The Impact of Asset Allocation, Savings and Retirement Horizons, Savings Rates, and Social Security Income in Retirement Planning: A Monte Carlo Analysis

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November 2009

Keywords: Retirement planning, Portfolio choice

JEL Classification: G11 – Portfolio Choice

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Abstract

This study uses Monte Carlo simulation to evaluate the ability of various deposit percentages and asset allocation weights to support withdrawals in retirement that permit smoothed income over the life of an individual. The results indicate that, in general, individuals need to deposit at least 15 percent of pre-retirement salary for 30 or more years in a portfolio consisting of at least 50 percent equity to achieve a high success rate for portfolio withdrawals. When Social Security payments are excluded from the retirement income, the success rate is greatly impacted by the savings rate, the savings period, and the amount of equity investment in the portfolio.

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1. Introduction

Traditionally, retirement planning and spending has focused on the “three-legged stool,” consisting of pension benefits, Social Security, and personal savings. In recent years, structural changes indicate that for many workers, the three-legged stool is quite wobbly. Increasingly workers cannot count on pension benefits in their retirement planning as they are nonexistent for many workers. In fact, less than 20 percent of private sector workers are covered by a defined benefit plan. Even more perilous for retirement planning than the disappearance of defined benefit pension plans is the looming insolvency of Social Security. In its 2009 annual report to Congress, the Social Security Trustees estimated that unless changes are made, the Social Security Trust Funds will be exhausted by 2037.

With the increased individual responsibility in retirement planning, there are several critical questions facing individuals: The fundamental question a retiree faces is: how should I prepare financially so that I will not outlive my retirement portfolio? To answer this question other questions have to be answered. First, what level of pre-retirement income is necessary to retire comfortably? Second, how much of my income must I save in order to retire comfortably? Third, what should be the asset composition of my retirement portfolio? Fourth, when should I begin saving for retirement? Fifth, what is my expected retirement income horizon? Sixth, when I retire, should I manage my funds or purchase an annuity? Seventh, if I decide to manage my funds what should be my retirement withdrawal rate? The specter of reduced or non-existent Social Security further exacerbates retirement planning. Each of these issues is important in its own right and has been examined by recent academic research in isolation or conjointly with selected other topics. However, these decisions are inter-dependent and need to be addressed concurrently. Our purpose in this paper is to jointly examine the nexus of decisions surrounding retirement income planning in the presence and absence of Social Security income.

The remainder of the paper is organized in the following manner: the next section discusses prior literature on the topic, the third section outlines our data and research methods; the fourth section discusses our results; and the last section contains our concluding remarks.

2. Literature Review

Fundamental to addressing retirement portfolio asset allocation, savings and withdrawal decisions is the question: “What level of retirement income is necessary to maintain my current standard of living?” This issue has been addressed in perhaps the most complete longitudinal study on the topic by Aon Consulting/Georgia State University commencing in 1988 and repeated approximately every four years. Although the replacement ratio varies according to pre-retirement income, in the most recent iteration of this study (2008) post-retirement income of about 78 percent of pre-retirement income is generally sufficient to sustain current life styles for families with pre-retirement income of $60,000 or greater.

Once a benchmark retirement income level is set, the joint decisions of how much to save, what instruments to invest in, when should savings commence and retirement life expectancy have to be addressed. Tezel (2006) finds that for a portfolio of 80 percent equity and 20 percent fixed income a savings rate of 17 percent over 30 years is necessary to achieve a 70 percent income replacement ratio. Ibbotson, Xiong, Kreitler, Kreitler and Chen (2007) focus on the pre-retirement decisions necessary to amass a portfolio that could sustain a retiree's pre-retirement lifestyle. Assuming a life expectancy of 18.3 years for males and 20.5 years for females retiring at age 65, using targeted maturity funds as an investment vehicle, employing Monte Carlo simulation to estimate investment returns, investing retirement capital in inflation indexed lifetime fixed payout annuities, and including Social Security payments in retirement income, they create a table (stratified by age and income levels) with suggested savings rates in order for an individual to retire with 80 percent of net pre-retirement income (gross income less retirement savings) adjusted for inflation.

The Ibbotson et. al. study provides practical retirement planning guidance for those individuals invested in targeted maturity funds. However, other asset allocation strategies can be utilized and will affect retirement planning. The risk versus return tradeoff faced by an individual deciding retirement portfolio allocations has dire consequences if ineffective but fundamentally is no different from the dilemma faced when investing in non-retirement funds: at any point in time how much risk should be taken for a given level of return? Markowitz (1952), Sharpe (1963) and Elton, Gruber and Padberg (1976) provide general frameworks for the solution of the portfolio selection problem under conditions of risk.

Most studies that focus on the empirical implications of asset allocation theory for retirement planning suggest that portfolios should consist of equities and fixed income securities and be re-balanced over time. Elton and Gruber (1975) use dynamic programming to analyze multi period portfolio problems that maximize the utility of terminal wealth. Accounting for the probabilistic nature of income replacement ratios, Booth (2004) uses Monte Carlo simulation to analyze retirement targets and asset allocation. He finds that for shorter time horizons the optimal allocation is 100 percent risk free bonds. As the time horizon is lengthened more equities are optimal. Vora and McGinnis (2000) address optimal asset allocation as the retiree draws down the retirement portfolio. They conclude that retirement portfolios should rely heavily on equity. Van Eaton and Conover (2002) suggest that in earlier work life years retirement portfolio contributions should be 100 percent equity and gradually reduced to bonds as retirement approaches.

