

The role of the equity risk premium in the shortfall risk of target-date funds

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Abstract

Target-date mutual funds are unique because the fund manager is expected to maintain the most efficient allocation for the investor in different investment climates. Using a bootstrap simulation with forward-looking equity risk premiums, we illustrate that a 50/50 stock/bond portfolio will run out of money less frequently than a target-date fund if future stock returns replicate past stock returns. When we introduce equity risk premium adjustments, a portfolio with a greater weight in bonds still outperforms a target-date fund. This analysis suggests that these funds may need to reconsider their asset allocation strategies irrespective of market conditions. © 2011 Academy of Financial Services. All rights reserved.

JEL classification: D14; G11; J26

Keywords: Target-date fund; Shortfall; Equity risk premium; Retirement; Bootstrap

1. Introduction

The United States has entered an era of a growing senior population. The combination of an aging population and longer life expectancies could cause damage to the Social Security System, and retirees may not have enough savings to live comfortably. Moreover, the number of Americans covered by traditional defined-benefit plans has been steadily decreasing.¹ These numbers continue to fall because many employers are hesitant to undertake the financial obligation of these plans. These plans have been replaced by defined-contribution plans and 401(k) plans.

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Traditionally, the combination of Social Security, pensions, and savings could provide enough money for a comfortable retirement lifestyle. With the uncertainty surrounding Social Security and the decline of pensions, future retirees must rely on their personal savings rather than employers or the government to fund their retirement. As part of this new savings model, different investment vehicles have been invented to lessen the burden on individual investors. Among the various retirement products developed include target-date mutual funds. Investors have turned to target-date funds because they do not choose their investments, do not decide at which proportions to invest their money, and do not worry about rebalancing their allocation. A target-date fund provides diversification across different asset classes and an automatically rebalancing asset allocation that change over time. These funds are rapidly increasing in popularity because of the Pension Protection Act of 2006, which has allowed plan sponsors to utilize target-date funds as a “default” investment choice (Cope-land, 2009). The Employee Benefit Research Institute (EBRI, 2009) reports that 37% of 401(k) plan participants had at least some part of their account in target-date funds in 2007, and target-date funds held about 7% of total assets in 401(k) plans. An investor must consider the asset allocation strategy (the “glide path”) of these funds during retirement years because the asset allocation decision is not the investor’s choice but the fund manager’s choice.

One should examine the future equity risk premium to determine what can be expected from these funds in the years ahead. Although there are several accepted definitions of the equity risk premium, this article defines it as the following: The equity risk premium is the expected return of the stock market less the expected return of a riskless bond.² The equity risk premium is important in financial theory and is generally examined from three different points of view. From the investor’s perspective, the equity risk premium is the extra return needed to entice him or her to invest in stocks rather than bonds. From the corporation’s perspective, the equity risk premium helps determine both the cost of equity capital, and the weighted average cost of capital. From the valuation perspective, the equity risk premium figures into the calculation of the discount rate that ultimately determines present value. This study examines the equity risk premium’s affect on the performance of the target-date fund from the investor’s perspective.

This critical question about future stock market performance extends far beyond the asset allocation problem. The equity risk premium plays a critical role in retirement planning (Siegel, 2005). Target-date fund performance depends on it because of the unique advisory relationship between the investor and the mutual fund manager. The proper asset allocation decision for these funds depends on the future equity risk premium value, and on a justification for why the equity risk premium value may be different than the past.

The expected return for fixed income securities is reflected in the bond’s yield and, therefore, the planning decision is less complicated. Conversely, the calculation for equities calls for an estimate of the equity risk premium. There are three possible scenarios: The expected equity risk premium declines, remains equal, or increases. If the expected equity risk premium declines, there are only two ways the investor will achieve the same amount of retirement savings: The investor either will be required save more, or will be required to increase the percentage of the portfolio allocation to equities. If the future equity risk premium stays the same as the past levels, the investor will see his or her purchasing power

decrease over time. If the future equity risk premium increases, the investor will be pleased as his or her purchasing power increases over time.

