeting individuals born between 1931 and 1941 (i.e., age 51 to 61). New surveys collected information from these individuals every two years. New cohorts were added to the survey in 1993, 1998, and 2004. These additional cohorts included both younger and older cohorts, so the survey is now representative of the entire population over age 51. The survey has rich data on household assets, including both defined contribution and defined benefit pension plans, and information on lifetime earnings.[6]

Engen, Gale, and Uccello (2004) uses a lifecycle model of behavior – that is assuming that individuals attempt to "... smooth the marginal utility of consumption [within an] optimizing model of consumption." They develop a simulation model to generate distributions of optimal ratios of wealth to lifetime earnings for households. These distributions differ for each possible combination of a set of observable characteristics. They then compare the distribution of wealth-earnings ratios from their simulation model to the distribution of wealth-earnings ratios in the 1992 HRS sample. They conclude that households with median wealth-earnings ratios in the sample are saving more than predicted, that higher-income households save much more than predicted, and that households in the bottom of the wealth distribution are significantly undersaving.

Scholz, Seshadri, and Surachai (2006) also uses a lifecycle model and data from the 1992 HRS. However, using reported and administrative data on earnings and information on wealth, the authors solve for optimal savings for each household. They then compare the amount of wealth accumulated by each household to the predicted "optimal" amount of wealth. They find that fewer than 20 percent of households have wealth less than the target amount, and that projected shortfalls are small – on average about $5,000. They conclude that, "Households age 51 to 61 in 1992 are well prepared for retirement."

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[5] These studies typically include a survey of the relevant literature. Table 1 from Haveman, Holden, Wolfe, and Romanov (2006) is particularly helpful in this regard.

[6] There is earnings information reported by the respondent and there also is available, through matched Social Security administrative records, Form W-2 information for the survey participants. Prior to 1990 W-2 reported earnings are capped at the Old Age Survivors and Disability Insurance (OASDI) earnings base amount, and from 1991 to 1993 are capped at the Hospital Insurance (HI) earnings base amount. Beginning in 1994, the HI tax was applied to all earnings, so uncapped earnings are available.

Instead of defining "optimal" or "adequate" savings using a lifecycle model, Hurd and Rohwedder (2006) defines adequacy based on the observed consumption patterns of past generations of retirees. That is, using HRS data combined with data on consumption, the authors determine if those near retirement have enough resources to finance the consumption path of past generations. The authors conclude that current pre-retirees are "... adequately prepared for retirement in that they will be able to follow a path of consumption that begins at their current level of consumption and then follows an age pattern similar to that of current retirees."

Haveman, Holden, Wolfe, and Romanov (2006) uses the HRS and an earlier data set, the New Beneficiary Survey (NBS), to compare the cohort of individuals that retired in the 1990s with the cohort that retired in the 1980s. The authors find that more recent retirees are wealthier on average, but that the percentage that are likely to have income in retirement less than the poverty level has increased from 4 percent of the population to 8 percent of the population. However, as these individuals also had low income prior to retirement, it is not clear that increased savings is the solution to post-retirement inadequacy. The authors conclude, "…vulnerability in working life appears to persist into retirement."

This study does not revisit the HRS data to further investigate the question of retirement preparedness. The underlying assumption of this study is that those who do not find the studies listed above convincing have specific concerns regarding the studies. This paper attempts to address these concerns. In particular, no assumptions are made regarding individual preferences other than the assumption that individuals wish to have real net income in retirement that is approximately equal to real net income prior to retirement. Second, the focus of the research is expanded beyond assets accumulated by those currently close to retirement and (1) looks at savings over the entire working career; (2) assumes that workers will not receive defined benefit pension plan benefits in retirement; (3) looks at the effects of any future cuts to Social Security benefits; and (4) assesses outcomes under a range of potential investment returns. Because the focus reaches beyond households included in the HRS sample, no claim is made that the empirical investigation is as robust as the papers cited above. However, the paper attempts to address the question of retirement preparedness for groups beyond those who retired in the 1980s or the 1990s.[7] Finally, some of the skepticism regarding these papers may come from a lack of understanding of all the complex issues involved in determining retirement income. To some extent the goal of this paper is heuristic: by using simplified examples it hopes to make the issues easier to understand.

3. Baseline Simulations

The representative individuals in the simulations are assumed to be born on January 1, 1966. These individual are age 40 in 2006, and reach their normal retirement age of 67 in 2033. Assumptions are made about the individuals' earnings, savings, and investment returns to calculate replacement rates in retirement.

a. Construction of Representative Earnings Paths

The construction of earnings paths begins by estimating median annual 2004 earnings for workers by education status using the March 2005 Current Population Survey (CPS).[8] Specifically, median earnings for individuals age 35 to 44 who worked full time for the entire previous year are used, with the sample median for three educational levels calculated: high school graduates, college graduates, and workers with a graduate degree.[9] Inflating the values to 2006 values using the growth rate of average wages between 2004 and 2006, median earnings for these three groups are approximately $35,000, $55,000 and $75,000. These estimates are used to anchor the lifetime earnings paths.

In calculating Social Security benefit replacement rates, the SSA produces two sets of earnings paths.[10] The first are "flat" earnings paths. These paths assume that for any given level of earnings, a worker's earnings grow over their lifetime at the rate of growth of the average wage. The second are "scaled" earnings paths. These paths assume that for any given level of

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[7] A more recent study -- Love, Smith, and McNair (2007) – looks at the 2004 wave of the HRS. Like Haveman, Holden, Wolfe, Romanov (2006) they use the poverty rate as a measure of adequacy. They find that, as with studies using earlier data, few households over age 51 in 2004 are at risk of falling below the poverty level in retirement.
[8] Data available at http://www.census.gov/cps/.
[9] Median annual earnings were tabulated for six exclusive categories: less than high school, high school graduate, some college, associates degree, college degree, and graduate degree. Without loss of generality, earnings profiles were based on medians for high school graduates, college graduates, and workers with graduate degrees. In the sample, median earnings increase monotonically with education, so that those with a high school degree make more than those with less than a high schools degree, those with some college make more than those with a high school degree, and so forth.
[10] For a discussion of these series, see, for example, Mitchell and Phillips (2006).

earnings, a worker's real earnings grow in the early part of their career but decline in the years prior to retirement.

The earning series in this paper are created by taking the average of two separate wage series for each education level. The first series is similar to the SSA's "flat" earnings path. I start with the median earnings at age 40 noted above, allowing it to grow at the rate of average earnings in future years (and to decline by the growth rate of average earnings in previous years). For the construction of these series historical and projected wage growth rates reported by SSA (2006) are used. The second series is a smoothed series of median earnings by age from the crosssection,[11] which has an age-based earnings pattern similar to the SSA's "scaled" earnings paths. Using the average of these two series implicitly assumes that, after age 40, the distribution of earnings by age within the cross section will remain constant for each level of education, but that, over time, the entire distribution of earnings by age shifts in line with the overall rate of wage growth.

Figure 1 plots the median earnings by age for workers with a high school education, a bachelor's degree, and a graduate degree, respectively. The averages of the "flat" and "scaled" series that I create are three of the four series that will be used throughout the study, with their names reflecting their origin and level of 2006 earnings: (1) HS-35K (high school graduate earning $35,000 in 2006); (2) Col-55K (college graduate earning $55,000 in 2006) and (3) Grad-75K (worker with a graduate degree earning $75,000 in 2006). A fourth series is also created, Scaled Grad-100K, which is simply the Grad-75K series scaled up by one-third. The four earnings paths are plotted together in Figure 2.

It is often assumed that lifetime earnings follow a hump-shape, increasing early in a worker's career, leveling off, and then declining in the years prior to retirement. However, using longitudinal earnings data from W-2 records linked to the HRS, Mitchell and Phillips (2006) show that the median worker's real earnings continue to increase as they approach retirement age. The series used in this paper have an age pattern more similar to that found in Mitchell and Phillips (2006) than either the scaled or flat earning series used by the SSA.

Note that the names of the series are meant to be suggestive of their derivation, but conclusions regarding savings behavior and income in retirement are made in reference to the

[11] Median annual earnings by education were tabulated for the following age groups: under 25, 25 to 34, 35 to 44, 45 to 54, 55 to 64, and 65 and over. The cross-sectional series are smoothed series from these statistics.

earnings paths, not to levels of education. For example, for each earnings path, I will look at replacement rates for single individuals, for married couples with one earner and for married couples with each individual earning half of total household earnings. If results are presented for single men with lifetime earnings equal to HS-35K, the results may be representative of single men with a high school education. However, if results are presented for two-earner married couples with lifetime earnings equal to HS-35K, the results are not likely to be representative of a two-earner married couple if both spouses are high school graduates. That is, a married couple composed of two working high school graduates working full time may have income closer to Grad-75K than to HS-35K.

The examples are meant to be flexible in that they provide a range of simulated results for a given earnings path. This should allow the reader to approximate what results would be for, say, a married couple with similar total earnings but with a different composition of earnings.

b. Social Security, Savings, and Income in Retirement

Income in retirement is assumed to come from only two sources: Social Security benefits and income generated by financial assets accumulated in a worker's 401(k) account. Economic and demographic assumptions used in the simulations are roughly consistent with those used by the Social Security Administration (SSA) in their intermediate projection (Social Security Administration, 2006).

i. Social Security Benefits

Workers are assumed to work until normal retirement age, which, in the case of these examples would be age 67 in year 2033. Parameters for the calculation of Social Security benefits use either historic values (for 2006 and years prior) or are consistent with the SSA's intermediate projection. Most parameters used in the calculation are indexed to wage growth, using the average wage index (AWI). The SSA's intermediate projection has average real wages growing by a steady 1.1 percent a year after 2015, with nominal wage growth of 3.9 percent and inflation of 2.8 percent.

Social Security benefits are based on an individual's earnings history, with earnings below the annual earnings base ($94,200 for 2006) – also referred to as covered earnings –

included in the calculation. Covered earnings before age 60 are indexed using the AWI at age 60; nominal earnings are used after age 60. That is,

$$IE_t = E_t * \frac{AWI_{60}}{AWI_t} \text{ for all years where } t \leq 60$$
$$IE_t = E_t \text{ for all years where } t \geq 60 \qquad (1)$$

where E_t is nominal covered earnings at age t; and
IE_t is indexed earnings at age t

Average indexed monthly earnings (AIME) is the sum of indexed earnings from the 35 highest earning years (chosen after indexation) divided by 420 (the number of months in a 35-year period). The benefit that a recipient is entitled to upon reaching full retirement age is the primary insurance amount (PIA). The formula for the PIA is 90 percent of AIME up to the first breakpoint, plus 32 percent of AIME above the first breakpoint up through the second break point, plus 15 percent of any AIME in excess of the second breakpoint. The breakpoint values used to calculate an individual's benefit are set at the time the recipient attains age 62, the age at which a worker is first eligible for benefits. For example, for those attaining age 62 in 2006 the PIA formula breakpoints are $652 and $3,995.[12] A retiree's initial Social Security benefit at the time of retirement is equal to the PIA obtained using this formula, but adjusted to account for inflation that occurred between the year the recipient attained age 62 and the year the individual became entitled to benefits.[13] Thus, in the examples in this paper, the initial benefit is equal to the PIA plus an adjustment to account for inflation that occurs between age 62 and the normal retirement age, age 67.[14] The initial benefit is also indexed to inflation in the years after retirement.

For each earnings path, I calculate Social Security benefits three ways: assuming the earnings are for a single individual, assuming the earnings are for a single-earner married couple, and assuming the earnings are for a married couple with each spouse earning one-half of total earnings (hereafter, "dual-earner married couple"). For any given earnings path, married couples receive more in Social Security benefits than single individuals. In the case of single-earner

[12] For reference, these breakpoints are equivalent to annual covered earnings of $7,824 and $47,940, respectively.
[13] Social Security benefits are adjusted each year by the lesser of the rate of inflation or the rate of wage growth. Since wage growth typically outpaces inflation, I use the term "adjusted for inflation" in the text as shorthand.
[14] If an individual claims Social Security benefits before or after normal retirement age, additional reductions or credits apply to the PIA.

married couples, this is because the non-working spouse is eligible for Social Security benefits equal to 50-percent of the working spouse's benefit. In the case of dual-earner married couples, this is because of the progressivity of the benefits formula: because each spouse earns half the amount of the single individual, their benefits replace a higher proportion of earnings.

ii. Savings and Income from Financial Assets

Table 1 summarizes the assumptions regarding the savings behavior used in the simulations. These assumptions are simply meant to be behavior that *a priori* seems reasonable to the author. Generally, no post-simulation adjustments were made to calibrate the assumptions[15] and they are not intended to represent "optimal" savings paths. Contributions to 401(k) plans as a percent of earnings, inclusive of any employer match, range from 4 percent a year for married couples with the HS-35K earnings path to 10 percent a year for those with the Scaled Grad-100K earnings path. The age at which workers start contributing to a 401(k) plan ranges from age 32 for single individuals with the Scaled Grad-100K earnings path to age 52 for married couples with the HS-35K earnings path. Those with higher earnings paths contribute a higher percentage of earnings and start contributing at an earlier age. Similarly, because they have more earnings on a per person basis, single individuals are assumed to begin contributing at an earlier age than married couples with the same earnings path and, in the case of HS-35K earners, contribute a higher percentage of earnings. It is also assumed that higher earners work for employers with more generous matching formulas.

In the baseline case, 401(k) contributions are invested in inflation-indexed Treasury bonds, also known as Treasury inflation-protected securities (TIPS). Yields are assumed to be 2.4 percent real, which, through most of the projection period, yields a nominal rate of 5.2 percent.[16] Table 2 reports the amount of assets accumulated by the time a worker retires by

[15] The lone exception is the case of single-earner Scaled-Grad 100K workers. I had initially assumed they would ramp up 401(k) contributions from 10 percent of earnings up to 15 percent of earnings between the ages of 42 and 52. However, replacement rates appeared exceedingly high, so I changed the assumption to assume that they maintained a flat 10 percent contribution rate from age 32 to age 66.

[16] As of October 30, 2006 the yield on a 10-year TIPS was 2.39 percent. The SSA's intermediate projection includes an implied real rate of 2.9 percent after 2015. However, the real return in the projection is calculated as the rate earned on debts held in the trust fund less current inflation; it is not a projection of the yield on a TIPS security. For example, in 2005, the SSA's real rate was 0.8 percent, but the 10-year TIPS yield was 1.8 percent. Because I do not know the long run relationship between TIPS yields and SSA's real interest rate, I use the current yield of 2.4 percent in the calculations. This is also, presumably, the real interest rate that is consistent with the real annuities prices discussed below. If it is believed that a 2.9 percent real interest rate assumption would be more appropriate,

earnings and marital status. Those with higher earnings are assumed to accumulate more in assets because they have higher earnings, contribute a higher proportion of their earnings, and begin contributing earlier. Controlling for total income, single individuals accumulate more because they are assumed to begin saving at an earlier age. For married couples, assets at retirement (in 2006 dollars) range from $28,245 for HS-35K earners to $464,417 for Scaled Grad-100K earners. For single individuals, assets range from $77,709 to $559,562.

Upon retirement, it is assumed that the entire 401(k) balance is used to purchase a real life annuity.[17] That is, an annuity is purchased that provides an annual payment until death and adjusts the payment each year to account for changes in the cost of living. Pricing for the real life annuity was obtained from the Vanguard website.[18] Because the SSA's intermediate projection assumes life expectancy at age 65 will increase 1.9 years for males and 1.5 years for females between 2005 and 2035, annuity prices in 2033 for a 67 year-old individual or couple are assumed to be equal to annuity prices in 2006 for a 65 year-old individual or couple. Because females have longer life expectancies than males, an annuity for a female provides less income for any given amount invested.[19]

c. Results from the Baseline Simulation

The individuals or married couples in the simulation are assumed to retire at the normal retirement age, 67, in the year 2033. Two measures of replacement rates are presented. The first measure is nominal income in year 2033, the first year of retirement, compared to nominal earnings in 2032, the final year of earnings. Replacement rate studies typically use this measure or a similar measure with average earnings from the 5 years prior to retirement as the denominator. This measure is presumably used in the literature for two reasons. First, many of the studies are using cross-sectional data and thus are unable to use any other measure: The

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the results presented below may be too pessimistic regarding the income attained from financial assets in retirement, as both the amount of financial assets accumulated at the time of retirement and the real annuity income that could be purchased with a given amount of financial assets would be underestimated.

[17] A retiree has many options regarding withdrawal of funds from a 401(k) account. The assumption that a real annuity is purchased is made for reasons of exposition; no judgment is implied as to whether or not a real annuity is the optimal choice. Section 6 examines the range of outcomes that a retiree might expect if an alternative payout method was chosen, and Section 6.3 discusses the retiree's choice between an annuity and other payout methods.