Cooley, Hubbard, and Walz (1999, 2001) examine the joint impact of asset allocation strategies and withdrawal rates on retirement income sustainability. They find that a six to seven percent nominal withdrawal rate appears sustainable for most periods if the portfolio is comprised of at least 50 percent equity. If the equity portfolio weight drops below 50 percent, the portfolio withdrawals do not consistently last for 15 years. Their findings also show the importance of a diversified portfolio in funding retirement withdrawals. For many withdrawal rates and periods, a portfolio of stocks and bonds has a greater likelihood of successfully funding retirement withdrawals compared to a portfolio consisting of only stocks or a portfolio consisting of only bonds. Stout and Mitchell (2006) and Stout (2008) find that in general retirement portfolios should be heavily equity weighted (50 percent to 75 percent). Their model projects that overall portfolio withdrawal rates can be increased through periodic withdrawal adjustments based on portfolio performance and remaining life expectancy. Spitzer (2008) also finds that periodic withdrawal adjustments can decrease the risk of running out of money and increase the withdrawal amount. Fullmer (2007) suggests that distributions from a retirement portfolio can be increased through a dynamic asset allocation strategy using the cost of lifetime annuitization as a benchmark.

There is a dissenting viewpoint on retirement portfolio re-balancing. Hughen, Laatsch and Klein (2002) suggest that retirement portfolios should consist of a 100 percent equity allocation which their study found to have higher mean aftertax cash flows and terminal value.

Bierwirth (1994) focuses on the impact of annual returns on retirement portfolios. He models fund withdrawals from a retirement portfolio consisting of 20 percent U.S. Treasury bills, 40 percent long-term government bonds, and 40 percent large capitalization common stocks. Using data from 1926 to 1992, he analyzed the historical dollar withdrawal amount an investor could make without invading principal assuming a 27-year retirement period. His results highlighted the importance of the timing of returns. A major determinant of whether a portfolio can support withdrawals is the rate of return early in the fund withdrawal period. More generally, the conclusion of his study is that if returns are too low or negative early in the withdrawal period the portfolio value may fall to a level that makes recovery impossible.

These studies indicate that there is no universal agreement on portfolio asset allocation even among those versed in financial theory. Evidence exists that some 401(k) plan participants have made allocation decisions without the benefit of exposure to financial theory. When exposed to financial education, their allocation choices improve. Dolvin and Templeton (2006) find financial literacy seminar attendance associated with increased portfolio diversification and improved risk management. Clark, d'Ambrosio, McDermed and Sawant (2006) find that financial education produces significant changes in how individuals think and plan for retirement. Lusardi and Mitchell (2007) find that planners are more financially literate than non-planners and arrive at retirement with much higher wealth levels.

Whether or not an individual is versed in portfolio theory, Helman and Paladino (2004) and Thaler and Bernatzi, (2004) find that some individuals may not have the propensity to save the amounts required to achieve their goals. There also is evidence that retirement portfolio allocation may be impacted by non-financial theory factors. Agnew, Balduzzi and Sunder (2003) examine the investment patterns of participants in a 401(k) plan and find that while 22 percent of the participants have 100 percent average annual equity allocations, 48 percent of the participants have zero percent. They find stock allocations to be higher for married investors with higher incomes and job seniority.

Regardless of whether individuals allocate their retirement portfolios based on their exposure to financial theory or even abide by it when exposed, 401(k) asset allocation is an empirical matter. The bulk of 401(k) assets are in stocks. The Employment Benefit Research Institute (EBRI) reports that in year end 2007 about two thirds of 401(k) participant's assets were invested in equity securities with the bulk of remaining assets in fixed income securities.

Although many theorists laud the benefits of more conservative retirement portfolio re-balancing as one approaches retirement, this advice isn't widely heeded. The automatic re-balancing of portfolios as participants age through life-cycle funds is offered by two thirds of 401(k) plans (EBRI) but has not been broadly utilized. As of 2007 only 7 percent of 401(k) plan assets were held in life-cycle funds. This result is confirmed empirically by Agnew, Balduzzi and Sunder. They find that the participants in their sample survey re-balanced infrequently. Over 87 percent of the participants did not re-balance their portfolio. There is some empirical support for this strategy. Using simulation, Schleef and Eisinger (2007) conclude that life-cycle funds that reduce equity allocations over time underperform fixed asset allocation models when trying to amass a targeted portfolio value.

In summary, although many theorists suggest that retirement portfolio allocation strategies should be dynamic over time, there is not widespread agreement on an optimal strategy. Furthermore, empirical studies suggest that static portfolio allocations outperform dynamic ones and that plan participants haven't widely adopted the dynamic allocation rubric. Thus an important retirement planning issue that hasn't been fully addressed to date is: if a retirement plan participant desires a fixed asset allocation strategy, which one should she choose? This paper seeks to empirically extend the literature on retirement portfolio planning by comparing the performance of various fixed allocation strategies using varying savings rates over varying work life and retirement withdrawal time horizons. In other words, for different portfolio asset allocation strategies, what are the implications of various contribution periods, savings rates and withdrawal horizons for the probability of sustaining a pre-retirement life style?

Prior studies have kept some of the retirement planning parameters constant when studying one or more aspects of retirement planning. To create a table of suggested savings rates Ibbotson, Xiong, Kreitler, Kreitler and Chen stabilize life expectancy as well as the investment and retirement financing vehicles. To gauge the impact of annual returns Bierwirth holds the asset allocation and retirement period constant. This study extends prior literature by varying most of the retirement planning attributes: asset allocation, savings rates, work life and withdrawal period.

This paper aspires to provide insight on how individuals can be expected to fare economically in retirement for a given set of retirement planning parameters. We also study the impact of Social Security income on success rates. Our hope is that our results will provide retirement planning guidance for individuals at various stages in their work lives with various levels of risk aversion and varying propensities to save, both in the presence and absence of Social Security income.