Whether target-date fund allocation strategies have any fundamental scientific basis is not explored here. The purpose is not to compare the asset allocation of one target-date fund to another. Instead, we compare the performance of the target-date fund to the performance self-managed allocations. We investigate the same subset of 131 funds Spitzer and Singh's article (2008).³ These funds have target retirement dates from 2000 to 2014. Although the funds used are the same, this article includes six more years of equity and bond data, and includes adjusted equity risk premiums.

The question of primary interest is: "Given adjusted future equity risk premiums, how successful is a fund manager's asset allocation strategy for the target-date fund in comparison to an investor's self-managed allocation?" Another question of interest is, "If we assume that the equity risk premium stays constant (i.e., we do not take it into consideration), does this change the effectiveness of the target-date fund asset allocation in comparison to a self-managed allocation?" "Success" is defined by shortfall risk so the minimum shortfall risk portfolio is the most successful allocation. Besides shortfall risk, the preferred portfolio depends on the specific risk preference of the investor. Risk preference is not explored here.

Both Spitzer and Singh (2007) and Spitzer and Singh (2008) conclude that changing the weighting of a portfolio to more bonds during retirement does not result in a greater ending portfolio balance. Spitzer and Singh (2008) show that the target-date fund has a smaller balance at the end of 30 years than a 50/50 stock/bond allocation portfolio balance. The present study illustrates that their doubts about the asset allocation of target-date funds are warranted. We also demonstrate that the optimal shortfall risk portfolios with equity risk premium adjustments have a lower weight in equities than without an adjustment.

2. Literature review

2.1. Target-date fund

Despite the infant nature of target-date funds, there is a plethora of previous literature. Many authors have taken interest because they have not performed well.⁴ A recent work that is the main motivation for this study is Spitzer and Singh (2008). Using a bootstrap simulation and rolling period method, Spitzer and Singh (2008) illustrate that a 50/50 fixed stock/bond allocation outperforms the target-date fund in terms of both shortfall probability and average ending portfolio balance.

The present study draws on the methodology of Spitzer and Singh (2008). Particularly, we examine both equivalent and additional asset allocations that allow us to compare our results to Spitzer and Singh (2008) and also propose new conclusions. We bootstrap additional asset allocation strategies, and most critical to our contribution is our simulations with equity risk premium adjustments. We examine additional simulations because investors over the 30 year distribution period face the risk of a changing economic environment. Suppose that an investor assumes an average 10% return on investments, but we then enter a long-term bear

market in which the average return on investments drops by 3%. We account for this probable downturn by adjusting the equity returns.

Meynard and Templeton (2002) use a Monte Carlo simulation to examine constant allocations of 50/50 stock/bond and 100/0 stock/bond to a 100 minus age equity allocation strategy. A 100 minus age strategy means that the proportion of equities in the portfolio is equal to 100 less the investor's age. They conclude that the 50/50 stock/bond CW portfolio performs similarly to the 100 age allocation based on risk and return. Schleef and Eisinger (2007) use a Monte Carlo simulation to determine how likely investors are to reach a certain target portfolio value (inflation-adjusted value). They find that a majority of investors do not reach their goals in terms of ending portfolio value. This conclusion is true for both fixed allocation strategies and a target-date fund strategy.

Bodie and Trussard (2007) characterize a "natural TDF holder" as a person for whom the target-date fund strategy is optimal. Differences in risk aversion are one reason they propose a "safe" target date-fund for those investors who are not near the optimal strategy. These participants have the option to choose the regular target-date fund or the safe target-date fund. They conclude that people who are highly averse would benefit from a safe target-date fund.

The EBRI (2009) analyzes how target funds in 401(k) plans affect portfolio allocations. Specifically, they observe whether investor behavior changes in a retirement plan when the target-date fund is a default option. Those who use the target-date fund in conjunction with other investment options are "mixed" TDF users, and those that use the target date fund by itself are "pure" TDF users. They conclude that a mixed user may have a worse risk-return trade-off than that of a pure user, and may have a portfolio that is not weighted correctly. This occurs because the target-date fund is controlled by the fund manager, who assumes that the fund is the only investment in the portfolio. Combining other investments along with the target-date fund can be detrimental to the final portfolio value.