[18] Pricing was obtained on 10/31/06 for an annuity with a single annual payment, with payments commencing one year after the initial investment, and with no guaranteed minimum payments or death benefit. Website: https://flagship.vanguard.com/VGApp/hnw/accounttypes/retirement/ATSAnnuitiesOVContent.jsp

[19] Amount of annual income per $100,000 invested is reported in Table A1.

researcher only observes earnings and financial assets in the year of the survey, and thus compares the earnings that are observed to a calculation of annuity income that can be generated by the amount of financial assets that are observed. Second, annuity income is typically calculated as a nominal annuity, making problematic any single measure that compares annual retirement income and annual earnings across time.

Given the empirical limitations of many of these studies, it is understandable why this measure is typically used. However, there is no theoretical basis to think that replacement of a certain percentage of final earnings is the goal of retirement planning. The intuition provided by lifecycle models is that individuals wish to smooth consumption.[20] To the extent that earnings are volatile or trending either up or down, earnings in the year prior to retirement, or in any other single year, may be a bad proxy for average annual consumption. In addition, it is real, not nominal, consumption that individuals are attempting to smooth. If assets are assumed to be used to purchase a nominal annuity, retirement income in the first year of retirement will overestimate the average amount of real consumption in retirement. This paper assumes real annuities are purchased, which would reduce the measurement error associated with using first year retirement income. However, because this paper analyzes simulations rather than cross-sectional survey data, I am able to use a second measure that is meant to better capture the ability of an individual to maintain average lifetime consumption in retirement. This replacement rate measures average real income in retirement to average real earnings prior to retirement. Given the sharp increase in earnings in the early part of working careers, especially for those with higher education, and acknowledging that some tastes – such as the willingness to share living quarters with unrelated individuals – may change over time, only earnings after age 30 are included in the real earnings average. Note that the measure of average income in retirement takes into account survival probabilities, and thus places greater weight on income received in the early years of retirement.[21] Specifically, the formula is:

[20] Optimization over the lifecycle generally requires that the marginal utility of consumption be equal in each time period. If certain other conditions are met this would also imply that an individual would prefer to smooth consumption over time. See Engen, Gale and Uccello (2004) and Scholz, Seshadri, and Surachai (2006) for a more formal description of lifecycle models.

[21] Real income in the base case is constant over retirement as both Social Security benefits and annuity income are indexed to inflation. However, average income in retirement is used because later simulations will incorporate Federal and state income taxes (which are not fully indexed) and stochastic investment returns.

$$\text{Average Retirement Income} = \frac{\sum_{t=67}^{t=100} (B_t + S_t) * \Pr(alive)_t}{\sum_{t=67}^{t=100} \Pr(alive)_t} \quad (2)$$

where B = real Social Security benefit;
S = real income from accumulated savings;
$\Pr(alive)_t$ = probability individual who is alive at age 67 is alive at age t;[22] and
t indexes the age of the individual[23]

Results from the baseline simulation are presented in Table 3. All reported dollar amounts are in 2006 dollars. The top panel shows the earnings of the individual or couple in 2032, the year prior to retirement, as well as the average earnings over age 30. Because real earnings increase over time in the earnings paths used, average real earnings for each series are higher than real earnings at age 40, and the earnings in the year prior to retirement are higher than average earnings. For example, for the Col-55K earnings path, average real earnings after age 30 are $58,306 and earnings in 2032 are $64,644.

For each earnings series, the next lower panel shows the annual Social Security benefit that individuals and married couples would receive. For single individuals, the annual benefits range from $18,814 for the HS-35K earnings path to $33,315 for the Scaled Grad-100K earnings path. As noted above, controlling for total earnings, married couples receive higher benefits. For example, for the Col-55K earnings path, single-earner married couples would receive $39,187 annually and dual-earner married couples would receive $32,547 annually, compared to $26,124 for single individuals.

The next panel shows a standard Social Security replacement rate measure that compares nominal benefits in the first year of retirement to final annual earnings. Replacement rates are higher for lower earners and for married couples. For single individuals, replacement rates range from 49 percent for the HS-35K earnings path to 30 percent for the Grad-100K earnings path.

[22] Life expectancy is taken from 2003 mortality statistics reported by the National Center for Health Statistics in Arias (2006). Life expectancy for married couples is derived from the single-sex mortality tables. Specifically I derive a probability that both spouses survive, that one spouse survives, and that neither spouse survives. This method implicitly assumes that there is no correlation in survival between spouses, which is likely to be an incorrect assumption. However, I know of no mortality data that are published in a usable fashion that calculate these statistics.

[23] Because the life expectancy tables in Arias (2006) end at age 100, I assume any surviving retirees die at age 100. This in no way is meant to be interpreted as an implicit policy suggestion.

Replacement rates for married single-earners range from 74 percent to 46 percent, and range from 65 percent to 44 percent for married dual-earners. Presented below the nominal replacement rate is the preferred measure of replacement: real average income in retirement compared to real average earnings.[24] Given that Social Security benefits are indexed for inflation and that average real earnings are not much below real earnings at age 66, the preferred measure is not radically different from standard replacement rates, typically higher by 3 or 4 percentage points.[25]

Income derived from 401(k) plans is reported in the bottom half of the table. In the simulations, single individuals accumulate between $77,709 (for the HS-35K earnings path) to $559,562 (for the Scaled-Grad 100K earnings path). Because they start saving later in life, and in the case of the HS-35K earnings path save less, married couples accumulate fewer assets, controlling for total earnings. Married couple 401(k) balances range from $28,245 to $464,417. With these balances, single males could purchase real annuities providing annual income ranging from $4,587 for those with the HS-35K earnings path to $33,032 for those with the Scaled Grad-100K earnings path. Because females typically live longer than males, annual annuity payments for single females are 7 percent lower. Married workers were assumed to purchase joint and 50-percent survivor annuities. That is to say, upon the death of a spouse, the surviving spouse would continue to receive one-half of the original annuity payment. With less money to invest – both absolutely and on a per-person basis – married couples can purchase annuities with annual payments ranging from $1,455 for HS-35K workers to $23,919 for Scaled Grad-100K workers.[26]

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[24] Average income in retirement for married couples is calculated conditional on both spouses surviving. Replacement rates for surviving spouses have also been calculated, but not reported here. In the replacement rates presented in Table 3 through Table 7, replacement rates for surviving spouses are generally close to 50-percent of the couples replacement rate. This is not the case later in the paper, where I allow for alternate methods of distributing accumulated assets in retirement.

[25] Because the standard replacement rate uses nominal values, it differs from the preferred replacement rate in both the numerator and denominator. That is, if real 2033 retirement income were compared to real 2032 earnings the standard replacement rate would be lower than reported because the inflation adjustment would reduce retirement income proportionally more than it would reduce earnings. The standard replacement rate cannot be computed by using the reported earnings and benefits reported in Table 2 because real earnings and benefits are reported.

[26] Curiously, price quotes for joint and 50-percent survivor annuity were such that a married couple would be better off splitting their accumulated assets and buying two single-life annuities. Perhaps this pricing reflected longer life expectancies for married couples. Because I was unsure a married couple would be allowed to buy separate annuities to create their own joint and 50-percent survivor annuity – that is, that married couples could purchase single life annuities at the quoted price – I used the joint and 50-percent survivor prices quoted on the Vanguard website. If, in fact, couples could buy separate single-life annuities, these simulations underestimate replacement rates for married couples.

Replacement rates for retirees that take into account both Social Security benefits and annuity income are presented in the bottom panel of Table 3. Using a standard measure, replacement rates for single individuals are near 60 percent for all of the earnings paths, with males having a slightly higher replacement rate than females because of higher annuity payments. Married one-earner couples have replacement rates ranging from 78 percent for HS-35K workers to 67 percent for Scaled Grad-100K workers. Because of lower Social Security benefits, married dual-earner couples have lower replacement rates, holding total earnings fixed, and this is most pronounced at lower earnings levels. Once again, the preferred replacement rate, which compares average real income in retirement to average real earnings, produces replacement rates that range from 3 percent to 6 percent higher than the standard measure. Through the remainder of the paper, only the replacement rates that compare average real income in retirement to average real earning are presented.

d. Discussion of Baseline Simulation Results

The focus of the paper is to see if savings behavior thought *a priori* to be reasonable would result in individuals and couples saving "enough" for retirement. Steinberg and Lucas (2004) notes that workers and plan sponsors are commonly told to replace "75 percent to 80 percent of pre-retirement income," a number the authors attribute to a 1981 *Report of the President's Commission on Pension Policy*. Replacement rates below 100 percent were an attempt to adjust for the fact that some pre-retirement income was saved and thus did not need to be replaced in retirement, and the fact that effective tax rates in retirement differ from effective tax rates while working. More recent studies suggest higher replacement rates are needed. For example, Alford, Farmer, and Schacket (2004) suggests rates from 75 percent to 90 percent, and Steinberg and Lucas (2004) suggests 85 percents to 95 percent. The replacement rate in these studies is most analogous to the standard measure in this paper – nominal 2033 income to nominal 2032 earnings. By these measures, all the single individuals simulated have saved too little, and only single-earner married couples with HS-35K or Col55K earnings paths are near or above the 75 percent replacement rate threshold. However, because the lifecycle model suggests consumption smoothing and not the smoothing of gross income, the correct replacement rate as a percentage of income is not intuitively obvious.

In addition, even if these "rule of thumb" replacement rates are initially derived making some assumption about savings and taxes, they are often treated as if the replacement rates are fixed goals; that is, those using the "rule of thumb" do not realize that the savings rate and the replacement rate are intimately related. The result is, for example, that a household can be advised to save over 25 percent of their gross income from age 35 to age 65 in order to be able to replace 85 percent of pre-retirement gross income in retirement.[27]

The next section of the paper comes up with replacement rate measures that are more appropriate for judging the adequacy of retirement savings.

4. Adjusting for Savings, Taxes, and Owner-Occupied Housing

As noted above, the basic insight of lifecycle models is that individuals generally prefer to smooth consumption over time. One adjustment to standard replacement rates has already been made to better measure the ability of individuals to maintain consumption in retirement: rather than comparing nominal income in the first year of retirement to nominal earnings in the year prior to retirement, this paper compares average real income in retirement to average real earnings while working. However, neither gross income nor gross earnings measure potential consumption. First, earnings that are saved for retirement are, by definition, not used for consumption and thus do not need to be replaced in retirement. Second, income or earnings used to pay taxes cannot be consumed and must be accounted for. Third, for many people, owner-occupied housing represents a substantial portion of their wealth, but the measures used so far do not account for it. The remainder of this section adjusts for these factors to produce more useful replacement rate measures.

a. Adjusting for Savings and Taxes

To better approximate consumption possibilities, this section compares income before and after retirement net of savings and taxes. The removal of savings from the measures is straightforward: savings prior to retirement are not included in average earnings; individuals are assumed not to save after retirement. Accounting for taxes requires calculating payroll taxes and

[27] See, for example, www.myfinancialawareness.com at http://www myfinancialawareness.com/Topics%20Financial/Retirement%20Income%20-%20Replacement%20Ratios.htm.

Federal and state income taxes for all of the simulated individuals. In order to make these calculations, certain assumptions must be made.

Payroll taxes are the sum of two taxes: the Social Security or Old Age, Survivor, and Disability Insurance (OASDI) tax of 6.2 percent of earnings up to the annual earnings base (which, as note above, was equal to $94,200 for 2006);[28] and the Medicare or Hospital Insurance (HI) tax of 1.45 percent on total earnings. For 2006 and prior years, historical earnings base numbers are used; after 2006, the earnings base is assumed to grow in line with SSA's intermediate projection.

For the Federal income tax, filing status and the number of exemptions are based on marital status. Adjusted gross income (AGI) while working is assumed to be equal to earnings less employee 401(k) contributions. In retirement, AGI is set equal to distributions from the 401(k) account plus includable Social Security benefits. Only a portion of total Social Security benefits are included in AGI. Specifically, the first $25,000 ($32,000 for married-filing joint) of benefits are excluded from AGI; benefits between $25,000 and $34,000 ($32,000 to $44,000 for married-filing joint) are included at a 50-percent rate; and benefits above $34,000 ($44,000 for married filing joint) are included at an 85-percent rate.

Deductions are assumed to be the greater of the standard deduction or itemized deductions. Taxpayers over age 65 receive a higher standard deduction. Because I am not yet considering the treatment of owner-occupied housing, itemized deductions are assumed to be equal to state income taxes.[29] Taxable income is equal to AGI less deductions and exemptions, and Federal income taxes are calculated by applying the tax rate schedule to taxable income.[30]

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[28] The earning base only affects the calculation of payroll taxes (and benefits) for singles and single-earner married couples with the Scaled-Grad-100K earnings profile, and even in this case only for a few years. Specifically, this earnings path exceeds the earnings base only in the years 2004 to 2014.

[29] Together, home mortgage interest expense and real estate taxes accounted for about 44 percent of itemized deductions in 2004 (see Statistics of Income, 2005, Table 2.1). State and local income and sales taxes accounted for another 21 percent of itemized deductions. Of the remaining itemized deductions, the largest category of deductions was charitable donations (both cash and in-kind), which represented 17 percent of itemized deductions. Modeling charitable deductions would reduce taxes. However, because charitable deductions represent a net cost in terms of consumption, fully accounting for charitable deductions in this analysis would likely increase the replacement rates reported in this paper.

[30] Children often provide tax benefits – for example, a personal exemption, a child tax credit, and possibly a dependant care credit and expanded eligibility for the earned income credit. These simulations do not account for the presence of children, although it would be entirely possible to include children in the simulation in a future extension of this paper. However, despite the fact that children reduce tax liability, it is likely that a full accounting for children would increase the replacement rates reported in this paper: unless my personal household management skills are lacking, it is my firm belief that raising a child represents a net cost even after accounting for the associated tax benefits.

Throughout the simulation – that is, for both periods before and after 2006 – it is assumed that 2006 tax law applies. That is, current law tax rates are applied in all periods, and the parameters of the tax code that are indexed are adjusted for inflation in periods both before and after 2006.[31] Of note, the provision determining the inclusion rate for Social Security benefits is not indexed for inflation.

Without loss of generality, state income taxes are calculated using the Virginia income tax. Again, filing status and number of exemptions are determined by marital status. As with the Federal AGI, Virginia AGI before retirement is equal to earnings less employee 401(k) contributions. Unlike the Federal AGI, 100-percent of Social Security benefits are excludable from Virginia AGI in retirement. Taxpayers either itemize deductions or take the standard deduction.[32] Allowable deductions are similar to Federal income tax, but state income taxes are not deductible. Married couples with two earners can claim a spousal earning credit. As with the Federal income tax, taxpayers over age 65 get to claim a higher standard deduction, but lower-income individuals over age 65 also get to claim an old-age deduction of $12,000. The old-age deduction phases out dollar for dollar for taxpayers with Virginia AGI over $50,000 for single filers and over $75,000 for married couples filing joint returns. Statutory marginal tax rates range from 2 percent to 5.75 percent.

The percentage of earnings accounted for by savings and taxes differs by the level of earnings and by marital status. The percentage reduction in income due to savings differs because higher earners and single individuals are assumed to begin saving earlier and (in some cases) contribute a higher percentage of earnings to their 401(k) than do lower earners and married couples. The percentage reduction in income due to the payroll tax is similar among all workers.[33] Because of the progressivity of both the Federal and the Virginia income taxes, income taxes as a proportion of income increase with earnings. For a given level of total earnings, married couples pay lower taxes than single individuals. Because Virginia has a spousal earnings credit, dual-earner married couples pay slightly less in Virginia income taxes than do married single-earner couples.

[31] Indexation is done without regard to rounding rules.

[32] When choosing to itemize or take the standard deduction, taxpayers must choose for state tax purposes the same status they chose for Federal income taxes. Thus, this is a joint optimization problem.

[33] As noted in footnote 25, earnings in almost all cases are below the wage base, so nearly all earnings are subject to the full 7.65% payroll tax rate.

The results from the simulations that account for taxes and savings are presented in Table 4. The average real pre-tax earnings, first presented in Table 3, are repeated in the top panel of Table 4, and range from $36,219 for HS-35K workers to $102,874 for Scaled Grad-100K workers. The next panel reports average real earnings after netting out taxes and savings, and the next panel reports the percentage reduction in average real earnings due to taxes and savings. Single individuals have earnings reduced by between 26 percent for HS-35K workers to 36 percent for Scaled Grad-100K workers. Holding total earnings fixed, married individuals have a lower reduction in income from savings and taxes, ranging from 18 percent to 30 percent.

The reductions of gross income in retirement are much lower. First, there is no longer any need to save. Second, because there are no earnings, no payroll taxes are due. Finally, income tax burdens are lower because gross income is lower, because Social Security income is at least partially excludable from taxable income, and because of increased deductions and credits.