3. Data and Analysis

Our feedstock data is returns on financial instruments, inflation and wage growth. The returns used in the construction of our portfolios are for large capitalization stocks, long-term corporate bonds, and inflation from Ibbotson's *Stocks, Bonds, Bills, and Inflation 2009 Yearbook.* We used return data from 1926 to 2008. Wage growth data was obtained from the U.S. Department of Labor's website. Since the latter source became available in its present form in 1971, we used wage growth data from 1971 to 2008. Employing these historical returns we use the Crystal Ball Monte Carlo simulation program to generate 10,000 simulated return series. We chose Monte Carlo simulation because of the inherent statistical independence of Monte Carlo simulation versus other estimation methods (Cooley, Hubbard and Waltz, 2003, Ibbotson et. al. 2007, Booth 2004).

The deposits, withdrawals, and investment returns are monthly. However, salary increases and Social Security inflation adjustments are on an annual basis. We calculate the annual salary (withdrawal) based on the previous year's annualized value and the annual wage growth (Social Security inflation adjustment). We then make equal monthly deposits or withdrawals based on this beginning of year value.

We used these returns to construct portfolios to analyze retirement fund terminal values. For simplification, and analogous to Ibbotson et. al., the portfolios are composed of large capitalization stocks and long-term corporate bonds. To extend prior research, we assess the impact on retirement planning of varying investment portfolio compositions. We examine portfolios with equity weights of 100, 75, 50, 25, and 0 percent. The remainder of the portfolio is invested in bonds.

Implicitly assumed in retirement planning studies is that individuals are in the workforce and have the wherewithal to save for retirement. Some individuals may begin saving for retirement immediately when entering the workforce, whereas others may postpone retirement savings until later in life, if at all. Furthermore, individuals may temporarily leave the labor force for job changes (e.g. layoffs), health reasons (e.g. extended sickness), family reasons (e.g. child care), military service or a variety of other causes. There may be periods where an individual works part time. Even when a person is in the workforce he or she may not set aside retirement funds. In general the retirement savings horizon is a subset of work life expectancy, which can be used to establish plausible ranges for retirement savings horizons.

According to Krueger, Skoog and Ciecka (2006), the average years in the active labor force for a male who enters the U. S. labor force at age 18 is 38.63 years, and that of females is 33.48 years.[1] For those males who presumably furthered their education and entered the labor force at a later age (25) average active labor force participation is 34 years, that of females is 29.01 years. To accommodate different retirement savings horizons for individuals based on work life expectancy we examine savings periods of 20, 30, and 40 years.

In addition to determining plausible ranges of work life savings, feasible ranges of retirement withdrawals must be established. Life expectancies are derived from the United States Life Tables produced by the U. S. Department of Health and Human Services. According to this source the average life expectancy of someone 63 years old (eligible for Social Security benefits) is 20.6 years. Consequently we examine withdrawal periods of 20 and 30 years.

The main outcome of Ibbotson et. al.'s study is suggested savings rates at varying ages and income levels in order for an individual to retire with 80 percent of net pre-retirement income adjusted for inflation. Our focus is slightly different. We assume that individuals have different propensities to save for retirement and focus on the retirement income horizon implications of these decisions. We examine savings rates varying from 10 percent to 25 percent of work life salary. This study is indifferent to matching employer contributions. We are concerned with what percentage of one's income is set

[1] The last report on work life expectancy produced by the United States Bureau of Labor Statistics (Bulletin 2254) was in 1986. Since then it has been incumbent on researchers to update the methodology and data sources for work life expectancy calculations.

aside for retirement. The employer/employee allocation will impact the employee's discretionary income during her work life, but not how much is invested for retirement in her name. Furthermore, employer contributions can be backed out of the savings percentage. For example, with a three percent of salary match and a 15 percent of salary savings rate, the employee would be saving 12 percent of salary.

Some individuals may have higher savings rates at the end of the pre-retirement period than the beginning due to circumstances such as children being grown, home mortgage being a smaller percentage of income or paid off, etc. Success rates may be improved due to the increased savings. To assess this effect on retirement planning we also examine the impact of increasing savings percentages over time on each asset allocation and time frame subset.

Our study focuses on income replacement ratios of 80 and 100 percent both with and without Social Security income. Although variation certainly exists in retirement income levels, our study assumes that an investor retires at an income of $100,000. Although this is admittedly at the high end of the income spectrum, this level was chosen because the onus of accruing a sustainable retirement portfolio is on the investor, as at this income level Social Security comprises about 25 percent of retirement income at an 80 percent income replacement ratio.[2] At a retirement level of $40,000 Social Security comprises about 51 percent of retirement income at an 80 percent income replacement ratio. In other words, in the presence of Social Security income if a portfolio strategy can successfully sustain someone who retires with a $100,000 income, it can assuredly sustain someone who retires at a lesser income level. In still other words, since Social

[2] The current formula of the Social Security Administration is used to calculate initial retirement year Social Security income. (Social Security Administration, *Your Retirement Benefit: How It Is Figured*)

Security is a larger component of total retirement income for individuals with pre-retirement income levels less than $100,000, our results will be understated when interpreted with the inclusion of Social Security. Success rates will be higher than posted in our results for individuals with pre-retirement incomes below the $100,000 threshold.