2.2. *Equity risk premium*

There is vast equity risk premium literature that has been focused on forecasting the future premium. There are four basic approaches used in forecasting. The first approach uses historical return data to estimate future returns. The second approach uses investor demand. Investors demand higher expected returns for more risk relative to riskless securities. The third approach uses a supply perspective. This perspective examines how the economy and companies can influence expected returns. The fourth approach uses surveys to provide an estimate of what investors believe the equity risk premium will be in the future (Goetzmann, 2006). Investors' views are important because they are the foundation for the market. Investors' expectations should be accounted for in the price of stocks, and the best way to include their expectations is to ask their consensus forecast of the equity risk premium.

There have been published surveys of investors, professors, and analysts. The particular survey we use to forecast the equity risk premium is Graham and Harvey (2010). They take a survey of U.S. Chief Financial Officers every quarter between June 2000 and June 2010. This survey spans two major recessions, and shows that expectations definitely vary with the business cycle. Their study illustrates that equity premiums are higher during recessions

(3.57%) and lower during nonrecessions (3.31%). With nearly 14,000 responses to the survey, they found the average 10-year equity risk premium to be 3.40%, with a standard deviation of 3.25%.⁵

Welch (2000) surveys 226 financial economists in 1997–1998 and finds the average equity risk premium over 30 years to be 7% with a standard deviation of 2%. Respondents to the survey also predict that the stock market will have an average return of 11% and a standard deviation of 2.1% over the next 30 years. The survey illustrates that short-term forecasts are lower than long-term forecasts of the equity premium. Welch (2001) surveys 510 professors. The average 30 year equity risk premium forecast is 5.5%, which is significantly lower than the 7% measure in the previous survey. Welch (2008) asks professors what equity risk premium they use in the classroom, and Welch finds it to be between 4% and 8.5%.

Ibbotson and Sinquefeld (1976a, b) use historical stock and bond returns to forecast the equity risk premium. Mehra and Prescott (1985) use the demand approach. They conclude that to compensate investors for the higher return on stocks compared with government bonds, individuals must have implausibly high risk aversion. They coin this idea as the equity premium puzzle. In Ibbotson, Siegel, and Diermeier's article (1984), liquidity, taxation, and idiosyncratic risk are shown to impact investor demand.

The supply models use economic factors such as GDP growth, dividends, earnings, and book values to forecast equity returns. Gordon (1962) presents one of the first supply models. Gordon's discounted cash flow model takes a constant predicted growth rate in dividends, and adds a dividend yield to find an expected return. To calculate the equity risk premium, one simply has to subtract the risk-free rate. Diermeier, Ibbotson, and Sigel (1984) further explore the supply side. They use a discounted cash flow model to forecast market returns, and they assume constant factor shares. This means that the capital markets are a constant share of the economy. Many scholars have followed these two major pieces of literature; two such articles are Siegel (1999) and Ibbotson and Chen (2003). Siegel (1999) finds that the combination of high equity valuations and low dividend yields will result in a lower equity risk premium in the future. Ibbotson and Chen (2003) use a building blocks method to decompose equity returns. They propose that equity returns can be decomposed as per growth rate in dividend payout ratio, growth in rates on return of equities, growth in book value of equities, or growth of GDP per capita. They find the equity risk premium to be 5.90% on an arithmetic basis.

Regardless of the methodology used to forecast the equity risk premium, many studies state that future stock returns will shrink in the future. Siegel (1992); Campbell, Diamond, and Shoven (2001); Carlson, Pelz, and Wohar (2002); and Ilmanen (2003) are some examples of these studies. To account for a possible decline in the equity risk premium, this study downwardly adjusts equity returns.

2.3. *Withdrawal*

A constant 4% is withdrawn each year from the portfolios. The 4% rule is a guideline for relative safety, yet it is often misunderstood. The withdrawals are not 4% of the current portfolio value; they are 4% of the initial portfolio balance when withdrawals commence. A fixed amount of money (\$4) is withdrawn each year with an initial portfolio balance of \$100.