As first reported in Table 3, the fourth panel in Table 4 once again shows average gross income in retirement, which is the sum of Social Security benefits and income from a real annuity purchased with 401(k) balances. The next two panels show average net retirement income after taxes and the percentage reduction in income due to taxes. As can be seen, the percentage reduction in income due to taxes is much lower in retirement than the percentage reduction in income due to savings and taxes prior to retirement. For single individuals with HS-35K earnings, taxes in retirement are negligible, while for those that have Scaled Grad-100K earnings, the reduction in income is around 15 percent. For married couples, taxes are negligible for those with HS-35K and Col-55K earnings, and only reduce income by 7 percent for those with Scaled Grad-100K earnings.

The bottom panel reports the new measure of replacement rates that account for savings and taxes. For single individuals, the range of replacement rates increase from 62 to 67 percent of gross income up to 83 to 92 percent of net income. For married couples, the range of replacement rates increase from 64 to 82 percent of gross income up to 83 to 102 percent of net income. On average, accounting for savings and taxes typically causes the measured replacement rates to increase by 20 percentage points or more.

b. ***Adjusting for Owner-Occupied Housing***

Of households with a household head age 55 to 64, nearly 80 percent own their home; and for these home-owning households the net-equity in their house (i.e., the value of the home less mortgage debt) composes, on average, 40 percent of household net worth.[34] However, there is a tremendous debate in the literature regarding the proper treatment of owner-occupied housing when measuring retirement preparedness. To a large extent this debate is driven by the preferred measure of retirement preparedness – some measure of annuitized wealth compared to income prior to retirement – rather than the actual behavior of households during retirement. Venti and Wise (2000) argues that, because retirees typically do not liquidate their housing wealth – by selling their house, downsizing, or taking out a reverse mortgage – housing wealth should not be included in the wealth measure that is annuitized to determine savings adequacy. Others point out that ignoring housing wealth ignores the typical household's single largest asset. In addition, excluding housing wealth is problematic because a household which sold their house a day before the collection of the survey data would appear better off than an identical household that sells their house a day after the collection of survey data. Still other researchers, possibly invoking the wisdom of King Solomon, annuitize one-half of housing wealth. For example, the preferred measure of optimal savings in Scholz, Seshadri, and Surachai (2006) annuitizes all housing wealth, but, in an exercise to show the sensitivity of their results to their assumptions, the paper also reports a measure that annuitizes only one-half of housing wealth. In response to this debate, a literature has developed that examines retiree behavior regarding housing wealth.[35]

To a large extent, this debate misses the point. Whether or not households liquidate their housing assets, owner-occupied housing remains an important household asset. The primary benefit of owner-occupied housing is that it supplies rental services in excess of expenses. That is, if a household did not own their house, they would be required to pay rent to live in their house. Whether the asset is liquidated or not, households that own their home will be better off than otherwise identical households that rent. Thus, at a minimum, a household that owns their dwelling will need less income in retirement than they would if they did not own their home. In addition, owning a home is a hedge against housing services inflation. A measure of savings

[34] Author's tabulations from the 2004 Survey of Consumer Finances (SCF), Federal Reserve Board of Governors. Net worth does not include any estimate for the value of Social Security benefits. Data available at http://www federalreserve.gov/pubs/oss/oss2/scfindex html.
[35] See, for example, Coronado, Maki, and Weitzer (2006), which finds evidence that many retirees do in fact tap their housing wealth in retirement, particularly by selling their house and purchasing a less expensive replacement house.

adequacy that accounts for the imputed rental value of owner-occupied housing is superior to measures that ignore housing wealth, without requiring empirical evidence that retirees liquidate housing wealth. It is possible that accounting for the option to liquidate some or all of housing wealth would result in calculating even higher wellbeing in retirement for the simulations in this study, but liquidating home equity is not a component of the measure used.[36]

To construct a replacement measure that accounts for owner-occupied housing, it is assumed that, if a retiree has paid off her mortgage, she need not replace the earnings used to pay principal and interest on the mortgage prior to retirement. The monthly payment for a self-amortizing mortgage consists of two components: a payment to principal and a payment of interest expense. A payment to principal is savings and, like a 401(k) contribution, the savings need not be replaced in retirement. Payment of interest expense, assuming the mortgage is paid off, will not be necessary in retirement. Other expenses of home ownership – property taxes, insurance, and maintenance – are incurred both before and after retirement, and thus are not deducted from pre-retirement earnings.[37] To measure the adequacy of savings for those households that own their home and have no mortgage debt, average retirement income net of taxes is compared to average pre-retirement earnings net of savings, taxes, and mortgage payments.

To calculate mortgage payments, it is assumed that all individuals and couples: (1) purchase a home at age 35; (2) finance 100 percent of the purchase price using a 30-year fixed-rate mortgage charging a 7.0 percent rate of interest; and (3) pay off the mortgage at age 65. The purchase price of the home is assumed to vary by earnings path and is set (approximately) equal to the observed median purchase price of a house in the second quarter of 2006 in specific geographic regions and reported by the National Association of Realtors (2006). In 2006 dollars, the purchase prices are assumed to be $300,000 for the Scaled Grad-100K earnings path (equal

[36] If the homeowner simply sells her house and rents the house back, the retiree is not necessarily better off, and, in fact, may be worse off since she is no longer hedged against housing services inflation. It is possible that the homeowner would be better off if she reduces housing consumption in retirement, either by selling her current home and purchasing a less expensive home with the proceeds, or by selling the home and renting a less expensive home. For example, downsizing is likely to increase wellbeing if children are no longer present and the additional housing services provided by the original larger home have little marginal value to the retiree.

[37] In this study, it is assumed that these expenses increase at the general rate of inflation. If it is assumed, for example, that these expenses represent a larger proportion of expenses in retirement and that these expenses increase at a rate that is greater than the general rate of inflation, I believe that these assumptions would argue for a standard of adequacy that is above 100 percent replacement of net pre-retirement earnings, not an adjustment of the replacement rate measure. The replacement rate that represents adequacy in discussed further below.

to the median purchase price of a home in the Northeast region); $230,000 for the Grad-75K earnings path (equal to the median purchase price of a home in all of U.S.); $190 for the Col-55K earnings path (equal to the median purchase price of a home in the Southern region); and $100,000 for the HS-35K earnings path (equal to the median purchase price of a home in Buffalo, NY).

Although property taxes are not deducted from the measure of pre-tax income, property taxes are calculated in the process of recalculating income taxes. The real price of the house is assumed to stay constant, with the nominal price increasing at the rate of inflation. Property taxes are assumed to be 1.5 cents per dollar of value.[38] As before, simulated taxpayers are assumed to choose the itemization status that minimizes tax burden. However, for Federal income tax purposes, itemized deductions are calculated as state income taxes plus property taxes paid on the house plus mortgage interest expense, and for state income tax purposes, itemized deductions are calculated as property taxes plus mortgage interest expense.

The results of these simulations are presented in Table 5. The effect of accounting for owner-occupied housing is that pre-retirement net income is reduced substantially. Mortgage payments, net of tax benefits, reduce pre-retirement income an additional 10 percent to 15 percent beyond the reduction due to savings and taxes. All told, savings, taxes, and mortgage payments reduce pre-retirement gross income, on average, from 30 percent to 46 percent. The purchase of a house does not affect income in retirement, thus taxes continue to take anywhere from 0 percent to 15 percent from gross retirement income.[39] The result is that measured replacement rates increase substantially. Replacement rates for single individuals range from 98 percent for single females with Scaled-Grad 100K earnings to 109 percent for single males with Col-55K earnings. For married couples, replacement rates range from 102 percent for split earner couples with Col-55K earnings to 124 percent for single-earner couples with Grad-75K earnings.

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[38] To check whether or not the assumptions regarding purchase price were reasonable, I calculated the percentage of pre-tax income represented by the sum of the total mortgage payment (both interest and principle payments) plus property taxes. For HS-35K workers, mortgage payments plus property taxes represented 29 percent of pre-tax income in the first year of the mortgage and represented 13 percent of pre-tax income in the final year of the mortgage. The corresponding numbers for the other earnings paths are: (1) 35 percent and 15 percent for Col-55K earners; (2) 32 percent and 14 percent for Grad-75K earners; and (3) 31 percent and 14 percent for Scaled-Grad earners. These ratios do not appear to be unreasonably high. If it is thought that the purchase prices are too low, then calculated replacement rates will be understated.

[39] In the simulations, it is always optimal for retirees to take the standard deduction, whether or not they own a home.

c. Discussion of Results

This section suggests adjustments that should be made to traditional measures of replacement rates to make them a more meaningful measure of replacement. However it does not define what the proper replacement rate should be. A starting point would be to assume that a retiree would want to replace 100 percent of his average real net earnings, after accounting for savings, taxes, and (if he owns his house) mortgage payments.[40] The results presented from these simulations suggest that most workers can achieve, or come close to achieving, this goal by supplementing Social Security benefits with income from a 401(k) plan, with moderate 401(k) contribution rates, and starting contributions at some age over age 30.

However, it is not obvious that 100 percent is the correct replacement rate. There are arguments that an adequate replacement rate could be below 100 percent. There are certain expenses – such as commuting expenses, purchases of lunch and coffee, and buying work clothes – that may be eliminated or reduced in retirement. Besides housing, the household often purchases other long-lived products (i.e., consumer durables) that continue to provide services well into retirement.[41] Perhaps most importantly, if workers raised children while working, household expenses presumably would be lower if these individuals or couples are no longer supporting minor children in retirement.

There are also arguments that suggest that an adequate replacement rate would be above 100 percent. The replacement rates presented in this paper are in real terms. However, if retirees consume a different bundle of goods than the average consumer, it is not clear that accounting for inflation is a sufficient adjustment to pre-retirement consumption when measuring adequacy in retirement. For example, health care costs may increase at a faster rate than general inflation and, perhaps more importantly, the amount of health care consumed is likely to increase in retirement. Indeed, health care needs in retirement appear to be the key consideration if one is to believe that the amount of resources needed for a secure retirement would suggest a net income replacement rate above 100 percent.

[40] A replacement rate that adjusts for savings and taxes would be appropriate for a renter. A replacement rate that adjusts for savings, taxes, and mortgage payments would be appropriate for a homeowner who has paid off her mortgage. For a homeowner with mortgage debt, the appropriate replacement rate measure is likely to be between these two measures.

[41] For example, it is not uncommon for me to see olive-green kitchen appliances and brown-and-orange-plaid couches when I visit my elderly relatives or neighbors.

Although increased health care needs in retirement may suggest that retirees require a higher replacement rate than they otherwise would, a few other factors need to be considered. First, any analysis of health care needs in retirement must make assumptions about the future evolution of government health programs – Medicare and Medicaid. Although health care expenditures may represent an increased share of expenditures in retirement for many retirees, other retirees, especially at the lower end of the income distribution, may find that the combination of Medicare and Medicaid, as least as currently structured, compares favorably to the health insurance coverage that they had prior to retirement. Second, the current calculations assume that the home is used only to provide residential services. If, in fact, home equity were to be tapped in retirement, homeowners would have more resources than suggested by the calculated replacement rates. And, if increased health care needs coincide with a reduced need for residential services – for example, moving from owner-occupied housing into an assisted living facility – selling the residence or renting it out may be an option to generate needed financial assets. Finally, if the reason people are not adequately prepared for retirement boils down to increased health care expenditures in retirement, perhaps solutions other than increased savings should be considered.

5. Cuts in Social Security Benefits

As widely reported, projected Social Security benefit payments under the current formula are larger than the amount of revenue that is projected to be collected from payroll taxes at current payroll tax rates. To make Social Security sustainable in the long run, either payroll taxes must be increased or benefits must be cut (or some combination of the two). Using assumptions consistent with the SSA's intermediate assumptions, the Congressional Budget Office (2006) projects that the government will no longer be able to finance current law benefits by 2047. They project that revenues in 2049 will be able to finance 79 percent of current law benefits and by 2100 will only be able to finance 69 percent of current law benefits. However, benefits cuts that begin earlier and that are phased in can restore balance will less drastic cuts. For example, Harris and Simpson (2005)[42] look at three alternative benefits cuts that, if begun 2012, would produce solvency and a stable positive ratio of trust fund assets to benefits: (1) an

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[42] Projections differ considerably from year to year, so the projections from CBO (2006) are not necessarily directly comparable to Harris and Simpson (2005).

across-the-board 19 percent cut in benefits; (2) indexing the normal retirement age to longevity coupled with a 12 percent across-the-board benefit cut; and (3) indexing the benefit formula to price inflation rather than to the growth rate in wages from 2012 to 2032. They also look at each one of these options combined with a minimum benefit that would guarantee that any individual with 30 years of covered earnings would receive Social Security benefits at least equal to the poverty level. Adding a minimum benefit would change the three stable options to: (1) an across-the-board 24 percent cut in benefits; (2) indexing the normal retirement age to longevity coupled with a 17 percent benefit cut; and (3) indexing the benefit formula to price inflation rather than to the growth rate in wages from 2012 to 2040.

This section examines replacement rates under two scenarios: (1) benefits are cut across-the-board by 28 percent; and (2) benefits are cut by the use of so-called “progressive indexing” starting in 2012. Note that these two alternatives are not “stable” reforms. Cutting the benefits by 28 percent in 2033 would cut benefits more than would be needed to bring the system into balance; that is, a cut of this size could be delayed substantially. Current law benefits could be paid until 1946 and benefits equal to 79 percent of current law benefits could be paid in 2047. A cut in benefits of 28 percent would not likely to be needed until much later in the century. Similarly, progressive indexing from 2012 to 2033 would not bring the system into balance; progressive indexing would likely have to continue beyond 2033 and be coupled with either other benefit cuts – such as indexing the normal retirement age to longevity – or a tax increase. However, these two policy options will give some indication of the range of Social Security benefit cuts that are contemplated.

The calculation of a 28-percent across-the-board benefit cut is straightforward. Progressive indexing requires some explanation. As noted above, when calculating benefit payments, a worker’s earnings history (before age 60) is indexed by growth in average wages, not growth in average prices (i.e., inflation). Because nominal wage growth has typically exceeded inflation, the formula, in some sense, gives a worker “credit” for earnings in excess of his real earnings. It has been suggested that the formula be changed to index earnings by inflation rather than wage growth to reduce future benefit payments. Critics of this proposal worry that this will lead to a large reduction in benefits relative to current law, particularly in the long run, and are particularly concerned for lower-wage workers.

Progressive indexing is an alternative to full inflation indexing of the benefit formula. In principle, progressive indexing provides wage indexing for workers below some level of average earnings, provides inflation indexing for workers above a higher level of earnings, and provides a combination of inflation and wage indexing for those in between. In practice, mechanically applying progressive indexing to the benefit formula is a little more complicated. In this section I simulate a specific proposal to progressively index Social Security beginning in 2012 as described in Purcell (2005). All dollar amounts are expressed in 2006 dollars for ease of comparison.

When applying the formula to determine PIA, the first step is to define the "hold-harmless" level of AIME below which the PIA formula would be unchanged. Using the SSA intermediate projection assumptions, the hold-harmless level for a worker age 67 retiring in 2033 for this proposal would be equal to AIME of $1,813 or the equivalent of average indexed annual earnings of $21,752.[43] The second step is to determine level of benefits for which complete inflation indexing would be used. In this proposal, inflation indexing would apply to only the highest possible level of benefits; that is, the benefits that would accrue to an individual that earned at least the maximum amount of covered earnings in every year included in the calculation of AIME. This level of AIME is projected to be $8,472 for an individual age 67 retiring in 2033, or the equivalent of average indexed annual earnings of $101,660. The third step is to calculate Social Security benefits for the top earner under current law. Maximum monthly benefits are projected to be $2,829 ($33,943 annually). The fourth step is to calculate "inflation-indexed" benefits for top earners. Inflation indexing is achieved by reducing the percentage of AIME included in the PIA formula by the difference between wage growth and inflation between 2012 and 2028 – the year in which an individual retiring at the normal retirement age in 2033 attains age 62. Over this period, wages are projected to grow about 18 percent more than inflation. Thus the "inflation-indexed" formula uses the same AIME and AIME bend points in the PIA formula, but reduces all the rates by 18 percent, from rates of 90 percent, 32 percent, and 15 percent under current law, to 76 percent, 27 percent, and 13 percent, respectively. The inflation-indexed maximum monthly benefit is calculated to be $2,398

[43] The hold-harmless level of AIME is set equal to the first AIME bend point in the PIA formula plus 28.6 percent of the difference between the first PIA formula bend point and the second PIA formula bend point. In real 2006 dollars, the PIA bend points for an individual retiring at age 67 in 2033 are projected to be $743 and $4,482 in 2033, up from $592 and $3,567 for an individual reaching normal retirement age in 2006. Thus, the hold-harmless level would be $743 + 0.286*($4,482 – $743) = $1,813.