Regardless of pre-retirement income level, a critical question for any retiree is what percentage of pre-retirement income will be needed in retirement to sustain a given lifestyle. The 2008 Aon Consulting study finds that to sustain pre-retirement living standards, replacement ratios should be from 78 to 81 percent of pre-retirement income for salaries ranging from $50,000 (81 percent) to $90,000 (78 percent). Salaries below $50,000 require replacement ratios of up to 94 percent. In this study we used a post-retirement income of 80 percent of pre-retirement income. Our results will be most applicable for individuals with pre-retirement incomes of $50,000 and above. They will be understated for individuals with pre-retirement income of less than $50,000.

We adjust the post-retirement income for pre-retirement savings. To adjust for the pre-retirement savings rate, consider an individual who makes $100,000 per year and saves 10 percent of income. This implies the income after retirement savings is $90,000. Thus, 80 percent of pre-retirement income is $72,000.[3] This figure is adjusted for Social Security payments received during retirement years. For an individual who retires at a $100,000 income, the Social Security payments would constitute about 25 percent of post-retirement income. To account for total income smoothing, we also examine a post-retirement replacement ratio of 100 percent. Since this study focuses on the probability of

[3] Since Social Security is a payroll tax and not a voluntary deduction, it is not deducted from pre-retirement income to compute post retirement income.

attaining a percentage (80 percent or 100 percent) of pre-retirement income, our results are invariant to income levels when Social Security income is excluded.

Our method of analysis assumes an investor deposits an equal percentage of income each year into his retirement portfolio. We assume that income increases at the average wage growth rate. Since wage growth has generally increased at a faster rate than inflation, this implies that real purchasing power increases in the pre-retirement period. To keep purchasing power constant in the post-retirement period, we increase withdrawals each year by the inflation rate. Additionally, we increase Social Security payments by the inflation rate. In practice, Social Security payments are increased by lagged inflation. Because we increase these payments by current inflation, the difference should not be large.

The calculation of the growth of the portfolio implicitly assumes portfolio rebalancing each month. We do not include rebalancing costs in our analysis. While transaction costs of rebalancing could have potentially been large in the past, current investors can rebalance at a very low cost by using no-load index mutual funds or exchange-traded funds (ETFs). Taxes on portfolio gains are not considered. If the portfolio is held in a tax-deferred vehicle such as an IRA or 401k, taxes on the gains can be ignored since they are not paid until withdrawal. The results of this paper also do not address the issue of taxable retirement plans and tax-deferred retirement plans. Additionally, since pre-retirement income is considered on a pretax basis, withdrawals should also be considered on a pretax basis. For a discussion of the tax issue in retirement savings accounts, see Poterba (2004).

Whatever the pre-retirement savings horizon, savings rate and asset allocation decisions, before someone commences retirement a decision has to be made on whether to self-manage the retirement portfolio or purchase an annuity. If one self manages her retirement portfolio she is saddled with the risks of: low or negative investment returns, longer than “normal” longevity, and higher than expected inflation. The retiree can transfer these risks to an insurance company by purchasing an annuity. However, with this option the retiree loses the potential to have a higher level of withdrawal rates than provided by an annuity if favorable market conditions persist in addition to the possibility of passing any post-death retirement funds to heirs. In this study we assume that the retiree manages her portfolio. This allows us to focus on the effects of various retirement portfolio strategies pre and post retirement. Results may vary for those individuals choosing to purchase a retirement annuity.

In summary, for a given portfolio asset allocation we jointly assess the effects of contribution periods varying from 20 to 40 years and savings contributions varying from 10 to 25 percent of salary on portfolio survival for retirement incomes of 80 percent (and 100 percent) of ending work life income (with and without Social Security income) for withdrawal periods of 20 and 30 years. We begin each savings period by making an initial deposit. Each year, the same percentage of income is deposited in the account. At the end of the savings period, we begin withdrawals. The portfolio is considered a success if the terminal value of the portfolio at the end of the withdrawal period is greater than $0. We then calculate the success rate as the number of successful portfolios divided by the total number of simulated return series (10,000).

The structure of our study will allow us to examine two issues not concurrently addressed in previous studies. First, for a given asset allocation we assess the impact on retirement portfolio sustainability of allowing for variability in savings and retirement time horizons with varying savings rates. Second, we gauge the impact of Social Security on retirement portfolio sustainability.

3. Results

A. Summary Statistics

Table 1 shows moments of the distributions for stock and bond returns. Using the Anderson-Darling test for normality, stock returns and bond returns are best described by a Student's *t* distribution.[4] Stock returns had a mean annual return of 11.99 percent and a standard deviation of 19.11 percent. The bond returns had a mean annual return of 5.90 percent and a standard deviation of 7.39 percent. On average inflation reduces the nominal returns of stocks and bonds by 3.10 percent per year with a standard deviation of 1.86 percent. Stock returns had a low positive correlation with bond returns over this period, while inflation was negatively correlated with both stock and bond returns.

<<INSERT TABLE 1 ABOUT HERE>>

B. Static Work Life Savings Percentages

Table 2 shows the results for an 80 percent replacement ratio assuming full Social Security payments. For example, if an individual saves 15 percent of pre-retirement

[4] While stock returns are generally found to be lognormal, Crystal Ball reported that the returns were best described by a Student's *t* distribution. Although not reported here, we analyzed the success rates assuming a lognormal distribution with results similar to those reported here.

income for 30 years before retirement, invests in 100 percent equity, the withdrawals for 20 years will be successful 94.95 percent of the time.

<<INSERT TABLE 2 ABOUT HERE>>

The time horizon norm for analyzing retirement portfolio allocation and savings strategies under various replacement and Social Security income scenarios is a 30 year work life and at least a 20 year retirement period. This is approximately the worklife for a college graduate (males 34 years, females 29 years) and retirement period expectancies (20.6 years). In general for any set of allocation and savings values longer work lives and shorter retirement periods will result in higher success rates. Conversely, shorter work lives and/or longer life expectancies will result in lower success rates.