We use a 4% constant withdrawal rate because if the withdrawal rate does not vary, then the only difference in performance among portfolios will be because of asset allocation.

The 4% rule was first established in a work by Bengen (1994), and later solidified by Warshawsky (2000). Over a 30 to 35 year period, Bengen believes that an annual 4% inflation-adjusted withdrawal is the maximum that can be withdrawn to have enough money during retirement. Bengen looks at withdrawal rates of 4%, 5%, and 6%. Over a 30 to 35 year period, he finds using hypothetical retirement amounts that a 4% withdrawal lasts, while the 5% and 6% withdrawals result in failures. Cooley, Hubbard, and Walz (1998) follow up on Bengen's study by examining different allocations, payout periods, and withdrawal rates.⁶ The above studies only look at stocks and bonds, while later studies on withdrawals look at other investment vehicles (Scott, Sharpe, and Watson, 2009). Kotlikoff and Burns (2008) explore the withdrawal debate taking into consideration not just assets, but also taxes and liabilities. Our study does not make a distinction between the different types of allocations within equities. For instance, we do not differentiate between domestic and international equities, large cap, mid cap, or small cap stocks, and so forth. The allocation strategies are simply divided between equities and fixed income to have a better comparison to previous literature and keep the study manageable. We use the 4% inflation-adjusted withdrawal rate for the bootstrap with and without equity risk premium adjustments.

2.4. Shortfalls

Shortfall is the risk that a portfolio will not meet the continuing objectives of an investor. Therefore, shortfall of a portfolio is a meaningful measure of risk to an investor. The classic approach to measuring risk is the standard deviation of the value of the ending portfolio, which is not as readily consequential to an investor in terms of financial planning. Other approaches such as estimating an expected return and standard deviation or variance, projecting a terminal wealth value, and computing a confidence interval around that terminal value makes a normality assumption. Because returns are not normally distributed, shortfalls are a more relevant risk measure. Investors are concerned with longevity risk, and this risk is best measured by shortfalls. Roy (1952) argues that investors think in terms of a minimum adequate ending portfolio value called the "disaster level." Investors choose the investment vehicle with smallest probability of going below their disaster level.⁷ We deem a shortfall occurs when a portfolio experiences a 100% decline in real wealth.

3. Research methods, assumptions, and data

3.1. Methods

We use a bootstrap simulation to examine the success of the asset allocation strategy of the target-date fund in comparison to that of self-managed allocations. This is a specific simulation in which a set of data are generated by sampling with replacement from a given sample. Efron (1979) is the first to describe the term "bootstrapping." Efron (1979) describes bootstrapping as random resampling to estimate empirical distributions of sample statistics.

Table 1 Summary of thirteen asset allocation strategies with and without equity risk premium adjustments (no adjustment, 2%, 2.77%, 4%)

Allocation	Strategy
TDF	Percentage of equity falls gradually (50% to 25%) for 30 years of withdrawal less ERP adjustment
0%/100% CW	Fixed equity allocation at 0% for 30 years of withdrawal less ERP adjustment
10%/90% CW	Fixed equity allocation at 10% for 30 years of withdrawal less ERP adjustment
20%/80% CW	Fixed equity allocation at 20% for 30 years of withdrawal less ERP adjustment
30%/70% CW	Fixed equity allocation at 30% for 30 years of withdrawal less ERP adjustment
40%/60% CW	Fixed equity allocation at 40% for 30 years of withdrawal less ERP adjustment
50%/50% CW	Fixed equity allocation at 50% for 30 years of withdrawal less ERP adjustment
60%/40% CW	Fixed equity allocation at 60% for 30 years of withdrawal less ERP adjustment
70%/30% CW	Fixed equity allocation at 70% for 30 years of withdrawal less ERP adjustment
80%/20% CW	Fixed equity allocation at 80% for 30 years of withdrawal less ERP adjustment
90%/10% CW	Fixed equity allocation at 90% for 30 years of withdrawal less ERP adjustment
100%/0% CW	Fixed equity allocation at 100% for 30 years of withdrawal less ERP adjustment
DYNAMIC	Percentage of equity equal to 100 minus the investor's age for 30 years of withdrawal less ERP adjustment