($28,770 annually), which represents a cut in benefits of 15 percent. The final step is to produce a formula that is the same as current law for individuals with AIME under the hold-harmless level, reduces the 32 percent and 15 percent rates in the formula proportionally for those above the hold-harmless level, and results in top earners receiving benefits equal to the benefit that would be calculated under full inflation-indexing. For individuals age 67 in 2033, this can be achieved by reducing the 32 percent and 15 percent rates by about 26 percent, to approximately 24 percent and 11 percent. The resulting PIA formula is presented in Table 6.

Table 7 presents results from the simulations that incorporate cuts to Social Security benefits. The top panels examine progressive indexing of benefits. As a percent of average net retirement income, the cuts vary by earnings, gender, and marital status. Not surprisingly, the cuts represent a larger percentage cut in income for higher earners, with higher earners having larger reductions in income controlling for gender and marital status, and, controlling for total income, with single individuals and single-earner married couples having larger reductions than dual-earner married couples. In addition, because Social Security benefits make up a larger proportion of their retirement income, controlling for total earnings: single females have larger reductions in net income from progressive indexing than single males and single-earner married couples have larger reductions in income than single individuals. Because the AIME for each spouse in a dual-earner married couple with HS-35K earnings is below the hold-harmless level, they do not have a reduction in Social Security benefits. For single individuals, cuts in net retirement income range from 5 percent for single males with HS-35K earnings to 9 percent for single females with Scaled Grad-100K earnings. For married couples, cuts in net income range from 3 percent for married dual earners with Col-55K earnings to 11 percent for married single earners with Scaled Grad-100K earnings.

Turning to replacement rates, calculated replacement rates with progressive indexing, not accounting for owner-occupied housing, range from about 75 percent to 85 percent for single individuals and from about 85 percent to 95 percent for married couples. Accounting for owner-occupied housing, replacement rates range from about 90 percent to 100 percent for single individuals and from about 100 percent to 110 percent for married couples.

In 2033, a 28 percent across-the-board cut would represent a much more substantial cut in benefits and net income than would progressive indexing. Despite the fact that all benefits are cut proportionately, these cuts represent a more substantial cut to net retirement income for lower earners and for married couples because Social Security benefits represent a larger proportion of their retirement income. For example, a 28 percent cut in Social Security benefits represents nearly a 27 percent cut in net retirement income for a single-earner married couple with HS-35K earnings, but only a 17 percent cut in net retirement income for a single individual with Scaled Grad-100K earnings. Thus, unlike progressive indexing, an across-the-board cut in benefits leads to proportionally larger cuts in net income and to generally lower replacement rates for lower-earning individuals and couples. Not accounting for owner-occupied housing, replacement rates range from about 65 percent to 80 percent. Accounting for owner-occupied housing, replacement rates generally range from 75 percent to 90 percent.[44]

6. Stochastic Simulations

In this section, 401(k) assets are invested in assets that do not have a fixed or guaranteed rate of return. Assets are assumed to be invested in a portfolio that is one-half large corporate stocks and one-half corporate bonds, with the portfolio rebalanced annually. Because investment returns are no longer deterministic, stochastic simulations are used to show the range of possible investment results. Specifically, I use a Monte Carlo simulation technique. This technique assumes that, in any given year, investment returns are a random draw from all possible investment returns. It is assumed that annual investment returns are normally distributed, with the mean and standard deviation of annual returns set equal to observed historic measures.

a. Accumulation of Assets Prior to Retirement

Data on investment returns from 1926 to 2004 were taken from Ibbotson Associates (2005), with annual stock returns taken from Ibbotson's Large Company Stocks Total Return series and annual bond returns taken from Long-Term Corporate Bonds Total Return series. Investments are assumed to be in mutual funds, with mutual fund expenses reducing the return earned by investors below the pure market returns reported by Ibbotson. It is assumed that expenses are equal to 120 basis points for stock funds and 70 basis points for bond funds.[45] The

[44] Single-earner married couples with Grad-75K earnings are an outlier, with a replacement rate of 98 percent.
[45] In 2005, the average 401(k) participant incurred an asset-weighted stock mutual fund fee of 76 basis points in total expenses and an asset-weighted bond mutual fund fee of 58 basis points (see Holden and Hadley, 2006). These averages were increased to 120 basis points and 70 basis points, respectively, to account for both direct and indirect fund-portfolio trading expenses. Direct trading expenses include payments to brokers, as either direct fees or bid/ask spreads. Indirect trading expenses include the reduced price that a stock gets if large blocks of the stock are

401(k) portfolio is assumed to be invested half in a stock mutual fund and half in a bond mutual fund, with the portfolio rebalanced each year. Real historical returns are calculated as nominal returns in a given year less inflation experienced that year. As reported in Table 8, over the 1926 to 2004 period, the calculated average (i.e., arithmetic mean) real annual return for the portfolio is 5.2 percent with a standard deviation of 12.8 percent. The geometric mean real annual return is 4.4 percent. In the remainder of the section, simulations assuming savings are invested in this portfolio will be referred to as the "investment account" and a simulations assuming savings are invested in a TIPs will be referred to as the "baseline case."

For a single simulation of investment returns, random real rates of return are generated for each year over a 47-year period corresponding to the time period over which a simulated individual is aged 20 to 66.[46] It is assumed that real investment returns are distributed normally, with mean and variance taken from historic experience.[47] Nominal returns are calculated as the sum of real returns plus inflation. Inflation is either historical inflation (before 2006) or as projected in the SSA's intermediate projection (2006 and after). Assumptions regarding savings behavior are exactly the same as used in the baseline case and presented previously in Table 1. A single simulation takes the path of returns – drawn randomly from the full distribution of possible returns – and the assumed savings behavior to derive eight account balances at retirement, one for each possible combinations of marital status and earnings path. This process is then repeated 5,000 times to get a range of possible outcomes.

Results from these simulations by marital status and earnings path are presented in Table 9. On average, the investment account would be expected to outperform the baseline case, and this advantage increases with the amount of time funds are invested. For example, single individuals with Grad-75K earnings are assumed to begin saving at age 32 and would be

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sold at a single time (for example, to meet cash flow needs due to share redemptions). See Edelen (1999) for a discussion of these costs. Intermediation costs are not restricted to mutual funds. Because of transaction costs and the costs of other investment services, no investor earns the pure market rate of return.

[46] Because no simulation assumes that 401(k) contributions begin prior to age 32, returns in the early years of the simulation have no effect on the results. I simulate returns over the entire age 20 to age 66 period because the computer program I set up is designed to be flexible with regard to assumed contribution behavior.

[47] Dus, Maurer, and Mitchell (2006), which laid the groundwork for the stochastic analysis in this paper, used the assumption that investment returns were distributed according to the lognormal distribution. Presumably, this is, in part, to ensure that returns are not such that the account balance cannot turn negative – that is, to ensure that investment returns do not go below negative 100 percent. I instead assume a normal distribution. This is, in part, because the geometric mean of investment returns from 5,000 40-year simulations is much closer to historical experience when assuming a normal distribution of returns than when assuming a lognormal distribution. I separately impose the restriction that account balances cannot be negative, but the restriction was not binding during any simulation.

expected to have 73 percent more in accumulated assets with the investment account. In comparison, married individuals with HS-35K earnings are assumed to begin saving at age 52 and would be expected to have only 24 percent more in accumulated assets with the investment account. This result not only holds on average over all simulations, but also when looking at the middle decile of simulations (i.e., the middle 500 simulations), although the differentials are less pronounced. On average for the middle decile of simulations, assets range from 19 percent to 52 percent higher than the baseline case depending on the investment horizon.

However, these typically higher accumulations come at a cost: the investment is subject to more risk. To give an idea of the range of results that could be observed, Table 9 also reports the average accumulation for the top decile – the top 500 simulations ranked by accumulated assets – and the bottom decile – the bottom 500 simulations ranked by accumulated assets. In the highest ten percent of simulations, returns were substantially higher for the investment account than for the baseline case – with accumulated assets twice as high for those starting contributions at age 52 and nearly four times as high for those starting contributions at age 32. However, in the lowest ten percent of simulations, the investment account substantially underperformed the baseline case, with accumulated assets anywhere from 27 percent to 30 percent lower, depending on the investment horizon. An alternative measure of the risk is the percentage of cases in which the investment account outperformed the baseline case. This ranged from 72 percent of the time for investors with the shortest investment horizon to 82 percent of the time for investors with the longest investment horizon.

b. ***Distribution of Assets During Retirement***

This section considers three different payout options: a real annuity, a nominal annuity, and a payout from an account invested in the investment account. It is assumed that payments from the annuities and the investment account are annual and that they commence one year after the initial investment. Annuity payments for single individuals are for life, with no death benefit. Annuity payments for married couples are also for life, with payments cut in half if one spouse dies, and with no death benefit upon the death of the second, or surviving, spouse. For single individuals, it is assumed that any remaining balance in the investment account upon death is left to heirs. For married couples, it is assumed payments continue until the surviving spouse dies, and then any remaining balance in the investment account is left to heirs.

i. Definition of Terms

Annual withdrawals from the investment account are based on remaining life expectancy. Conditional on survival to age *t*, withdrawals from the account are equal to:[48]

$$W_t^I = A_{t-1} * \frac{1}{L_t^s} \tag{3}$$

where W_t^I = withdrawal from the investment account (indicated by the superscript *I*) at time *t*;
A_{t-1} = account balance at age *t*-1 (i.e., Dec 31 of previous year = January 1 of this year);
L_t^s = life expectancy conditional on surviving to age *t*, by gender/marital status;[49]
s indexes the gender/marital status of the individual;

Account balances evolve in the following manner:

$$A_t = A_{t-1} * (1 + r_t) - W_t^I \tag{4}$$

where r_t = rate of return earned on the portfolio at age *t*

All who die in a given year are assumed to die in the middle of that year.[50] Thus, in the event of the death of a single individual at age *t*, or, in the case of a married couple, in the event of death of the surviving spouse at age *t*, the amount of the bequest is calculated as:

$$B_t = A_{t-1} * (1 + (0.5) * r_t) \tag{5}$$

To compare payout streams, this paper borrows measures developed by Dus, Maurer, and Mitchell (2005) to measure the present discounted value (PDV) of benefit payments (that is, either annuity payments or withdrawals from the investment account), bequests, and shortfall. These measures take into account life expectancy as well as the time value of money. The PDV of benefit payments is calculated as:

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[48] This is essentially the formula used by the IRS to determine required minimum distributions (RMD) from IRAs and 401(k) plans (which must begin in the year after the beneficiary attains age 70-1/2. Specifically, the balance as of January 1 determines the RMD for that year, and the distribution must be made by December 31. The *t* subscripts in the formula represent end-of-year measures, so the withdrawal is based on *t*-1account balances (assumed to also be equal to the balance on January 1) and withdrawals take place at time *t*, that is, December 31 of year *t*.

[49] For married couples, the average of male and female conditional life expectancy is used.

[50] Distributions from the account occur annually. An individual dying the day after a distribution would have fewer assets to bequeath than an individual dying the day before a distribution. The representative individuals in these examples are assumed to die in the middle of the year, which is roughly equivalent to what the average value of bequests would be from many individuals with deaths spread out over the entire year.

$$\text{PDV Benefits} = \sum_{t=67}^{t=100} \frac{W_t^I * \Pr(alive)_t}{(1+r*)^{(t-66)}} \text{ for the investment account}$$

$$\text{PDV Benefits} = \sum_{t=67}^{t=100} \frac{W_t^A * \Pr(alive)_t}{(1+r*)^{(t-66)}} + \frac{(L_{100}^s * W_{100}^A) * \Pr(alive)_t}{(1+r*)^{(45)}} \text{ for life annuities} \quad (6)$$

where t = age
W_t^I = withdrawal from investment account at age t
W_t^A = annuity payment at age t
$\Pr(alive)_t$ = probability individual who is alive at age 67 is alive at age t
$r*$ = risk-free rate of return (=5.2%; 2.4% real + 2.8% inflation)

In the case of annuities, the value of payments after age 100 for those that survive to age 100 is estimated as the conditional life expectancy at age 100 (in years) multiplied by the annual annuity payment.[51]

In the case of the investment account, any remaining balance at the time of death is bequeathed to the heir. The PDV of bequest is calculated as:

$$\text{PDV Bequest} = \sum_{t=67}^{t=100} \frac{B_t * \Pr(die)_t}{(1+r*)^{(t-66)}} \quad (7)$$

where B_t = bequest at age t (defined in equation (5) above); and
$\Pr(die)_t$ = probability individual who is alive at age 67 dies after age *t-1* and before age t

Note, the probability of dying is a flow concept – that is, it is the probability that a single individual dies or, in the case of a married couple, the probability that the surviving spouse dies, in a given year.[52] Upon death, annuity payments cease and there are no death benefits paid. Thus, the PDV of bequests in the case of an annuity is always equal to $0.

To help quantify the risks involved in the various payout methods, Dus, Maurer, and Mitchell (2005) develops a measure of shortfall relative to the amount of payment that would be received for an equivalent investment in an inflation-indexed, or real, annuity. The measure is:

$$Shortfall_t = 1 \text{ if } W_t^{(I \text{ or } A)} < W_t^{A_R} \quad (8)$$
$$= 0 \text{ otherwise}$$

[51] As noted in Footnote 22, the life expectancy tables in Arias (2006) end at age 100.
[52] $\Pr(die)_t$ is not the inverse $\Pr(alive)_t$ – which is a stock concept. The inverse of the probability that one is alive is the probability that one is dead – which is also a stock concept – not the probability that one dies in a given year.

where $W_t^{A_R}$ = real annuity payment at age t

To summarize the size of the shortfall when it does occur, Dus, Maurer, and Mitchell (2005) also defines a measure of the PDV of the shortfall:

$$\text{PDV Shortfall} = \sum_{t=67}^{t=100} \frac{SF_t * \Pr(alive)_t}{(1+r)^{(t-66)}} \tag{9}$$

where $SF_t = W_t^{A_R} - W_t^{(I \text{ or } A)}$ if $W_t^{(I \text{ or } A)} < W_t^{A_R}$
= 0 otherwise

To summarize the number of years that a shortfall would be expected for any individual, I define the shortfall count as:

$$\text{Shortfall Count} = \sum_{t=67}^{t=100} Shortfall_t * \Pr(alive)_t \tag{10}$$

ii. Comparison of Payout Options

The assumptions regarding the portfolio of the investment account during the distributions phases are exactly the same as the assumptions regarding the portfolio of the investment account during the accumulation phase. That is, it is a portfolio composed of 50 percent stock mutual funds and 50 percent bond mutual funds, with the portfolio rebalanced annually. As was done for the accumulation phase, 5,000 stochastic simulations are run.

To understand how alternate payouts compare in retirement, Figures 3, 4, and 5 plot, for single men, single women, and married couples, respectively, the payout, conditional on survival, from a $100,000 investment in a real life annuity, in a nominal life annuity, and in the investment account. Given the fact that payouts from the investment account will vary depending on market returns, results are reported for the top 10 percent, the middle 10 percent, and the bottom 10 percent of simulation results ranked by the PDV of withdrawals.

Payment streams for the alternate payouts are plotted in the top panels of the figures. Conditional on survival, an inflation-indexed annuity pays a constant real amount of benefits each period. A nominal annuity pays a constant nominal amount, but the real benefit declines over time. The nominal annuity pays out a higher amount than a real annuity initially, but pays less than a real annuity by age 80 for women and married couples and by age 79 for men, and the benefit continues to decline in real terms thereafter.

For the middle decile of simulation results ranked by the PDV of withdrawals, the investment account payment maintains its value better than the nominal annuity. For women, median payouts from the investment account exceed real annuity payments from age 69 to age 92, and thereafter exceed nominal annuity payments until age 97. For men, median payouts from the investment account exceed real annuity payments from age 68 to age 86, and thereafter exceed nominal annuity payments until age 92. For married couples, conditional on both surviving, the median payouts from the investment account exceed real annuity payments from age 67 to age 90, and thereafter exceed nominal annuity payments until age 95. In addition, because payments are modeled as being the same whether both spouses survive or one spouse survives, surviving spouses fair even better with the investment account. Conditional on one spouse surviving, median payouts from the investment account exceed real annuity survivor payments from age 67 to age 96, and thereafter exceed nominal annuity survivor payments until age 99 (not shown).

However, these higher expected payouts come at a risk. On the one hand, in the top 10 percent of simulations payouts from the investment account greatly exceeded both real and nominal annuity payments. On the other hand, in the bottom 10 percent of simulations, payouts were generally below both real and nominal annuity payments.[53]

The bottom panels of Figures 3, 4, and 5 chart a few other items to consider when comparing payouts. First, unlike an annuity, an account balance will exist in the event of death, providing a potential benefit to heirs. The average end-of-year account balance is charted for the top, middle, and bottom deciles of the simulations ranked by the PDV of withdrawals. Second, the benefits charted in the top panel are conditional on survival. The bottom panel also charts the probability that an individual retiring at age 67 will be alive at any given age.[54] For example, women age 67 in 2033 are expected to have about a 49 percent chance to survive to age 86 and

[53] The exception is the case of married couples where only one spouse survives. In this case, payments from the investment account corresponding to the lowest 10 percent of simulations ranked by PDV of withdrawals were higher than real annuity survivor payments from age 67 to age 88, and greater than nominal annuity survivor payments from age 67 to age 93.