If an individual desires to sustain an 80 percent income replacement ratio over a 20 year retirement life expectancy, that individual should save at least 15 percent of salary and invest in portfolios consisting of at least 50 percent equity over at least 30 years. These portfolios have greater than 90 percent success rates. Within this range of portfolio equity content the success rates are almost invariant to asset allocation strategies. A 100 percent equity allocation has a 94.95 percent success rate, compared to 96.11 percent for 75 percent equity allocation and 94.71 percent for 50 percent equity allocation. These strategies can also extend the retirement horizon to 30 years since they have an over 90 percent success rate in that time frame. Over increased retirement horizons these savings rate and asset allocation strategies have a greater than 90 percent success rate and should be successful.

Savings rates must be increased for risk averse individuals to achieve the same 90 percent or greater success rate. For those who desire a retirement portfolio with a 25 percent equity allocation and expect a 20 year retirement life, at least 20 percent of salary must be set aside for retirement over at least 30 years. If the portfolio is to consist of 100 percent bonds, at least 25 percent of salary must be set aside for at least 30 years.

In summary, in the presence of Social Security income, a strategy of contributing at least 15 percent of worklife income to a retirement portfolio consisting of at least 50 percent equity over 30 years should result in post retirement income at 80 percent of pre-retirement levels. A more conservative investment strategy would require larger savings contributions. Shorter work life contribution horizons would require substantial increases in savings rates and would not be expected to be achievable at the 90 percent success rate level for a 100 percent bond portfolio.

To examine the importance of Social Security in retirement spending, we examined success rates assuming no Social Security payments were made. Table 3 shows the success rates for an 80 percent replacement ratio and no Social Security payments.

<<INSERT TABLE 3 ABOUT HERE>>

The results of Table 3 indicate that in the absence of Social Security income retirement portfolios should be more heavily weighted by equity when measured against a standard of 90 percent or greater success rate. For a 30 year contribution horizon retirement portfolios should consist of at least 75 percent equity and savings rates must be increased 5 percent (to 20 percent of pre-retirement income) to achieve an 80 percent income replacement objective over a 20 year retirement life expectancy. These results are consistent with Tezel's finding that a 17 percent savings rate is necessary over 30 years in a portfolio consisting of 80 percent equity to achieve a 70 percent income replacement ratio. To expand the retirement horizon of these portfolios to 30 years at a threshold of 90 percent success, retirement contributions should be increased by an additional 5 percent (to 25 percent of pre-retirement income)

Risk averse individuals fare poorly if Social Security is not factored into retirement income. To achieve an 80 percent income replacement for a 30/20 worklife/retirement horizon at the same 90 percent success rate level, portfolios consisting of 50 percent equity should have savings contributions of 25 percent of pre-retirement income. For portfolios consisting of 75 to 100 percent bonds, an 80 percent pre-retirement income replacement is not achievable at the 90 percent success rate level.

Overall, our results in Tables 2 and 3 show the importance of Social Security payments in retirement planning. In general unless an individual saves at least 20 percent of pre-retirement income, the success rate in smoothing lifetime income is dramatically affected by the elimination of Social Security payments. Additionally, a high equity investment is an important determinant of the difference in the success rates with and without Social Security. With a high equity portfolio weight, the drop between the success rates with and without Social Security is much smaller than for portfolios consisting of 50 percent more in bonds. Portfolios consisting of a large bond weight are less likely to be able to fund retirement withdrawals.

Although retirement planners have generally deemed an 80 percent income replacement ratio to be sufficient to maintain one’s lifestyle in retirement, some individuals may opt for a 100 percent replacement ratio. Table 4 shows the results for a 100 percent replacement ratio and Social Security payments.

<<INSERT TABLE 4 ABOUT HERE>>

In general the results of Table 4 indicate that for 100 percent income replacement portfolios that consist of at least 50 percent equity savings rates must be increased about 5 percent above the levels required for 80 percent income replacement. More concretely, to sustain a 100 percent income replacement ratio over a 20 to 30 year retirement life expectancy, an individual should save at least 20 percent of salary and invest in portfolios consisting of at least 50 percent equity over at least 30 years. These portfolios have 90 percent or greater success rates.

Savings rates must be increased for those who desire a retirement portfolio consisting mainly of bonds. For portfolios with 75 percent bonds that are expected to fund a 20 year retirement, at least 25 percent of salary must be set aside for retirement over at least 30 years. A 90 percent success rate is unattainable with a 100 percent bond portfolio.

The results for a 100 percent replacement ratio and no Social Security payments are shown in Table 5. In general, for an approximately 90 percent success level an individual must set aside at least 25 percent of salary over a period of at least 30 years and invest in a portfolio consisting of at least 50 percent equity in order to retire over 20 years at 100 percent of pre-retirement income. Success rates approach 90 percent for a 30 year retirement horizon only if an individual invests in at least 75 percent equity and saves 25 percent of income. A 90 percent success rate is unattainable for a portfolio consisting of at least 75 percent bonds.

<<INSERT TABLE 5 ABOUT HERE>>

Overall the results of Tables 4 and 5 underscore the importance in retirement planning of starting retirement savings early, having high savings rates and investing in stocks. If Social Security income is factored in an individual is able to retire (at a 90 percent or higher success rate) at pre-retirement income levels over a 30 year horizon if she sets aside 20 percent of income over 30 years and invests in a portfolio consisting of at least 50 percent equity. If the retirement portfolio consists of at least 75 percent bonds a retirement horizon of 30 years at pre-retirement income is feasible at the 90 percent success rate level if one sets aside 25 percent of salary. If Social Security income is not included a person can expect to have pre-retirement income over 30 years only by investing 25 percent of income over a 30 year savings horizon in portfolios consisting of at least 75 percent equity.