Furthermore, Efron (1979) proposes a nonparametric bootstrap in which the distribution of the population is the data itself, and there is no distribution parameter assumption. Nonparametric bootstraps have been used for many studies. Hickman et al. (2001); Spitzer and Singh (2009); and Dolvin, Templeton, and Rieber (2010) use bootstrapping to assess asset allocations during the accumulation and distribution phases of the investment cycle.⁸ Below is the bootstrap of the current work (Eq. 1). Refer to Appendix A for further clarification on this algorithm.

$$A_{z,m+1} = A_{z,m}[1 + \lambda_z(R_{s,m} - ERP) + (1 - \lambda_z)R_{b,m}] - F \quad (1)$$

where:

A_z = z-th portfolio balance. Starting value at the beginning of year 1 is $b = \$100$ for all models

λ_z = z-th stock proportion

$\lambda_z = [0.50, 0.25]$ for TDF model where λ is decremented by 0.00833 each year.

$\lambda_z = [0.00, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1.00]$ for CW models.

$\lambda_z = [0.35, 0.05]$ for DYNAMIC model where λ is decremented by 0.01 each year.

F = annual withdrawal amount at \$4 (constant) made at the end of each year.

$R_{s,m}$ and $R_{b,m}$ are historical rates of return in year m on large company stocks and long-term government bonds, respectively.

ERP means equity risk premium adjustment (no adjustment, 2%, 2.77%, or 4%).

We consider 13 asset allocation strategies in three categories as illustrated in Table 1: A target-date fund allocation, constant-weighting asset allocations, and a 100 minus age asset allocation. The constant-weighting allocations are referred to as “CW” strategies. The 100 minus age asset allocation means that the percentage of equity in the portfolio is equal to 100 minus the investor's age, and is referred to as the “DYNAMIC” strategy. The target-date

fund is examined through a broad asset allocation strategy. The same sample of 131 funds from Spitzer and Singh's article (2008) is used here to derive a strategy from the most popular target-date fund offerings. The portfolio begins with a 50/50 stock/bond allocation, and ends with a 25/75 stock/bond allocation. This strategy is referred to as the "TDF" strategy.

Previous studies such as Spitzer and Singh (2008) and Spitzer and Singh (2009) have used purely historical data for their bootstraps using annual return data. In contrast, this study includes adjusted equity risk premiums to simulate forecasts for the future. We calculate an adjustment from a survey conducted of U.S. Chief Financial Officers on a quarterly basis from 2000 to 2010 (Graham and Harvey, 2010). We use an average 10-year risk premium of 3.40% to downwardly adjust historical inflation-adjusted returns on Large Company Stocks by 2.77%. Three other equity risk premium adjustments are considered in addition to the 2.77% adjustment: 0%, 2%, and 4% adjustments. The other three adjustments are tested to witness the effect of different equity risk premiums. We subtract each year of Large Company Stock returns by a constant 0%, 2%, 2.77%, and 4% in separate simulations (Appendix B).

We analyze the performance of each asset allocation strategy using real (inflation-adjusted) return data from 1926 to 2009. We bootstrap to examine the expected future performance of the various allocations. We gather annual inflation-adjusted rates of return from 1926 through 2009 for Large Company Stocks and Long-Term Government Bonds from *Stocks, bonds, Bills and Inflation: 2010 Yearbook, Ibbotson Associates* (Ibbotson, 2010). We use Long-Term Government bonds for inflation-adjusted bond returns. Primarily, they are comparable to common stock over a 30 year period because they have a longer duration than Treasury Bills. Secondly, investors want to understand the future of long-run future bond returns. This sample gives us 84 years of return data for both stocks and bonds. We then use a bootstrap to simulate the future performance of the different asset allocation strategies. The CW strategies, DYNAMIC strategy, and TDF strategy are considered.