[54] It is assumed that individuals are born on January 1, 1966. The probability of being alive is charted as of December 31 of any given year. Thus, the probability that a worker retiring at age 67 survives to age 67 is charted as being less than 100 percent. That is because there is less than a 100% chance they will survive from January 1, 2033 to December 31, 2033, when the first annuity payment or investment account payout is assumed to occur.

about a 20 percent chance to survive to age 93. Men are expected to have about a 47 percent chance to survive to age 83 and about a 19 percent chance to survive to age 90. For married couples, both the probability that both spouses survive and the probability that one spouse survives are plotted. A couple who are both age 67 in 2033 is expected to have a 47 percent chance that both spouses survive until age 79 and a 21 percent chance that both survive until age 85. There is a 50 percent chance that *exactly* one spouse will survive until age 85 (67 percent chance that *at least* one spouse survives until age 85) and a 21 percent chance that *exactly* one spouse will survive until age 94 (22 percent chance that *at least* one spouse survives until age 94).

For men, Table 10 converts these payments into PDV measures that take into account both the time value of money and life expectancy. The PDV of benefit payments from a real annuity purchased for $100,000 is $73,438. A nominal annuity has a PDV of $81,881, but the extra payments come at a cost. On average, and accounting for mortality, the nominal annuity will pay less than the real annuity in 5.5 years during retirement, and the PDV of the shortfall is $2,768.

On average, the investment account provides a much higher return. Taking the average over all 5,000 simulations, the PDV of withdrawals from the investment account is $84,424 – higher than the PDV of payments from both the real and the nominal annuity. Relative to the nominal annuity, the average likelihood of shortfall relative to the real annuity is also much lower with an investment account: 2.0 years, on average, with a PDV of $923. In addition, the expected value of bequests from an investment account is $44,032, making the total expected payment from the account $128,456. Compared to the real annuity, the average PDV of withdrawals for males is 15 percent higher and the average PDV of total payments, inclusive of the PDV of bequests, is 78 percent higher.

Table 10 also presents the investment simulation results by decile, ranked by the PDV of benefits. Looking only at the median 500 simulations, the results are similar to the overall average. Again, the investment account also carries with it much upside and downside risk. In the top 10 percent of simulations, the PDV of benefits is nearly twice that of a real annuity and the PDV of total payments, inclusive of expected bequests, is nearly three times that of the real annuity. Compared to the real annuity, the investment account was only expected to have a shortfall in 1.1 years over the retirement period, with the PDV of shortfalls of $199 in the top 10 percent of simulations. In the bottom 10 percent of simulation, the investment account had a lower PDV of benefits and about the same PDV of total payments (inclusive of bequests) as the real annuity. Those with returns in the bottom 10 percent were expected to have an investment account payout that was less than the real annuity payment in 15.6 years, on average, with a PDV of the shortfall of over $23,248.

Table 11 provides similar statistics for women. In general the results are similar to the men's results, although women are more likely than men to experience a shortfall with a nominal annuity. Compared to the real annuity, the average PDV of withdrawals for females is 22 percent higher and the average PDV of total payments is 77 percent higher.

Table 12 shows the PDV measures for married couples. As noted above, payments from the investment account are modeled to continue until there are no surviving spouses. Thus, compared to single individuals, the PDV of withdrawals from the investment account are higher and the PDV of bequests are lower. On average, the PDV of withdrawals represents 81 percent of the PDV of total payments for married couples, compared to 69 percent for single women and 66 percent for single men. Compared to the real annuity, the average PDV of withdrawals for married couples is 61 percent higher and the average PDV of total payments is 99 percent higher. Risks of shortfall are also lower for married couples. For example, compared to the joint-and-50-percent survivors real annuity, the lowest decile of simulations of the investment account are expected to have a shortfall in 14.1 years during retirement (compared to 15.1 years for single males and 18.2 years for single females), with a PDV of shortfalls of $11,867 (compared to $23,248 for single men and $23,746 for single women).

c. Replacement Rates in Retirement: Combining Accumulation and Distribution

This section combines the simulation results from the accumulation phase and the distribution phase – as well as the calculation of Social Security benefits and taxes – to compare net income streams in retirement for each of the simulated individuals and couples.

Figures 6 through 9 plot net retirement income conditional on survival for each simulation as well as the survival probabilities for each individual or couple. In each graph, the straight red line represents annual net income from the baseline case. The middle blue line is the net income generated if the individual or couple experienced market returns in both the accumulation phase simulation and the distribution phase simulation that were equal to the average return for the median decile of simulations.[55] To bound the potential outcomes from investing in the market, two other lines are plotted: the top light blue line is the net income generated if market returns in both the accumulation phase simulation and the distribution phase simulation were equal to the average return for the highest decile of simulations; the bottom light blue line is the net income generated if market returns in both the accumulation phase simulation and the distribution phase simulation were equal to the average return for the lowest decile of simulations. For single individuals, the green line plots the probability that the individual who is alive at age 67 is alive at any given age. For married couples, both the probability that both spouses are alive and the probability that only one spouse is alive are plotted.

Figure 6 shows the results for single males, single females, and married couples with the HS-35K earnings path. Net income generated when median returns are experienced in both the accumulation and distribution phase would be above the baseline net income until age 91 for single males, when the survival probability for men is 16 percent, and until age 96 for single females, when survival probability for women is 10 percent. For both single-earner couples and dual-earner couples, net income from the investment account experiencing median returns exceeds net income from the baseline case until age 93 if both spouses survive, when the probability of both spouses surviving is 2 percent, and until age 98 if one spouse survives (not shown), when the probability for one spouse surviving is 8 percent. Because married couples get more of their retirement income from Social Security benefits and less from invested assets, the range of outcomes due to market return variation is much lower for married couples than it is for single individuals.

Figures 7 through 9 plot the same information for the Col-55K earnings path, the Grad-75K earnings path, and the Scaled-Grad 100K earnings path. In comparison to the baseline case, results for the path that represents median market returns are similar to the HS-35K earnings path: the investment account produces more net income until late in the simulation (although it remains higher than the baseline case even at the end of the simulation period for the Scaled Grad-100K earnings path). As the proportion of income that is generated by the investment account increases, the variability in outcomes increases, as indicated by the increased distance between the top and bottom blue lines.

[55] Ranked by accumulated total assets in the accumulation stage and the PDV of withdrawals in the distribution phase.

Tables 13 through 18 present the same information on net retirement income as Figure 6 through 9, but in terms of replacement rates. Recall from above that the average replacement rate measures incorporate survival probabilities. In addition to the baseline case, the Tables present a range of possible outcomes from the simulations of the investment account. First, the expected value is presented, which is simply the average results of all 5,000 simulations for both the accumulation and distribution phase. Results are also presented that correspond to the average results from the highest decile, the middle decile, and the lowest decile of accumulation simulations ranked by accumulated total assets. For each of these accumulation deciles, results corresponding to the highest decile, the middle decile, and the lowest decile of the distribution simulations ranked by the PDV of withdrawals are presented.

Table 13 presents the results for single males. For example, for a worker with the Col-55K earnings path, accounting for savings, taxes, and mortgage payments, the baseline case replacement rate is 108 percent. The expected replacement rate from the investment account would be 129 percent, although it could range from as high as 207 percent to as low as 95 percent. If the worker experienced median returns in both the accumulation and distribution phase, he could expect a replacement rate of 124 percent. Having median returns in the accumulation phase would not be a guarantee that the investment account would outperform the baseline case: if he experienced returns that were the average of the lowest decile of simulations in the distribution phase, the replacement rate would be about the same as the baseline case. Similarly, experiencing accumulation phase returns that were the average of the lowest decile of simulations would be no guarantee that the investment account would underperform the baseline case: if he experienced returns that were the average of the highest decile of simulations, the replacement rate would be higher than the baseline case.

In general, Tables 13 through 18 show that an investment portfolio has much more volatility in outcomes than the baseline case. However, the downside of the results is limited in terms of replacement rates, as Social Security benefits provide a floor for retirement income. For example, controlling for savings, taxes and mortgage payments, the baseline case replacement rate for a female with Col-55K earnings would be 106 percent. If she instead invested an investment account and experienced average returns that were in the lowest deciles of simulations in both the accumulation and distributions phase, the replacement rate would be 93 percent. As the income from the 401(k) account represents a larger proportion of retirement income, the downside risk becomes larger. The baseline case replacement rate for a single female with Scaled Grad-100K earnings would be 98 percent, but would be only 83 percent if she instead invested an investment account and experienced average returns that were in the lowest deciles of simulations in both the accumulation and distributions phase. Conversely, a married couple with HS-35K earnings would receive little income from their 401(k) assets, so they face little downside risk. Compared to the baseline case, even receiving the lowest returns would reduce the replacement rate by only 2 percentage points for retired couples.

One result of note for married couples is that, because annuity payments are cut in half when a spouse dies but payments from the investment account are assumed to continue until both spouses die, surviving spouses can expect much more net income, on average, from an investment account relative to the baseline case (Tables 17 and 18).

d. ***Discussion of Stochastic Simulation Results***

The simulations described above show both the average or median return and the variance of that return that can be expected from investing retirement account assets in the equity and debt markets. The variance that is modeled is the variance in experiences across time periods rather than the variance in experience across individuals. That is to say, the simulations do not illustrate that some individuals will experience better investment returns than others. The simulations assume all individuals are invested in the same exact investment portfolio – a portfolio that is 50-percent corporate equity mutual funds and 50-percent corporate bond mutual funds – and that the portfolio is rebalanced annually. There is no variance in returns across individuals in these simulations. However, depending on the time period one invests over, the entire market would experience different rates of investment returns. Thus, all workers retiring in a given year would either have experienced historical returns that were above average, average, or below average. To the extent that individuals investing over the same time period experience different rates of return, it would represent an additional source of variation, and that source of variation is not modeled here.[56]

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[56] To the extent that other factors are correlated with market returns, it is possible that time variance in replacement rates obtained from the investment account may be different than those reported here. For example, if long-run market returns are correlated with wage growth, it is possible that there is less variance in investment account replacement rates than those reported. Alternatively, if TIPS rates were allowed to vary, the baseline case would produce a range of replacement rates, reducing the perceived relative risk of the investment account.

The point of the simulation exercise is to illustrate the range of potential outcomes that retirees might expect; it is not to recommend any particular investment option or payout method. To answer these questions would require that judgments be made about individual's preferences, including their tolerance for risk. And, the method of this paper was chosen specifically to avoid making such judgments. Nonetheless, questions are likely to arise as to which particular measure of income replacement should be used to judge retirement adequacy and whether or not the simulations provide insight into which investment options or payout methods should be chosen. To assist those wishing to make these judgments, I discuss a few issues that should be considered.

A generally accepted principle of economics is that the marginal investor should be indifferent between receiving the risk-free rate of return and an investment that has a higher expected rate of return but more risk. Thus, when considering the adequacy of any of the savings paths considered in the simulations, the baseline case measures are the most appropriate to consider. In particular, the marginal investor is assumed to be indifferent between the risk-free rate of return and the whole set of possible outcomes associated with the risky asset. So the baseline case, if nothing else, provides a convenient shorthand way to represent, *ex ante*, the full range of returns available in the marketplace.

Whether, in fact, an individual *should* choose either the risk-free investment or the risky investment is a separate question. If the individual is the marginal investor, then economic theory does not provide much insight: Because the investor is indifferent, the choice is essentially a coin flip. If the investor is not the marginal investor, she would gravitate to either the risk-less asset (if she is more risk averse than the marginal investor) or risky assets (if she is less risk averse than the marginal investor). I have no particular insight into which assumption would be the most appropriate, but I discuss below some factors that may influence an individual's choice.

Regarding the accumulation phase, it is commonly posited that most investors are better off if they have a diversified investment portfolio. For many individuals, their largest assets in retirement are their Social Security benefits and their home. For the baseline case simulation, Table 19 reports the allocation of assets at retirement for each of the cases simulated in this paper. Retirement assets are defined as 401(k) plan balances plus the lump-sum value of Social

Security benefits.[57] Net worth is defined as retirement assets plus the value of owner-occupied housing.[58] Controlling for marital status and gender, the value of 401(k) plan assets as a percent of both retirement assets and net worth increases with the earnings path. For single individuals, the ratio of 401(k) assets to total retirement assets (i.e., 401(k) assets as a percent of 401(k) assets plus the value of Social Security assets) ranges from 19 percent to 50 percent, and the ratio of 401(k) assets to net worth, from 15 percent to 40 percent. For married couples, the ratio of 401(k) balances to total retirement assets ranges from 5 percent to 34 percent, and the ratio of 401(k) assets to net worth, from 4 percent to 28 percent. For many of these individuals, the bulk of their assets are indexed for inflation (Social Security benefits) or represent a hedge against changes in the cost of residential services (owner-occupied housing). It may be that they would benefit by investing in more risky assets with their 401(k) account and diversifying their portfolio.

Regarding the distribution phase, standard lifecycle models predict that individuals will want to annuitize their wealth at retirement. This result relies to some extent on three underlying assumptions: (1) individuals are indifferent between the risk-free rate of return and riskier investments; (2) annuity prices are actuarially fair; and (3) individuals place no value on amounts bequeathed to heirs. Despite the strength of this prediction, empirical evidence shows that few individuals annuitize all of their financial assets at retirement. There are alternative explanations for this phenomenon. For example, it may be that individuals are not acting rationally.[59] Alternatively, they may be rational, but the decision may be so complex and the cost of obtaining proper information so high, that they make the wrong choice and choose not to annuitize. Or, individuals may be "boundedly" rational; that is, they are generally rational, but some aspect of their decision-making leads to suboptimal choices.[60] If these explanations are the true explanation for the empirical anomaly, then government programs that mandate or encourage annuitization or which provide education regarding financial decision-making may be appropriate public policy.

However, an alternative explanation is that the models used to make the prediction that individuals will choose to annuitize their wealth at retirement do not adequately account for all

[57] Social Security benefits are converted to a lump sum using the real annuity prices used throughout the paper.
[58] The value of owner-occupied housing is assumed to remain constant, in real terms, from time of purchase.
[59] If the assumption of rational behavior does not hold, I would suggest that the lifecycle model has larger problems than the fact that the prediction individuals will annuitize wealth at retirement does not hold.
[60] For an example of a paper that uses bounded rationality, see Laibson (1997).

the relevant factors that influence an individual's decisions. As noted above, it may be the case that an individual is not, in fact, indifferent between investments that pay the risk-free rate of return with certainty and riskier investments and thus would prefer to invest in the market rather than buy an actuarially fair real annuity. This may be more likely to be true if a large portion of their wealth is in the form of a real annuity – namely Social Security benefits.

Even if individuals would choose an actuarially fair annuity over a market investment, annuities offered in the private insurance markets are unlikely to be actuarially fair for the average individual. This is not due to some fault of private insurance companies, but rather to the existence of asymmetric information and adverse selection: It is likely that individuals have better information than the insurance company as to how long they will live. If an insurance company offered an annuity that was actuarially fair for the average individual, those who had private information indicating that they would live longer than average would choose to annuitize and those who had private information indicating that they would live shorter than average would choose not to annuitize, and the insurance company would lose money. In this case, in equilibrium, annuities will have prices that are not actuarially fair for the average individual, and only a portion of individuals, who in aggregate would be expected to live longer than average, will annuitize their wealth. The fact that annuities offered in the private market are not actuarially fair for the average individual can be seen by the PDV of benefits measures of real and nominal annuities: Using life expectancy data from the population as a whole, the PDV of a dollar invested in an annuity is well below a dollar. Presumably, for the pool of individuals that actually choose to annuitize, the PDV of a dollar invested in an annuity would be much closer to a dollar. That is to say, annuity prices are likely to be actuarially fair for the pool of individuals that buy annuities currently, but are not likely to be actuarially fair for the population as a whole. And the problem of asymmetric information and adverse selection is not likely to be solved short of mandatory annuitization.[61]

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[61] Social Security represents a government program that requires that benefits be paid out in the form of a mandatory real annuity. Note that mandatory annuitization would imply that an annuity could be offered that would be actuarially fair to the average individual (or, more exactly, to within some percentage of fair to allow for a reasonable insurance company profit) without the insurance company losing money (or, more exactly, having negative economic profits). It does not imply that each individual would receive a fair annuity, in the sense that they would assign a PDV of approximately a dollar to a dollar invested in an annuity: Those who expect to live longer than average would receive a benefit that *ex ante* would be greater than fair, and those who expect to live shorter than average would receive a benefit that *ex ante* would be less than fair.