In general the results of Tables 2 through 5 underscore the importance of setting aside at least 15 percent of earnings for retirement over at least 30 years in a portfolio consisting of at least 50 percent equity. Factoring in Social Security payments, this program should provide an individual with 80 percent of pre-retirement income over a 20 to 30 year life expectancy. If one expects to have a retirement income equal to pre-retirement income or is not counting on Social Security, the retirement savings program should have longer savings horizons and/or higher savings levels and be heavily equity weighted.

C. Dynamic Work Life Savings Percentages

To assess the impact of increasing savings rates over time, we increased the savings rate in equal increments of 5 percent over the savings life span. Using our benchmark 30 savings horizon as an example, an individual would initially set aside 10 percent of salary. The contribution would increase to 15 percent after seven and one half years, 20 percent at 15 years, and 25 percent at twenty two and one half years.

<<INSERT TABLE 6 ABOUT HERE>>

<<INSERT TABLE 7 ABOUT HERE>>

Table 6 shows the results for an 80 percent replacement ratio assuming full Social Security payments. For a 30 year savings horizon, an increasing savings strategy has a greater than 90 percent chance of success of sustaining pre-retirement income for 20 to 30 years even for portfolios consisting of only 25 percent equity. Table 7 shows the success rates for an 80 percent replacement ratio in the absence of Social Security payments. For a 30 year savings horizon none of the portfolio allocation strategies are successful even for a 20 year retirement. These results underscore the importance of beginning an equity biased retirement program with high savings levels if one is not counting on Social Security income. As indicated in Table 3, a person that sets aside 20 percent of salary for 30 years in a portfolio consisting of at least 75 percent equity can expect to fund her retirement for at least 20 years. If she procrastinates in maintaining high savings levels, her retirement portfolio will be inadequate.

If the post retirement living standard is set equal to the pre-retirement level (100 percent) the results in Table 8 indicate that in the presence of Social Security income with an incremental savings regime over a 30 year horizon one can expect to retire for 20 to 30 years at the 90 percent success rate level if the portfolio consists of at least 75 percent equity. A portfolio of 50 percent equity may last for 20 years. Any lesser equity allocation result in inadequate levels of success probability over even a 20 year retirement horizon.

<<INSERT TABLE 8 ABOUT HERE>>

<<INSERT TABLE 9 ABOUT HERE>>

The results for a variable savings program with a 100 percent replacement ratio and no Social Security payments are shown in Table 9. As foreseen by the results in Table 7, for a 30 year savings horizon none of the portfolio allocation strategies are successful even for a 20 year retirement period. As indicated by the results of Table 5, if Social Security income is not factored into retirement, one must set aside at least 20 percent of salary for at least 30 years to have any legitimate hope of funding retirement at a 100 percent replacement ratio.

4. Conclusions

Using returns from 1926 through 2008, we construct 10,000 return series. The asset classes we consider are U.S. large capitalization stocks and U.S. long-term corporate bonds. We analyze different portfolio weights with these asset classes and different savings and retirement periods. Using these simulated returns, we examine different savings rates for individuals to determine the savings rate necessary to support withdrawals in retirement at 80 percent and 100 percent of pre-retirement income with and without Social Security income.

Based on a benchmark 30 year savings horizon with at least a 20 year retirement expectancy, our results confirm the importance of equity in a retirement portfolio found in prior research. Our results also underscore the importance of Social Security income. If it is factored in, for savings rates of 15 (20) percent in retirement one can expect to sustain pre-retirement income levels of 80 (100) percent for 30 years with portfolios consisting of at least 50 percent equity. If one pursues a variable savings strategy over the same time horizon and includes Social Security income, pre-retirement income levels of

80 (100) percent are probably sustainable for 30 years with allocations of at least 25 (75) percent equity.

If Social Security is not factored in, one can expect to sustain 80 percent of pre-retirement income over 20 years only by setting aside at least 20 percent of salary for 30 years in portfolios consisting of at least 75 percent equity. If pre-retirement income levels are desired over the same time horizon (20 years), one must set aside at least 25 percent of salary for 30 years in portfolios consisting of at least 50 percent equity. No amount of equity allocation can salvage an incremental savings regime that commences with setting aside only 10 percent of salary.

Our results indicate that a relatively shorter savings period and/or a lower savings rate dramatically affect the probability of successful income smoothing. Additionally, both reduce the likelihood that the retirement savings will be able to fund a long retirement period or provide sufficient funds if Social Security payments were eliminated. Conversely, with a longer savings period, a higher savings rate, or a higher equity investment, the drop in the success rate is less affected by the absence of Social Security payments.

Our results extend previous retirement planning literature by concurrently analyzing various asset allocation strategies at various savings rates over various savings and withdrawal horizons. Most prior studies implicitly assume that the investor/retiree is financially literate and desires to optimize portfolio returns. A review of the financial education literature indicates that this isn’t always the case. Based on our results individuals can determine the likelihood of sustaining their pre-retirement lifestyle in retirement based on their current retirement planning situation. Furthermore the impact of Social Security for a given retirement planning strategy can also be assessed.

Table 1

Table 1 Panel A shows the distributions for stocks and bonds. Stock returns are normally distributed, while bond returns are best described by a logistic distribution.