Some academics may consider using the U.S. Treasury Bill as the risk free rate in this study. The logic is that there is little to no price risk in a treasury bill, whereas the price of a treasury bond can significantly fluctuate because of changing interest rates. Although Intermediate-Term Government Bonds are free from default, they are not risk-free securities. While this argument makes sense, using Treasury Bills only works if we want an equity risk premium over the next year (a single period). Our time horizon is longer than one year, so the Intermediate-Term Bond will provide more predictable returns.

3.2. Assumptions

- As in Spitzer and Singh (2008), we examine a target-date strategy where the fund manager gradually reduces the exposure to equities over time. We refer to this strategy as a TDF strategy as seen in Table 1.
- There are self-managed portfolios with different stock/bond allocations called CW strategies: 0/100, 10/90, 20/80 30/70, 40/60, 50/50, 60/40, 70/30, 80/20, 90/10, 100/0.
- There is a self-managed DYNAMIC strategy where the percentage of equity in portfolio in each year is equal to 100 minus the investor's age.

- Each portfolio starts with \$100.
- A constant amount of \$4 (4%) is withdrawn from the portfolios each year (inflation-adjusted). The 4% withdrawal takes place at the end of each year, and the portfolios are rebalanced at this point. If the withdrawal rate does not vary, then the only difference in performance among portfolios will be because of asset allocation.
- The portfolio value is determined using inflation-adjusted rates of return on Large Company Stocks and Long-Term Government bonds.
- We run four different equity risk premium scenarios with the thirteen allocations: Each year of Large Company Stock returns is subtracted by a constant 0%, 2%, 2.77%, and 4%. These are done in separate simulations.
- As both the size of the portfolio and rates of returns fluctuate, the value of the portfolio will change.
- 10,000 30-year sequences of withdrawals are performed on each of the portfolios in each simulation. The bootstrap for each of the 13 portfolios is subject to random sequences of stock and bond returns. Each of the portfolios is exposed to the same rates of return on stocks and bonds in the same order.
- We deem a shortfall occurs when a portfolio experiences a 100% decline in real wealth. Investors choose the investment vehicle with smallest probability of going below their disaster level.

3.3. Data

We use annual inflation-adjusted rates of return from 1926 to 2009 for Large Company Stocks and Long-Term Government bonds from *Stocks, Bonds, Bills and Inflation: 2010 Yearbook*, Ibbotson Associates. We estimate the equity risk premium from a quarterly survey of CFOs from 2000 through 2010 (Graham and Harvey, 2010). The risk premium in this survey is the expected 10-year S&P 500 return relative to a 10-year U.S. Treasury bond yield. To calculate the constant 2.77% adjustment, we use inflation-adjusted rates of return from 1926 to 2009 for Large Company Stocks and Intermediate-Term Government bonds from Ibbotson (2010).

4. Results

Using the resampling method for the TDF strategy, CW strategies, and DYNAMIC strategy produces some revealing outcomes. Of primary interest to this article is the performance of the TDF strategy in relation to the CW strategies and DYNAMIC strategy.

Before the simulations, we calculate some basic statistics on the original data set. Table 2 reports the mean returns, standard deviation of returns, median returns, minimum returns, maximum returns, and correlation of returns. As expected, the inflation-adjusted mean return of Large Company Stocks is 8.65%, which is much higher than the average return on inflation-adjusted Long-Term Government bonds at 2.88%. Correspondingly, the amount of risk (as measured by standard deviation) an investor takes by investing in common stock is much higher. The standard deviation of stock returns is nearly double the standard deviation

Table 2 Asset return statistics

	Stocks	Bonds
Arithmetic mean	8.65%	2.88%
Standard deviation	20.51%	10.69%
Median return	10.32%	2.08%
Minimum	−37.37%	−17.16%
Maximum	53.39%	35.13%
Correlation (equities, fixed income)	10.70%	10.70%

of the bond returns (20.51% and 10.69%, respectively). We also find that there is positive correlation between the stock and bond returns (10.70%).