Finally, even if a private insurance company offered an actuarially fair annuity and some individuals would otherwise choose the actuarially fair annuity, individuals may still choose not to annuitize their wealth if they place at least some value on the amount of money that they leave to their heirs. Given that annuities are typically not actuarially fair, the value that individuals place on bequests can play an important role in their choice to annuitize. For example, even if an investment account experienced returns equivalent to the lowest decile of simulations ranked by the PDV of benefits, the PDV of total payments, inclusive of the PDV of bequests, from an investment account would be either close to (single individuals) or higher than (married couples) the PDV of total payments from a real annuity. Depending on risk tolerance and the value an individual places on bequests to heirs, it is certainly possible that some would rationally choose not to annuitize their wealth.

7. Reevaluating the Empirical Evidence

To help provide some context for what the simulations imply for the population as a whole, Table 20 and Table 21 provide some general descriptive statistics regarding education and housing.

Table 20 shows the distribution of full-time non-dependent workers who worked in 2004 by education. Of all workers, 11 percent had a graduate degree, 21 percent had a bachelor's degree, 28 percent had some college or an associate's degree, 30 percent had a high school diploma or GED, and 9 percent had no high school diploma or GED. Although workers younger than age 65 are more likely to have education beyond high school than workers over age 65, the distribution of full-time workers by education does not vary markedly by age.

Table 21 reports statistics of homeownership by the age of the head of household in 2004 from the 2004 Survey of Consumer Finances (SCF). Homeownership increases monotonically with age but the incidence of mortgage debt falls after age 54. The loan-to-value ratio falls with age both for all homeowners and for just those homeowners that have mortgage debt. Among households headed by individuals age 65 to age 74, 81 percent own their own home, and of these households, 61 percent have no mortgage debt.[62] The loan-to-value ratio for all households in

[62] There is likely a selection bias in the sample because the sample is made up of households, and households are classified by the age of the household head. If, for example, the elderly who have fewer resources are more likely to move in with relatives and no longer be considered a household head, than the sample of the elderly that are household heads is likely to be more affluent than the elderly population in general.

this age group is 15 percent; for only those households in this age group with mortgage debt, the loan-to-value ratio is 38 percent.

Figure 10 plots homeownership and mortgage debt information by education level of the household head. Households headed by an individual with a bachelor's degree or a graduate degree are more likely to own a home, especially at younger ages. However, conditional on owning a home, those with a high school education or less are less likely to have mortgage debt (i.e., more likely to have no mortgage debt). Of those households with mortgage debt, those headed by individuals with a graduate degree have the highest average loan-to-value ratio after age 65.

a. Private Pensions

It is often stated that the private pension system in general, and 401(k) plans in particular, are not working properly and need significant reform. While I would certainly not contend that the complex web of rules and regulations that govern the private sector pension system are, in the words of Dr. Pangloss, "the best of all possible worlds," I would contend that some evidence of its failure is not as convincing as it might appear at first glance. For example, Munnell and Sundén (2004, 2006) argue that the 401(k) is "coming up short." Among the reasons cited for this shortcoming are that many who are offered a 401(k) plan do not participate, and those that participate do not contribute enough. Another fact often cited as a failure of the private pension system is that so few workers work for an employer that offers a plan. In light of the simulation results, this section reexamines these issues.

To look at the adequacy of pension coverage and participation, I examine data from the March 2005 Current Population Survey (CPS). Two questions are asked of respondents: (1) Does your employer provide pension benefits to any employee? And, (2) Do you participate in a pension plan? Note that the data do not distinguish between defined benefit pension plans and defined contribution pension plans, nor do they ascertain if the worker is eligible to participate. For the analysis, I focus on private-sector full-time workers, rather than all workers. Limiting my analysis to this group is not an attempt to deceive or driven by any animosity toward government or part-time workers. Private sector workers are the focus because few accuse government pension benefits of being inadequate. Full-time workers are the focus because the simulations in this study assume full-time earnings.[63]

Recall from the simulations that I assume that those with higher earnings begin contributing to a 401(k) plan earlier in life. The ages at which contributions start in the simulations range from age 32 for the highest-earning single individuals to age 52 for the lowest -earning married couples. The top panel of Figure 11 plots the probability that an employer sponsors a pension plan by the age and education level of the employee. Although for the sample as a whole the percentage of full-time private-sector workers that are employed at firms that offer a pension plan is 63 percent, the probability that a worker's employer offers a pension plan is not uniform among all workers. The probability that a firm offers a pension plan increases with an employee's education. And, controlling for education, the probability that a firm offers a pension plan increases with an employee's age. For example, full-time workers under age 25 without a high school diploma have only a 21 percent chance of working for a firm that sponsors a pension plan, and without a high school degree this probability never rises above 50 percent. For those with a high school degree, the probability ranges from 43 percent to 65 percent. In contrast among those age 55 to age 64, workers with a bachelor's degree have a 76 percent chance of working for an employer that sponsors a plan and workers with a graduate degree have an 80 percent chance. While it may be preferable for all workers to have access to a retirement savings plan at work, those who are most likely in the phase of their life in which they would desire to accumulate retirement assets are also most likely to work for a firm that sponsors a plan.[64]

The bottom panel shows the probability that an employee participates in a pension plan conditional on the employer sponsoring the plan. For the entire sample, 85 percent of workers

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[63] Because part-time workers have not been modeled, the simulations provide little insight into their participation behavior. I suspect that most part-time workers earn less than their full-time compatriots, would have a relatively higher replacement rates from Social Security benefits, and thus would have less of a need to accumulate retirement assets. Another reason for not including part-time workers in the analysis is that it is easier for an employer to deem a part-time worker ineligible for a pension plan under pension rules than it is for an employer to deem a full-time worker ineligible. Because the annual CPS March supplement data do not provide information on eligibility, this makes comparing full-time and part-time participation rates conditional on sponsorship problematic.

[64] One reason why there may be this correlation between worker characteristics and employer sponsorship of pension plans is the existence of pension nondiscrimination rules. If a firm has a workforce that, in general, does not desire to save for retirement, nondiscrimination rules may make it too costly to offer a pension plan to any employee. For a further discussion of the effect of nondiscrimination rules may have on firm behavior, see Brady (forthcoming).

that work for firms that sponsor a plan participate in the plan.[65] However, participation rates differ substantially by age and education. Controlling for age, workers with higher education levels have higher conditional participation rates. Not accounting for education, participation rates conditional on an employer sponsoring a pension range from 58 percent for employees under age 25 to 92 percent for employees age 55 to age 64. For every education level, conditional participation rates peak in the prime savings years of age 35 to age 64. For example, even among those with no high school diploma, 84 percent of workers age 55 to age 64 participate in a plan if their employer sponsors a plan. For workers in this age group with higher levels of education, the conditional participation rate is well over 90 percent. Again, this is not to say that all who should be contributing to a 401(k) plan are contributing to a 401(k) plan, but rather to note that who chooses to participate in a pension plan does not appear to be random. Those who are most likely in the phase of their life in which they would desire to accumulate retirement assets are also most likely to participate in a pension plan if the employer sponsors the plan.

To illustrate that most 401(k) participants make inadequate contributions to their 401(k) plan, Munnell and Sundén (2004, 2006) note that few participants (11 percent in their 2006 study) contribute the "maximum" to their 401(k) plan – which they define as the lesser of 25 percent of earnings or the legal maximum contribution ($15,000 at the time of the 2006 study).[66] The simulations above suggest that this is a poor statistic by which to judge the adequacy of contributions. No individual or couple in the simulations comes close to contributing the "maximum" to their 401(k), yet all manage to accumulate assets that appear adequate to finance their retirement.

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[65] Studies focusing on participation in 401(k) plans often get participation rates, conditional on sponsorship or eligibility, ranging from about 70 to 80 percent. Besides the fact that this analysis focuses on full-time workers only, there are at least two other reasons why the 401(k) conditional participation rates in these studies would differ from the conditional participation rate in the CPS data. First, CPS data do not distinguish between DB and DC pension plans, and DB plans may have a higher conditional participation rate. Second, many studies looking at 401(k) participation do not control for the presence of a DB plan. It may be that some of those not participating in a 401(k) plan are participating in a DB plan, and thus would be coded as participating in a pension plan in the CPS, even though they are not participating in a 401(k) plan that is offered.

[66] Examining a large sample of 401(k) plan participants, Holden and VanDerhei (2001) found that 11 percent of participants contributed up to the maximum to their 401(k) (that is, up to the so-called "402(g)" limit) which was $10,000 in 1999 – the year of the data analyzed. However, they conclude that, of those not at the limit, 52 percent could not have contributed the maximum because the plan-imposed limit was lower.

b. *7.2 Asset Accumulation*

The simulations showed that, making fairly modest contributions to a 401(k) plan, individuals and married couples could accumulate retirement assets that appeared to be adequate to fund consumption in retirement. This section examines data on asset accumulation to determine whether or not households are accumulating assets at a rate that is at all comparable to the rate of asset accumulation calculated in the simulations.

For households headed by individuals with a high school diploma or GED, the top panel of Figure 12 compares the time path of 401(k) plan balances from the baseline case simulation to the median amount of retirement assets (which include defined contribution pension plan balances and IRAs) and the median amount of total financial assets (which include retirement assets plus financial assets held in taxable accounts) held by households, as reported in the 2004 Survey of Consumer Finances (SCF).[67] As can be seen, the median amount of retirement assets accumulated by these households is very low. For households age 55 to 64, the median amount is less than $5,000. Over these same age ranges, the baseline case simulations calculate these households would be holding, on average (that is, averaged over the age range), about $15,000 for married couples and about $53,000 for single individuals. However, as noted earlier, less educated workers are less likely to be offered a retirement plan at work and less likely to participate in a plan if one is offered. Although the simulations assumed that individuals only accumulated assets in a 401(k) account, households may, of course, accumulate assets in taxable accounts. Looking instead at total financial assets, median asset accumulation is much higher.[68] For example, for households age 55 to 64 the median amount of financial assets is $31,000 – in between the amount predicted for married couples and single individuals.[69] The bottom panel of Figure 12 looks at a broader measure, namely net worth. Net worth includes the value of all household assets, including tangible assets such as owner-occupied housing and business assets, less all household debt, including mortgage debt. In this case, the median net worth of these

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[67] Amounts are inflated to 2006 levels using the September-to-September increase in the Consumer Price Index.

[68] At the time of withdrawal, a dollar held in a taxable account will produce more net income than a dollar held in an 401(k) account or a deductible IRA. This is because the entire distribution from the retirement account would be taxed as ordinary income, whereas only a portion of the distribution would be taxed if it came from a taxable account and, if the amount above basis were a capital gain, it would be taxed at lower rate.

[69] Benefits accrued under a defined benefit pension plan at a worker's current employer are not included in assets. Unless already distributed in the form of a lump sum payment or the respondent knows the lump sum value of accumulated benefits, defined benefit pension benefits accrued at a previous employer are also not included as assets. To the extent that households will receive benefits from such plans in excess of the amount reported, the measure of retirement assets, financial assets and net worth are underestimated.

households is above the amount predicted in the simulations for both married couples and single individuals. The accumulation pattern of retirement assets and total financial assets for the median household appears to be more similar to the pattern of married couples than to the pattern of single individuals in the simulation – that is, the accumulation of financial assets begins closer to age 52 than to age 42. However, it appears that the assumption that a home is purchased prior to this point concurs with the behavior of the median household, as net worth begins to increase at an earlier age than does the value of financial assets.

Figure 13 looks at the same data for households headed by an individual with a bachelor's degree. The median household aged 55 to 64 has accumulated about $77,000 in retirement assets – in between the amount predicted for married couples and single individuals. However, both total financial assets (at about $200,000) and net worth (at about $635,000) are much higher than predicted by the simulation. Unlike households headed by individuals with a high school degree, households headed by individuals with a college education begin accumulating retirement, financial, and tangible assets earlier in life, and appear to be doing so earlier than assumed in the simulations.

Figure 14 plots the same series for households headed by individuals with a graduate degree. The median household aged 55 to 64 has accumulated about $167,000 in retirement assets – below the amount predicted for both married couples and single individuals. Once again however, both total financial assets (at about $380,905) and net worth (at about $819,052) are much higher than predicted by the simulation, and accumulation of wealth begins earlier than the assumptions used in the model.

As noted above, the names for the earnings paths are descriptive of their derivation, but are not necessarily meant to be representative of households headed by individuals with a particular level of education. It is likely representative of single individuals and single-earner married couples. To the extent that both spouses work, households are likely to have total earnings greater than the corresponding earnings path. To allow a greater ability to compare asset accumulations from the simulations to actual levels of asset accumulation in the population, Table 22 shows, for households with a head age 55 to 64, the average amounts (over all ages of the grouping) accumulated in the simulations by marital status and earnings paths, and the 25th, 50th, and 75th percentile of the distribution of retirement assets, financial assets, and net worth by education level. Overall, I interpret the data on asset accumulation as being roughly consistent with the pattern of asset accumulation in the baseline case simulations.

8. Conclusions

Several recent studies (Engen, Gale, and Uccello, 2004; Hurd and Rohwedder, 2006; Scholz, Seshadri, and Surachai, 2006) suggest that current pre-retirees are either optimally or adequately prepared for retirement. A fourth recent study (Haveman, Holden, Wolfe, and Romanov, 2006) shows that current pre-retirees are, on average, wealthier than previous generations of retirees. To date, these studies have not seemed to affect the growing policy consensus that the nation is facing a retirement savings "crisis." One reason for this apparent disconnect may be that those who believe there is a looming crisis do not agree with the researchers' definitions of optimal or adequate savings. In particular, there may be "distrust" of the results from research that employs a lifecycle model because there is a belief that the results are driven largely by the assumptions regarding individuals' preferences that the researchers make. This paper suggests that the results of the aforementioned research do not depend primarily on the authors' assumptions regarding individual preferences. The conclusion that most households are preparing adequately for retirement can be reached assuming only that individuals would like to have approximately the same amount of after-tax income in retirement as the amount of income they had prior to retirement, after accounting for saving, taxes, and (if they own a home) mortgage payments. This paper shows that moderate savings rates can lead to adequate replacement rates in retirement; that this accumulation of assets can be achieved within a 401(k) account; and that individuals need not invest in risky assets to achieve these results (although they might rationally choose to do so). Reexamining the empirical data shows that pension participation rates and asset accumulation rates are roughly consistent with the moderate rates of savings assumed in the simulations.

To some extent, differences between studies that conclude that households are generally not prepared for retirement and studies that conclude that households are generally prepared for retirement may not be as large as might appear. For example, the baseline case simulations in this paper assume that individuals retiring in 2033 retire at the normal Social Security retirement age of 67. Munnell, Webb, and Delorme (2006) finds that nearly half of Americans will be "at risk" in retirement. However, the study's "base case" assumes that individuals retire at age 65.

Assuming, instead, that workers retire at age 67, the study finds far fewer at risk (although, admittedly, still more than would be suggested by the research described in this paper). To a large extent the differences between the studies do not appear to be primary disagreements as to the amount of assets that households have accumulated, but rather disagreements regarding what amount of assets are "enough." Focusing more on these differences, rather than the top line declaration of "crisis" or "no crisis" might be a fruitful path for future research to follow. If the primary issue about retirement preparedness is either early retirement, health care costs in retirement, or future cuts to Social Security benefits, perhaps a discussion focused more specifically on these issues might help the policy debate move forward.

It is also important to note that none of the studies, including this study, addresses the question of why households appear to be, on average, saving adequately for retirement. Is it because they are foresighted and plan optimally? Or is it because institutions exist – Social Security, employer-provided pension benefits, and tax-advantage savings accounts – that have led to the result that people are, on average, well prepared for retirement? The answers to these questions are crucial as reforms are considered for all of these institutions. Also, even if, on average, individuals are preparing adequately for retirement, there are likely to be portions of the population that will not have adequate resources in retirement. Who are these individuals and how can they best be helped?

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Table 1: Savings Behavior Assumptions by Earnings Path and Marital Status

Earnings Path	**Single** *Age start savings*	**Single** *Savings as percent of earnings*	**Married** *Age start savings*	**Married** *Savings as percent of earnings*
HS-35K	42	6% (6% employee; 0% employer)	52	4% (4% employee; 0% employer)
Col-55K	42	9% (6% employee; 3% employer)	47	6% (4% employee; 2% employer)
Grad-75K	32	9% (5% employee; 4% employer)	37	9% (5% employee; 4% employer)
Scaled Grad-100K	32	10% (5% employee; 5% employer)	37	10% (5% employee; 5% employer)

Source: Author's assumptions

Table 2: Asset Accumulation at Retirement for Baseline Case Simulation (2006 $)[70]

Marital Status	**Earnings Path HS-35K**	**Earnings Path Col-55K**	**Earnings Path Grad-75K**	**Earnings Path Scaled Grad-100K**
Single	$77,709	$188,867	$377,704	$559,562
Married	28,245	96,160	313,481	464,417

Source: Author's calculations

[70] Assumes savings are invested in inflation-indexed bond earning 2.4% real; inflation rates taken from history and Social Security Administration's Intermediate Projection.