	Equity Student's *t*	Bonds Student's *t*	Inflation Logistic
Mean	11.99%	5.90%	3.10%
Standard Deviation	19.11%	7.39%	1.86%
Scale	.039	0.011	.0026
Degrees of freedom	4	1.8541	

Table 1 Panel B shows the correlation between stocks, bonds, and inflation over the period examined.

	Equity	Bonds	Inflation
Equity	1.0000		
Bonds	0.2181	1.0000	
Inflation	–0.0566	–0.0995	1.0000

Table 2

Table 2 shows the success rates for the various savings rates, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 80 percent and the individual receives Social Security payments. The left hand column shows the pre-retirement savings rate. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

100 % Equity

	20/20	20/30	30/20	30/30	40/20	40/30
10%	48.29%	44.82%	84.27%	82.65%	93.96%	92.50%
15%	76.45%	73.52%	94.95%	93.43%	98.19%	97.34%
20%	90.21%	87.52%	98.49%	98.19%	99.06%	98.96%
25%	95.75%	95.44%	99.58%	99.43%	99.50%	99.45%

75% Equity/25% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	35.38%	31.40%	82.18%	78.75%	94.72%	92.87%
15%	73.86%	69.12%	96.11%	95.16%	98.71%	98.27%
20%	91.14%	88.99%	99.18%	98.89%	99.58%	99.40%
25%	97.60%	97.21%	99.78%	99.68%	99.71%	99.72%

50% Equity/50% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	17.56%	13.07%	72.84%	66.06%	90.49%	88.59%
15%	62.68%	55.51%	94.71%	92.36%	98.33%	97.28%
20%	89.61%	85.95%	98.91%	98.71%	99.48%	99.41%
25%	98.03%	97.15%	99.63%	99.45%	99.71%	99.71%

25% Equity/75% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	4.93%	3.44%	47.10%	39.11%	75.01%	69.33%
15%	40.70%	32.43%	83.69%	78.96%	92.14%	89.95%
20%	78.63%	69.82%	96.01%	93.31%	98.01%	96.65%
25%	93.80%	91.51%	98.03%	97.67%	99.22%	99.12%

100% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	2.32%	2.11%	19.69%	14.82%	43.44%	34.52%
15%	17.88%	12.05%	58.61%	49.07%	73.97%	66.74%
20%	52.72%	42.49%	82.42%	75.70%	87.20%	83.79%
25%	79.51%	73.53%	91.80%	88.22%	92.52%	90.08%

Table 3

Table 3 shows the success rates for the various savings rates, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 80 percent and the individual receives no Social Security payments. The left hand column shows the pre-retirement savings rate. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

100 % Equity

	20/20	20/30	30/20	30/30	40/20	40/30
10%	18.83%	15.34%	62.60%	56.02%	83.01%	79.59%
15%	43.52%	37.31%	81.83%	77.02%	91.94%	89.28%
20%	64.25%	56.73%	89.99%	87.34%	96.22%	95.19%
25%	78.81%	72.50%	95.23%	92.52%	98.41%	97.14%

75% Equity/25% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	8.09%	5.53%	51.27%	45.06%	78.45%	73.64%
15%	30.68%	24.06%	78.26%	71.52%	92.95%	90.18%
20%	56.73%	47.35%	91.73%	87.04%	96.73%	95.86%
25%	76.62%	67.84%	96.07%	93.77%	98.82%	97.95%

50% Equity/50% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	1.54%	0.67%	31.24%	23.13%	64.34%	55.60%
15%	13.00%	8.23%	64.18%	54.21%	88.20%	81.75%
20%	39.86%	27.27%	85.58%	78.25%	95.31%	93.19%
25%	65.60%	52.64%	94.66%	90.51%	98.37%	96.57%

25% Equity/75% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	0.19%	0.08%	8.86%	5.07%	34.82%	23.29%
15%	3.27%	1.46%	39.54%	25.97%	68.63%	55.38%
20%	15.94%	7.93%	68.81%	53.17%	86.07%	78.36%
25%	43.46%	27.91%	84.05%	75.52%	92.83%	88.55%

100% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	0.63%	0.74%	2.43%	1.50%	9.15%	4.92%
15%	1.66%	1.10%	14.80%	8.31%	35.54%	22.24%
20%	6.31%	2.95%	36.99%	22.46%	59.70%	44.99%
25%	20.10%	9.71%	60.52%	43.18%	74.01%	61.64%

Table 4

Table 4 shows the success rates for the various savings rates, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 100 percent and the individual receives Social Security payments. The left hand column shows the pre-retirement savings rate. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

100 % Equity

	20/20	20/30	30/20	30/30	40/20	40/30
10%	31.83%	27.77%	72.59%	69.10%	88.66%	87.32%
15%	61.84%	57.10%	88.77%	87.16%	96.85%	95.48%
20%	78.25%	75.94%	95.46%	93.99%	98.71%	98.53%
25%	89.75%	87.23%	98.23%	97.47%	98.90%	98.68%

75% Equity/25% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	18.31%	14.45%	67.53%	62.25%	87.15%	84.15%
15%	53.01%	46.34%	89.45%	86.39%	97.51%	96.14%
20%	77.80%	72.67%	95.56%	94.29%	99.11%	98.80%
25%	90.45%	87.49%	98.77%	98.50%	99.35%	99.20%

50% Equity/50% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	5.78%	3.71%	48.46%	40.50%	78.69%	72.02%
15%	35.05%	26.32%	82.90%	77.21%	95.27%	92.82%
20%	68.68%	60.07%	94.64%	92.59%	98.96%	98.52%
25%	88.97%	84.97%	98.75%	98.12%	99.53%	99.29%