We make some general observations about all of the allocations regardless of the equity risk premium adjustment. A greater percentage of a portfolio in equities (on average) results in a higher shortfall risk after 30 years of withdrawals as seen in Fig. 1 and Table 3. Even if the standard deviation of the portfolio increases with a greater allocation to equities, the shortfall risk will begin to decrease initially. This occurs because with a moderate amount of stock, the expected return of the portfolio dominates the standard deviation of the return. Though, as the equity percentage increases, the standard deviation dominates expected return.

4.1. Shortfalls without equity risk premium adjustment

We analyze the shortfall risk of the TDF strategy in relation to the DYNAMIC strategy and CW strategies with no equity risk premium adjustment. Fig. 1 shows the different asset

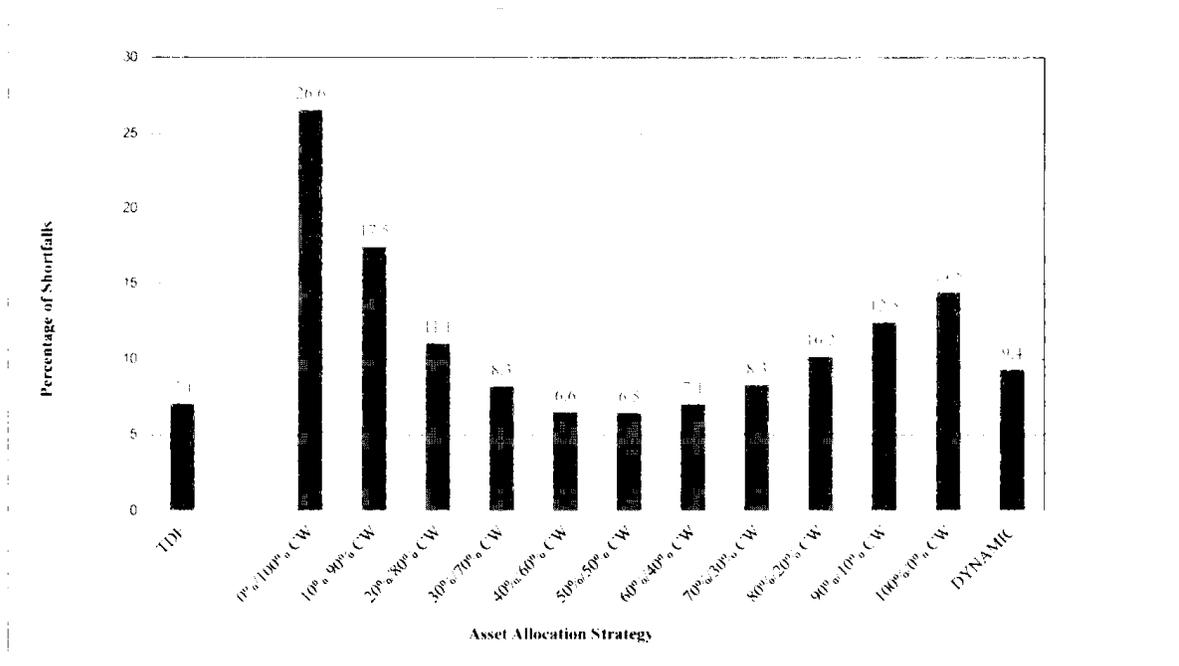


Fig. 1. Percentage of shortfalls without equity risk premium adjustment.