Table 3: Results From Baseline Case Simulation[71]

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Earnings (2006 $)				
Earnings in Year 2032	$39,278	$64,644	$84,423	$112,564
Average Real Earnings (over age 30)	36,219	58,306	77,156	102,874
Annual Social Security Benefit (2006 $)				
Single	$18,814	$26,124	$29,250	$33,315
Married 1-Earner	28,221	39,187	43,875	49,973
Married 50/50 earners	24,754	32,547	39,214	48,342
Replacement Rate Social Security Only (percent)				
Nominal 2033 Benefit To Nominal 2032 Earnings				
Single	49%	42%	36%	30%
Married 1-Earner	74	62	53	46
Married 50/50 earners	65	52	48	44
Average Real Benefit to Average Real Wage				
Single	52%	45%	38%	32%
Married 1-Earner	78	67	57	49
Married 50/50 earners	68	56	51	47
401(k) Balance at Retirement (2006$)				
Single	$77,709	$188,867	$377,704	$559,562
Married	28,245	96,160	313,481	464,417
Real Annuity (2006 $)				
Single Male	$4,587	$11,149	$22,297	$33,032
Single Female	4,263	10,362	20,722	30,699
Married Joint and 50% Survivor	1,455	4,953	16,146	23,919
Replacement Rate Social Security plus Real Annuity (percent)				
Nominal 2033 Income To Nominal 2032 Earnings				
Single Male	61%	59%	63%	61%
Single Female	60	58	61	58
Married 1-Earner	78	70	73	67
Married 50/50 Earners	69	60	67	66
Average Real Benefit to Average Real Wage				
Single Male	65%	64%	67%	64%
Single Female	64	63	65	62
Married 1-Earner	82	76	78	72
Married 50/50 Earners	72	64	72	70

Source: Author's calculation

[71] Assumes savings are invested in inflation-indexed bond earning 2.4% real; inflation rates taken from history and Social Security Administration's Intermediate Projection. At retirement, real annuity purchased, with pricing for annuity taken from Vanguard's annuity website on October 31, 2006.

Table 4: Results From Baseline Case Simulation[72] Accounting for Savings and Taxes

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Average Real Pre-Tax Earnings (over age 30, 2006$)				
All Cases	$36,219	$58,306	$77,156	$102,874
Average Real Earnings After Tax and Savings (2006$)				
Single	$26,850	$40,227	$51,005	$65,646
Married 1-Earner	29,434	44,688	56,644	72,250
Married 50/50 Earners	29,643	44,953	56,909	72,446
Reduction in Average Real Earnings Due to Tax and Savings (percent)				
Single	-25.9%	-31.0%	-33.9%	-36.2%
Married 1-Earner	-18.7	-23.4	-26.6	-29.8
Married 50/50 Earners	-18.2	-22.9	-26.2	-29.6
Average Real Benefit plus Annuity (2006$)				
Single Male	$23,401	$37,274	$51,546	$66,347
Single Female	23,077	36,486	49,972	64,015
Married 1-Earner	29,676	44,139	60,020	73,892
Married 50/50 Earners	26,209	37,500	55,359	72,261
Average Real Benefit plus Annuity After Tax (2006$)				
Single Male	$23,392	$35,680	$46,096	$56,150
Single Female	23,071	35,068	45,206	54,517
Married 1-Earner	29,676	44,139	58,064	69,390
Married 50/50 Earners	26,209	37,500	53,683	67,863
Reduction in Average Real Benefit plus Annuity Due to Tax (percent)				
Single Male	-0.0%	-4.3%	-10.6%	-15.4%
Single Female	-0.0	-3.9	-9.5	-14.8
Married 1-Earner	0.0	0.0	-3.3	-6.1
Married 50/50 Earners	0.0	0.0	-3.0	-6.1
Replacement Rate: Average Real Net Retirement Income to Average Real Net Earnings (percent)				
Single Male	87%	89%	90%	86%
Single Female	86	87	89	83
Married 1-Earner	101	99	103	96

[72] Assumes savings are invested in inflation-indexed bond earning 2.4% real; inflation rates taken from history and Social Security Administration's Intermediate Projection. At retirement, real annuity purchased, with pricing for annuity taken from Vanguard's annuity website on October 31, 2006.

	HS-35K	**Col-55K**	**Grad-75K**	**Scaled Grad-100K**
Married 50/50 Earners	88	83	94	94

Source: Author’s calculation

Table 5: Results From Baseline Case Simulation[73] Accounting for Taxes, Savings, and Owner-Occupied Housing

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Average Real Pre-Tax Wage (over age 30, 2006$)				
All Cases	$36,219	$58,306	$77,156	$102,874
Average Real Earnings After Tax, Savings, and Mortgage (2006$)				
Single	$22,522	$33,080	$42,693	$55,439
Married 1-Earner	24,897	36,399	46,845	60,590
Married 50/50 Earners	25,106	36,644	47,084	60,737
Reduction in Average Real Earnings Due to Tax, Savings, and Mortgage (percent)				
Single	-37.8%	-43.3%	-44.7%	-46.1%
Married 1-Earner	-31.3	-37.6	-39.3	-41.1
Married 50/50 Earners	-30.7	-37.2	-39.0	-41.0
Average Real Benefit plus Annuity (2006$)				
Single Male	$23,401	$37,274	$51,546	$66,347
Single Female	23,077	36,486	49,972	64,015
Married 1-Earner	29,676	44,139	60,020	73,892
Married 50/50 Earners	26,209	37,500	55,359	72,261
Average Real Benefit plus Annuity After Tax (2006$)				
Single Male	$23,392	$35,680	$46,096	$56,150
Single Female	23,071	35,068	45,206	54,517
Married 1-Earner	29,676	44,139	58,064	69,390
Married 50/50 Earners	26,209	37,500	53,683	67,863
Reduction in Average Real Benefit plus Annuity Due to Tax (percent)				
Single Male	-0.0%	-4.3%	-10.6%	-15.4%
Single Female	-0.0	-3.9	-9.5	-14.8
Married 1-Earner	0.0	0.0	-3.3	-6.1
Married 50/50 Earners	0.0	0.0	-3.0	-6.1
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings (percent)				
Single Male	104%	108%	108%	101%
Single Female	102	106	106	98

[73] Assumes savings are invested in inflation-indexed bond earning 2.4% real; inflation rates taken from history and Social Security Administration's Intermediate Projection. At retirement, real annuity purchased, with pricing for annuity taken from Vanguard's annuity website on October 31, 2006.

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Married 1-Earner	119	121	124	115
Married 50/50 Earners	104	102	114	112

Source: Author's calculation

Table 6: PIA Formula under "Progressive Indexing" Beginning in 2012
PIA formula for individual age 67 in 2033, expressed in 2006 dollars

AIME Level	Percent Factor Current law or "wage indexed"	Percent Factor "Inflation-indexed"	Percent Factor "Progressively indexed"
Under $743	90%	76%	90%
Over $743 below $1,813	32%	27%	32%
Over $1,813 below $4,482	32%	27%	24%
Over $4,482	15%	13%	11%

Source: Author's calculation using explanation from Purcell (2005).

Table 7: Results From Baseline Case Simulation[74] with Cut in Social Security Benefits

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
PROGRESSIVE INDEXATION				
Reduction in Net Retirement Income (percent)				
Single Male	-5.4%	-8.3%	-7.5%	-7.0%
Single Female	-5.5	-8.4	-7.9	-7.2
Married 1-Earner	-6.4	-10.7	-9.6	-10.1
Married 50/50 Earners	0.0	-3.2	-5.2	-7.3
Replacement Rate: Average Real Net Income in Retirement to Average Real Earnings Net of Taxes and Savings (percent)				
Single Male	82%	81%	84%	80%
Single Female	81	80	82	77
Married 1-Earner	94	88	93	86
Married 50/50 Earners	88	81	89	87
Replacement Rate: Average Real Net Income in Retirement to Average Real Earnings Net of Taxes, Savings, Mortgage Payments (percent)				
Single Male	98%	99%	100%	94%
Single Female	97	97	98	91
Married 1-Earner	112	108	112	103
Married 50/50 Earners	104	99	108	104
28% ACROSS-THE-BOARD CUT IN BENEFITS				
Reduction in Net Retirement Income (percent)				
Single Male	-22.5%	-20.3%	-17.5%	-16.6%
Single Female	-22.8	-20.6	-17.9	-17.1
Married 1-Earner	-26.6	-24.9	-19.5	-18.3
Married 50/50 Earners	-26.4	-24.3	-19.0	-18.1
Replacement Rate: Average Real Net Income in Retirement to Average Real Earnings Net of Taxes and Savings (percent)				
Single Male	68%	71%	76%	73%
Single Female	66	70	74	69
Married 1-Earner	74	74	83	79
Married 50/50 Earners	65	63	76	77
Replacement Rate: Average Real Net Income in Retirement to Average Real Earnings Net of Taxes, Savings, Mortgage Payments (percent)				
Single Male	80%	86%	89%	84%

[74] Assumes savings are invested in inflation-indexed bond earning 2.4% real; inflation rates taken from history and Social Security Administration's Intermediate projection. At retirement, real annuity purchased, with pricing for annuity taken from Vanguard's annuity website on October 31, 2006.

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Single Female	79	84	87	82
Married 1-Earner	87	91	100	94
Married 50/50 Earners	77	77	92	92

Source: Author's calculation

	Arithmetic Mean	Standard Deviation	Memo: Geometric Mean
NOMINAL			
Ibbotson total returns			
Large Company Stock	12.4%	20.3%	10.4%
Long-Term Corporate Bond	6.2%	8.6%	5.9%
50/50 Portfolio	9.3%	11.8%	8.7%
Ibbotson returns less expense[75]			
Large Company Stock	11.2%	20.3%	9.2%
Long-Term Corporate Bond	5.5%	8.6%	5.2%
50/50 Portfolio	8.3%	11.8%	7.7%
REAL (Current Nominal Return less Current Inflation)			
Ibbotson total returns			
Large Company Stock	9.3%	20.9%	7.2%
Long-Term Corporate Bond	3.1%	10.2%	2.6%
50/50 Portfolio	6.2%	12.8%	5.4%
Ibbotson returns less expense[75]			
Large Company Stock	8.1%	20.9%	5.9%
Long-Term Corporate Bond	2.4%	10.2%	1.9%
50/50 Portfolio	5.2%	12.8%	4.4%

Source: Author's calculation using data from Ibbotson Associates (2005) and U.S. Bureau of Labor Statistics

[75] Expense assumed to be 120 basis points for stock fund and 70 basis points for bond fund.

Table 9: Results from Stochastic Simulations: Accumulation

	SINGLE HS-35K	SINGLE Col-55K	SINGLE Grad-75K	SINGLE Scaled Grad-100K	MARRIED HS-35K	MARRIED Col-55K	MARRIED Grad-75K	MARRIED Scaled Grad-100K
Balance at the end of 2032 (2006$)								
Investment Account[76]								
Average	$113,679	$276,301	$653,018	$967,434	$ 35,060	$129,342	$499,425	$739,889
By Decile								
Top	216,736	526,857	1,394,984	2,066,643	56,896	228,518	1,013,163	1,500,983
Middle	104,249	253,369	575,095	851,993	33,495	121,112	449,302	665,633
Bottom	54,851	133,305	263,562	390,462	20,521	68,513	219,223	324,775
Baseline Case[77]	77,709	188,867	377,704	559,562	28,245	96,160	313,481	464,417
Difference between Investment Account[76] and Baseline Case[77] (percent)								
Investment Account[76]								
Average	46.3%	46.3%	72.9%	72.9%	24.1%	34.5%	59.3%	59.3%
By Decile								
Top	178.9	179.0	269.3	269.3	101.4	137.6	223.2	223.2
Middle	34.2	34.2	52.3	52.3	18.6	25.9	43.3	43.3
Bottom	-29.4	-29.4	-30.2	-30.2	-27.3	-28.8	-30.1	-30.1
Percent of Cases where Investment Account[1] Performs Better Than Baseline Case[77]								

[76] Assumes savings are invested in portfolio that is 50-percent stocks and 50-percent bonds. Five-thousand stochastic simulations are run assuming real returns after investment expenses are drawn from a distribution of returns with mean and standard deviation equal to historical experience (5.2% mean, 12.8% standard deviation); inflation rates taken from history and Social Security Administration's Intermediate projection.

[77] Assumes savings are invested in inflation-indexed bond earning 2.4% real; inflation rates taken from history and Social Security Administration's Intermediate projection.

	SINGLE HS-35K	SINGLE Col-55K	SINGLE Grad-75K	SINGLE Scaled Grad-100K	MARRIED HS-35K	MARRIED Col-55K	MARRIED Grad-75K	MARRIED Scaled Grad-100K
Percent of Cases	78.5%	78.5%	82.4%	82.4%	72.4%	75.6%	80.8%	80.8%

Source: Author's calculation

Table 10: Results from Stochastic Simulation: Distribution
Comparison of Present Discounted Value[78] of Investment Account and Annuities for Males
($100,000 investment at age 67 in 2033; payout age 67 to 100)

Option	Payments PDV of Benefits	Payments PDV of Bequest	Payments PDV of Total Payments	Relative to Real Annuity Years of Shortfall Weighted by Probability Alive	Relative to Real Annuity PDV of Shortfall Conditional on Shortfall
Annuities					
Real Annuity	$73,438	$0	$73,438	0.0	$0
Nominal Annuity	81,881	0	81,881	5.5	2,768
Investment Account					
Average	84,424	44,032	128,456	2.0	923
By Deciles					
Top	137,168	77,318	214,486	1.1	199
Middle	80,854	41,504	122,357	2.6	1,367
Bottom	50,129	23,614	73,743	15.6	23,248

Source: Author's calculation
Assumes investment account that annually pays out 1/E[T] of the account balance, where E[T] is life expectancy conditional on age; upon death, account balance is left to heirs. Life expectancy in 2033 at age 67 expected to equal life expectancy in 2006 at age 65. Account invested in portfolio that is 50-percent stocks and 50-percent bonds. Five-thousand stochastic simulation are run assuming real returns after investment expenses are drawn from a distribution of returns with mean and standard deviation equal to historical experience (5.2% mean, 12.8% standard deviation); inflation rates taken from Social Security Administration's Intermediate Projection.
The nominal annuity pays constant nominal amount until death. The real annuity pays amount that increases with inflation. There are no payments upon death. Pricing for annuity taken from Vanguard's annuity website on October 31, 2006. Life expectancy in 2033 at age 67 expected to equal life expectancy in 2006 at age 65; inflation rates taken from Social Security Administration's Intermediate Projection.

[78] PDV at time of purchase. Takes into account both probability alive and time cost of money, using nominal interest rate of 5.2%: 2.8% inflation plus 2.4% real.

Table 11: Results from Stochastic Simulation: Distribution
Comparison of Present Discounted Value[78] of Investment Account and Annuities for Females
($100,000 investment at age 67 in 2033; payout age 67 to 100)

Option	Payments PDV of Benefits	Payments PDV of Bequest	Payments PDV of Total Payments	Relative to Real Annuity Years of Shortfall Weighted by Probability Alive	Relative to Real Annuity PDV of Shortfall Conditional on Shortfall
Annuities					
Real Annuity	$76,112	$0	$76,112	0.0	$0
Nominal Annuity	$84,643	$0	$84,643	7.1	$3,378
Investment Account					
Average	$92,645	$41,874	$134,519	2.6	$872
By Deciles					
Top	$157,577	$78,049	$235,626	1.0	$366
Middle	$87,941	$39,064	$127,006	2.8	$1,045
Bottom	$52,165	$20,757	$72,922	18.2	$23,746

Source: Author's calculation
Assumes investment account that annually pays out 1/E[T] of the account balance, where E[T] is life expectancy conditional on age; upon death, account balance is left to heirs. Life expectancy in 2033 at age 67 expected to equal life expectancy in 2006 at age 65. Account invested in portfolio that is 50-percent stocks and 50-percent bonds. Five-thousand stochastic simulation are run assuming real returns after investment expenses are drawn from a distribution of returns with mean and standard deviation equal to historical experience (5.2% mean, 12.8% standard deviation); inflation rates taken from Social Security Administration's Intermediate Projection.
The nominal annuity pays constant nominal amount until death. The real annuity pays amount that increases with inflation. There are no payments upon death. Pricing for annuity taken from Vanguard's annuity website on October 31, 2006. Life expectancy in 2033 at age 67 expected to equal life expectancy in 2006 at age 65; inflation rates taken from Social Security Administration's Intermediate Projection.