25% Equity/75% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	0.45%	0.15%	20.68%	15.47%	50.52%	41.63%
15%	12.80%	7.30%	61.62%	51.41%	82.95%	75.49%
20%	46.69%	34.52%	86.27%	80.24%	94.05%	92.12%
25%	77.64%	68.10%	94.90%	92.44%	96.87%	96.12%

100% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	0.20%	1.10%	6.24%	4.27%	19.54%	12.84%
15%	3.73%	2.80%	29.52%	20.48%	52.05%	42.33%
20%	21.03%	13.60%	60.72%	47.71%	75.76%	67.58%
25%	51.34%	38.48%	81.94%	72.95%	86.71%	81.20%

Table 5

Table 5 shows the results for the various savings rates, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 100 percent and the individual receives no Social Security payments. The left hand column shows the pre-retirement savings rate. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

100 % Equity

	20/20	20/30	30/20	30/30	40/20	40/30
10%	13.66%	11.38%	54.14%	48.75%	76.95%	72.39%
15%	35.18%	28.68%	74.48%	69.29%	89.60%	87.52%
20%	57.14%	49.07%	87.02%	83.53%	95.73%	93.30%
25%	70.91%	65.93%	92.13%	89.72%	98.09%	97.04%

75% Equity/25% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	5.30%	3.54%	41.03%	33.85%	69.92%	63.90%
15%	21.71%	16.08%	70.05%	62.94%	88.50%	84.25%
20%	45.15%	37.00%	86.28%	79.84%	96.08%	93.46%
25%	65.72%	58.66%	92.93%	90.05%	98.53%	97.39%

50% Equity/50% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	0.15%	0.00%	18.78%	13.64%	49.89%	41.48%
15%	7.63%	4.08%	51.08%	41.19%	80.84%	71.21%
20%	25.50%	16.72%	76.26%	67.97%	92.60%	88.54%
25%	52.34%	39.97%	89.99%	84.41%	97.72%	95.54%

25% Equity/75% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	0.00%	0.00%	4.17%	1.87%	20.28%	12.36%
15%	0.93%	0.18%	23.31%	15.39%	53.38%	41.17%
20%	7.53%	4.21%	52.21%	37.84%	76.33%	64.92%
25%	26.63%	15.28%	75.40%	61.77%	89.70%	82.54%

100% Bonds

	20/20	20/30	30/20	30/30	40/20	40/30
10%	0.03%	0.81%	1.21%	1.10%	4.20%	1.96%
15%	0.27%	0.78%	7.18%	3.98%	21.85%	12.64%
20%	2.38%	1.65%	22.05%	13.34%	43.87%	30.43%
25%	9.75%	5.59%	42.82%	27.87%	63.93%	49.83%

Table 6

Table 6 shows the success rates for a varying savings rate, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 80 percent and the individual receives Social Security payments. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

		100 % Equity			
20/20	20/30	30/20	30/30	40/20	40/30
84.14%	81.82%	98.40%	97.40%	98.85%	98.67%
		75% Equity/25% Bonds			
84.45%	81.08%	99.17%	98.93%	99.36%	99.15%
		50% Equity/50% Bonds			
79.56%	72.38%	98.39%	97.64%	99.44%	99.33%
		25% Equity/75% Bonds			
59.63%	51.39%	93.68%	91.94%	96.78%	95.35%
		100% Bonds			
33.16%	25.48%	81.97%	74.41%	86.71%	81.90%

Table 7

Table 7 shows the results for a varying savings rate, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 80 percent and the individual receives no Social Security payments. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

20/20	20/30	30/20	30/30	40/20	40/30
100 % Equity					
48.82%	41.24%	87.72%	84.94%	94.39%	92.35%
75% Equity/25% Bonds					
36.07%	28.95%	86.75%	82.11%	95.93%	93.51%
50% Equity/50% Bonds					
18.35%	11.40%	78.49%	69.78%	93.58%	88.24%
25% Equity/75% Bonds					
5.18%	2.46%	58.60%	42.28%	80.69%	69.50%
100% Bonds					
2.14%	1.37%	26.95%	14.31%	51.87%	35.54%

Table 8

Table 8 shows the results for a varying savings rate, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 100 percent and the individual receives Social Security payments. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

	20/20	20/30	30/20	30/30	40/20	40/30
100 % Equity	64.16%	59.20%	93.27%	91.28%	97.26%	96.30%
75% Equity/25% Bonds	57.30%	51.26%	94.42%	92.22%	97.62%	97.17%
50% Equity/50% Bonds	43.11%	33.11%	92.54%	87.85%	97.13%	95.44%
25% Equity/75% Bonds	18.43%	10.55%	79.56%	71.17%	89.91%	86.81%
100% Bonds	7.11%	4.35%	51.25%	38.30%	68.74%	58.69%

Table 9

Table 9 shows the results for a varying savings rate, savings periods, and withdrawal periods. Withdrawals are in real terms. The replacement ratio in retirement is 100 percent and the individual receives no Social Security payments. The row above the success rates show the savings period/withdrawal period. For example, 20/30 is a 20 year savings period and a 30 year withdrawal period.

		100 % Equity			
20/20	20/30	30/20	30/30	40/20	40/30
35.09%	28.98%	81.36%	76.86%	90.71%	87.90%
		75% Equity/25% Bonds			
21.26%	15.37%	78.24%	70.09%	91.84%	87.06%
		50% Equity/50% Bonds			
7.46%	3.62%	64.12%	52.04%	86.04%	78.02%
		25% Equity/75% Bonds			
1.44%	0.49%	35.75%	23.15%	64.38%	52.82%
		100% Bonds			
1.03%	0.91%	12.20%	7.59%	34.28%	19.76%

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