Table 12: Results from Stochastic Simulation: Distribution
Comparison of Present Discounted Value[78] of Investment Account and Annuities for Married Couples
($100,000 investment at age 67 in 2033; payout age 67 to 100)

Option	Payments PDV of Benefits	Payments PDV of Bequest	Payments PDV of Total Payments	Relative to Real Annuity Years of Shortfall Weighted by Probability Alive	Relative to Real Annuity PDV of Shortfall Conditional on Shortfall
Annuities					
Real Annuity	$69,079	$0	$69,079	0.0	$0
Nominal Annuity	$80,702	$0	$80,702	9.4	$2,551
Investment Account					
Average	$111,404	$26,149	$137,553	0.2	$88
By Deciles					
Top	$192,057	$54,270	$246,327	0.0	$366
Middle	$105,483	$23,761	$129,244	0.4	$145
Bottom	$61,587	$10,888	$72,475	14.1	$11,867

Source: Author's calculation

Assumes investment account that annually pays out 1/E[T] of the account balance, where E[T] is life expectancy conditional on age; upon death, account balance is left to heirs. Life expectancy in 2033 at age 67 expected to equal life expectancy in 2006 at age 65. The measure of life expectancy used is the average of male and female life expectancy conditional on survival to a given age. Account is invested in portfolio that is 50-percent stocks and 50-percent bonds. Five-thousand stochastic simulation are run assuming real returns after investment expenses are drawn from a distribution of returns with mean and standard deviation equal to historical experience (5.2% mean, 12.8% standard deviation); inflation rates taken from Social Security Administration's Intermediate Projection.

Both annuities are joint and 50-percent survivor annuities. The nominal annuity pays constant nominal amount until death of one spouse, upon which it pays 50-percent of the initial nominal amount to the surviving spouse until death. The real annuity pays an amount that increases with inflation. This constant real amount is paid until death of one spouse, upon which the annuity pays the surviving spouse 50-percent of the initial real amount until death. There are no payments upon death. Pricing for annuity taken from Vanguard's annuity website on October 31, 2006. Life expectancy in 2033 at age 67 expected to equal life expectancy in 2006 at age 65; inflation rates taken from Social Security Administration's Intermediate Projection.

Table 13: Comparison of Baseline Case[79] with Stochastic Simulation of Investment Account[80] for Single Males

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings (percent)				
Baseline Case[79]	87%	89%	90%	86%
Investment Account[80]				
Expected Value	99	106	119	118
Accumulation: Highest Decile				
Distribution: Highest Decile	146	170	258	274
Distribution: Middle Decile	119	128	175	183
Distribution: Lowest Decile	101	109	132	132
Accumulation: Middle Decile				
Distribution: Highest Decile	112	121	146	148
Distribution: Middle Decile	95	102	110	108
Distribution: Lowest Decile	85	89	94	88
Accumulation: Lowest Decile				
Distribution: Highest Decile	93	99	103	99
Distribution: Middle Decile	83	86	87	82
Distribution: Lowest Decile	78	78	77	72
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings Less Mortgage Payments (percent)				
Baseline Case[79]	104%	108%	108%	101%
Investment Account[80]				
Expected Value	118	129	143	140
Accumulation: Highest Decile				
Distribution: Highest Decile	174	207	308	325
Distribution: Middle Decile	142	156	209	216
Distribution: Lowest Decile	121	132	157	156
Accumulation: Middle Decile				
Distribution: Highest Decile	133	147	174	175
Distribution: Middle Decile	113	124	132	128
Distribution: Lowest Decile	101	108	112	105
Accumulation: Lowest Decile				
Distribution: Highest Decile	111	120	123	117
Distribution: Middle Decile	99	105	104	97
Distribution: Lowest Decile	93	95	92	85

[79] Assumes savings are invested in inflation-indexed bond earning 2.4% real. At retirement, real annuity purchased, with pricing for annuity taken from Vanguard's annuity website on October 31, 2006.
[80] Assumes savings are invested in portfolio that is 50-percent stocks and 50-percent bonds. After retirement account pays out 1/E[T] of the account balance, where E[T] is life expectancy conditional on age. Five-thousand stochastic simulations are run assuming real returns after investment expenses are drawn from a distribution of returns with mean and standard deviation equal to historical experience (5.2% mean, 12.8% standard deviation).

Source: Author's calculation

Table 14: Comparison of Baseline Case[79] with Stochastic Simulation of Investment Account[80] for Single Females

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings (percent)				
Baseline Case[79]	86%	87%	89%	83%
Investment Account[80]				
Expected Value	98	105	118	116
Accumulation: Highest Decile				
Distribution: Highest Decile	147	171	260	277
Distribution: Middle Decile	117	126	170	177
Distribution: Lowest Decile	98	105	125	125
Accumulation: Middle Decile				
Distribution: Highest Decile	112	122	147	149
Distribution: Middle Decile	94	100	109	106
Distribution: Lowest Decile	84	87	91	86
Accumulation: Lowest Decile				
Distribution: Highest Decile	94	99	103	100
Distribution: Middle Decile	83	85	86	81
Distribution: Lowest Decile	77	77	75	70
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings Less Mortgage Payments (percent)				
Baseline Case[79]	102%	106%	106%	98%
Investment Account[80]				
Expected Value	117	127	141	137
Accumulation: Highest Decile				
Distribution: Highest Decile	175	208	312	329
Distribution: Middle Decile	139	154	204	210
Distribution: Lowest Decile	117	128	150	148
Accumulation: Middle Decile				
Distribution: Highest Decile	133	149	175	177
Distribution: Middle Decile	112	122	130	125
Distribution: Lowest Decile	100	106	109	102
Accumulation: Lowest Decile				
Distribution: Highest Decile	112	121	123	118
Distribution: Middle Decile	99	104	103	96
Distribution: Lowest Decile	92	93	90	83

Source: Author’s calculation

Table 15: Comparison of Baseline Case[79] with Stochastic Simulation of Investment Account[80] for Single-Earner Married Couples

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings (percent)				
Baseline Case[79]	101%	99%	103%	96%
Investment Account[80]				
Expected Value	104	107	128	122
Accumulation: Highest Decile				
Distribution: Highest Decile	116	137	211	214
Distribution: Middle Decile	108	120	163	162
Distribution: Lowest Decile	104	108	136	131
Accumulation: Middle Decile				
Distribution: Highest Decile	108	116	144	141
Distribution: Middle Decile	103	105	122	117
Distribution: Lowest Decile	100	99	108	102
Accumulation: Lowest Decile				
Distribution: Highest Decile	103	104	115	109
Distribution: Middle Decile	100	97	102	96
Distribution: Lowest Decile	99	94	93	87
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings Less Mortgage Payments (percent)				
Baseline Case[79]	119%	121%	124%	115%
Investment Account[80]				
Expected Value	123	131	154	146
Accumulation: Highest Decile				
Distribution: Highest Decile	138	168	256	255
Distribution: Middle Decile	128	147	197	194
Distribution: Lowest Decile	122	133	164	156
Accumulation: Middle Decile				
Distribution: Highest Decile	128	142	174	168
Distribution: Middle Decile	122	129	148	139
Distribution: Lowest Decile	119	121	131	122
Accumulation: Lowest Decile				
Distribution: Highest Decile	122	128	139	130
Distribution: Middle Decile	119	120	123	115
Distribution: Lowest Decile	117	115	112	104

Source: Author's calculation

Table 16: Comparison of Baseline Case[79] with Stochastic Simulation of Investment Account[80] for Dual-Earner Married Couple[81]

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings (percent)				
Baseline Case[79]	88%	83%	94%	94%
Investment Account[80]				
Expected Value	91	91	119	120
Accumulation: Highest Decile				
Distribution: Highest Decile	104	121	204	212
Distribution: Middle Decile	96	105	156	160
Distribution: Lowest Decile	91	93	128	129
Accumulation: Middle Decile				
Distribution: Highest Decile	96	101	136	139
Distribution: Middle Decile	91	90	114	115
Distribution: Lowest Decile	88	83	100	100
Accumulation: Lowest Decile				
Distribution: Highest Decile	91	89	106	107
Distribution: Middle Decile	88	82	93	94
Distribution: Lowest Decile	86	78	84	85
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings Less Mortgage Payments (percent)				
Baseline Case[79]	104%	102%	114%	113%
Investment Account[80]				
Expected Value	108	112	144	143
Accumulation: Highest Decile				
Distribution: Highest Decile	123	149	246	252
Distribution: Middle Decile	113	128	188	191
Distribution: Lowest Decile	108	114	154	154
Accumulation: Middle Decile				
Distribution: Highest Decile	113	123	165	166
Distribution: Middle Decile	107	110	138	137
Distribution: Lowest Decile	104	102	120	119
Accumulation: Lowest Decile				
Distribution: Highest Decile	107	109	128	128
Distribution: Middle Decile	104	101	113	112
Distribution: Lowest Decile	102	96	102	101

Source: Author's calculation

[81] Each spouse earns exactly one-half of total earnings.

Table 17: Comparison of Baseline Case[79] with Stochastic Simulation of Investment Account[80] for Survivor of Single-Earner Married Couples

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings (percent)				
Baseline Case[79]	50%	49%	52%	48%
Investment Account[80]				
Expected Value	56	63	84	85
Accumulation: Highest Decile				
Distribution: Highest Decile	74	98	201	214
Distribution: Middle Decile	60	73	119	122
Distribution: Lowest Decile	54	59	80	79
Accumulation: Middle Decile				
Distribution: Highest Decile	63	76	117	120
Distribution: Middle Decile	55	60	77	79
Distribution: Lowest Decile	51	52	60	58
Accumulation: Lowest Decile				
Distribution: Highest Decile	57	64	80	79
Distribution: Middle Decile	52	53	61	58
Distribution: Lowest Decile	50	46	50	47
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings Less Mortgage Payments (percent)				
Baseline Case[79]	60%	61%	62%	58%
Investment Account[80]				
Expected Value	66	77	102	101
Accumulation: Highest Decile				
Distribution: Highest Decile	87	120	243	255
Distribution: Middle Decile	71	89	144	146
Distribution: Lowest Decile	63	72	96	95
Accumulation: Middle Decile				
Distribution: Highest Decile	75	93	141	143
Distribution: Middle Decile	65	74	93	91
Distribution: Lowest Decile	61	64	73	69
Accumulation: Lowest Decile				
Distribution: Highest Decile	68	78	96	94
Distribution: Middle Decile	62	65	73	69
Distribution: Lowest Decile	59	59	60	56

Source: Author's calculation

Table 18: Comparison of Baseline Case[79] with Stochastic Simulation of Investment Account[80] for Survivor of Dual-Earner Married Couple Error! Bookmark not defined.

	HS-35K	Col-55K	Grad-75K	Scaled Grad-100K
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings (percent)				
Baseline Case[79]	44%	42%	48%	47%
Investment Account[80]				
Expected Value	50	55	80	84
Accumulation: Highest Decile				
Distribution: Highest Decile	67	91	197	213
Distribution: Middle Decile	53	65	115	121
Distribution: Lowest Decile	47	51	76	78
Accumulation: Middle Decile				
Distribution: Highest Decile	57	68	113	119
Distribution: Middle Decile	49	53	73	75
Distribution: Lowest Decile	43	44	56	56
Accumulation: Lowest Decile				
Distribution: Highest Decile	51	56	76	78
Distribution: Middle Decile	46	46	56	57
Distribution: Lowest Decile	44	41	46	46
Replacement Rate: Average Real Net Income in Retirement to Average Real Net Earnings Less Mortgage Payments (percent)				
Baseline Case[79]	52%	51%	57%	56%
Investment Account[80]				
Expected Value	59	68	97	100
Accumulation: Highest Decile				
Distribution: Highest Decile	79	112	238	254
Distribution: Middle Decile	63	79	139	145
Distribution: Lowest Decile	56	63	92	93
Accumulation: Middle Decile				
Distribution: Highest Decile	67	84	137	142
Distribution: Middle Decile	57	65	89	90
Distribution: Lowest Decile	53	54	67	67
Accumulation: Lowest Decile				
Distribution: Highest Decile	60	69	92	93
Distribution: Middle Decile	54	56	68	68
Distribution: Lowest Decile	52	50	55	55

Source: Author's calculation

Table 19. Portfolio Allocation at Retirement for Representative Individuals and Couples (Baseline Case)

Earning Path	Percent of Retirement Assets: 401(k) Balance	Percent of Retirement Assets: Social Security[82]	Percent of Net Worth (if own house): 401(k) Balance	Percent of Net Worth (if own house): Social Security[82]	Percent of Net Worth (if own house): Housing
Single Male					
HS-35K	20%	80%	16%	64%	21%
Col-55K	30	70	23	53	23
Grad-75K	44	56	35	44	21
Scaled Grad-100K	50	50	40	39	21
Single Female					
HS-35K	19%	81%	15%	65%	20%
Col-55K	29	71	22	55	23
Grad-75K	42	58	34	46	20
Scaled Grad-100K	49	51	39	41	21
Married Single-Earner					
HS-35K	5%	95%	4%	81%	15%
Col-55K	11	89	9	72	19
Grad-75K	27	73	23	60	17
Scaled Grad-100K	33	67	27	55	18
Married Split 50-50 Earners					
HS-35K	6%	94%	5%	78%	17%
Col-55K	14	86	11	68	21
Grad-75K	30	70	24	58	18
Scaled Grad-100K	34	66	28	54	18

Source: Author's calculation

[82] Annual Social Security benefit payments converted to a lump sum using real annuity price quotes from Vanguard as shown in Appendix Table A1.

Table 20: Education of Full Time Private Sector Workers by Age in 2004

Age	No HS Diploma	HS Diploma/ GED	Some College or A.D.	Bachelor's Degree	Graduate Degree	All	Memo: Percent of Sample
Under 25	14%	38%	35%	12%	1%	100%	
25 to 35	10	28	28	25	9	100	23.1
35 to 44	9	30	27	23	12	100	26.7
45 to 54	8	30	28	21	12	100	26.0
55 to 64	8	29	28	19	16	100	13.8
65 and above	14	34	21	15	16	100	2.3
All	9%	30%	28%	21%	11%	100%	

Source: Author's tabulation from March 2005 Current Populations Survey

Table 21: Homeownership and Mortgage Debt by Age of Household Head in 2004

	Incidence for All Households			Incidence Conditional on Owning A Home		Loan-to-Value Ratio	
Age of Household Head	**Own Home**	**Have Mortgage Debt**	**No Mortgage Debt**	**Have Mortgage Debt**	**No Mortgage Debt**	**All Homeowners**	**Homeowners with Mortgage Debt**
Under 25	17%	15%	2%	89%	11%	68%	76%
25 to 35	50	45	5	91	9	67	73
35 to 44	68	63	5	92	8	58	63
45 to 54	77	65	13	84	16	44	52
55 to 64	79	51	28	64	36	26	40
65 to 74	81	32	49	39	61	15	38
75 and above	85	19	67	22	78	8	38
All	69%	48%	21%	69%	31%	38%	55%

Source: Author's tabulation from 2004 Survey of Consumer Finances

Table 22: Asset Accumulation by Earnings Path and Education for Households with Head Age 55 to 64

Results from Simulation -- Baseline Case

	Retirement Assets		Net Worth	
Earnings Path	*Married*	*Single*	*Married*	*Single*
HS-35K	14,868	52,788	99,080	137,000
Col-55K	59,865	128,293	219,868	288,295
Grad-75K	224,917	280,316	418,604	474,003
Scaled Grad-100K	333,211	415,283	585,847	667,918

Assets by Percentile of Asset Distribution from 2004 SCF (in 2006 dollars)

	Retirement Assets			Financial Assets			Net Worth		
Education of Household Head	*25th*	*50th*	*75th*	*25th*	*50th*	*75th*	*25th*	*50th*	*75th*
Less than high school diploma	0	0	0	0	321	10,685	1	18,336	135,160
High school diploma or G.E.D.	0	4,274	55,560	2,885	30,985	130,352	36,648	147,073	375,135
Some college or associates degree	0	13,890	94,024	13,676	54,171	231,428	79,397	265,725	602,364
Bachelor's degree	11,753	76,929	274,593	57,750	199,908	696,955	177,556	634,792	1,181,927
Graduate degree	12,821	166,679	406,548	84,515	380,905	836,602	318,560	819,052	1,797,786

Source: Author's calculation and tabulations from 2004 Survey of Consumer Finances, Federal Reserve Board of Governors

Appendix

Table A1: Annual Annuity Payment per $100,000 Investment[83]

	Real Annuity	Nominal Annuity
Male Single Life	$6,069	$8,401
Female Single Life	5,640	7,720
Joint and 50% Survivor	5,295	7,566

Source: https://flagship.vanguard.com/VGApp/hnw/accounttypes/retirement/ATSAnnuitiesOVContent.jsp

[83] Price quotes as of October 31, 2006. Date of birth of annuitant(s) was October 31, 1941; annual payments commencing in one year after initial investment.