Table 3 Shortfall probabilities (%) with equity risk premium adjustments (no adjustment, 2%, 2.77%, and 4%)

Asset allocation strategy	Equity risk premium (no adjustment)	Equity risk premium adjustment (2%)	Equity risk premium adjustment (2.77%)	Equity risk premium adjustment (4%)
TDF	7.11	13.04	15.59	21.10
0%/100% CW	26.63	25.98	26.14	26.2
10%/90% CW	17.50	19.39	20.15	22.41
20%/80% CW	11.11	14.21	16.52	20.12
30%/70% CW	8.26	12.34	14.99	19.53
40%/60% CW	6.55	12.45	15.33	20.10
50%/50% CW	6.48	13.49	16.34	22.02
60%/40% CW	7.07	14.71	18.33	24.89
70%/30% CW	8.34	16.58	21.72	29.84
80%/20% CW	10.23	19.71	24.7	33.44
90%/10% CW	12.50	23.03	27.87	37.59
100%/0% CW	14.47	25.91	31.85	40.77
DYNAMIC	9.38	13.84	16.83	19.45

allocation strategies on the X axis, and the percentage of shortfalls for the respective allocations on the Y axis. We see that the number of shortfalls for the CW strategies decreases at a decreasing rate between 0% and 50% allocated to equities and increases at an increasing rate from 60% equities on upward. We see that the shortfall risk of the TDF is greater than a 50/50 CW asset allocation. The TDF strategy fails 7.1% of the time, while the 50/50 CW strategy fails just 6.5% of the time. The TDF outperforms the DYNAMIC strategy but underperforms the 50/50 CW strategy in terms of shortfall risk.

4.2. Shortfalls with equity risk premium adjustments

Table 3 indicates that the shortfalls do change significantly with the 2%, 2.77%, and 4% equity risk premium adjustments. Note that the first column (no adjustment) is a replication of Fig. 1 so that we can compare the different adjustments. The percentage of shortfalls increases for the TDF strategy, DYNAMIC strategy, and any CW strategy between 10% and 100% equity. We see that as the percentage to equity increases in these portfolios, the difference in shortfalls between no adjustment and the adjustments increase. For instance, a 10/90 CW strategy with and without the 2% adjustment differs by just 2% in terms of shortfalls, while a 90/10 CW strategy differs with and without a 2% adjustment by about 9% in terms of shortfalls. This occurs because as the equity weight increases, the effect of the equity risk premium adjustment has more effect on the performance of the portfolio. The 0/100 CW strategy with any adjustment is nearly identical to having no adjustment. The equity risk premium only affects the equity portion of the portfolio, and in this case, there is a 0% allocation to equity. Therefore, the difference in shortfalls for a 0/100 CW allocation with and without any equity risk premium adjustment is because of random chance in the resampling simulation.

Table 4 Median terminal values (\$) with equity risk premium adjustments (no adjustment, 2%, 2.77%, and 4%)

Asset allocation strategy	Equity risk premium (no adjustment)	Equity risk premium adjustment (2%)	Equity risk premium adjustment (2.77%)	Equity risk premium adjustment (4%)
TDF	161.3	105.4	89.53	65.56
0%/100% CW	44.26	44.9	43.08	42.77
10%/90% CW	67.24	59.03	56.79	52.57
20%/80% CW	98.02	75.49	68.2	55.57
30%/70% CW	128.6	91.55	77.62	59.98
40%/60% CW	158.3	106.6	88.06	64.05
50%/50% CW	191.7	119.3	92.72	64.51
60%/40% CW	228.5	122.6	95.6	62.03
70%/30% CW	252.6	129.2	93.51	53.26
80%/20% CW	276.2	126.6	90.42	47.02
90%/10% CW	287.8	122.4	81.72	35.90
100%/0% CW	305.3	115.5	72.78	26.88
DYNAMIC	104.4	79.12	72.19	60.28

The number of shortfalls for the CW strategies decreases at a decreasing rate between about 0% and 30% allocated to equities, and then begins to increase at an increasing rate from 50% equities on upward. Although this is similar to the shape of the distribution without an adjustment, we see that the distribution of shortfalls starts to turn upward faster than before. This occurs because each year of stock returns is either 2%, 2.77%, or 4% lower than before, and therefore the shortfall risk of the portfolio will increase at a more rapid rate as the equity allocation increases. Likewise, as the equity risk premium adjustment increases from 2% to 4%, the shortfall risk increases more rapidly for the 4% adjustment.

The DYNAMIC strategy also underperforms a 30/70 CW strategy, but not with a 4% adjustment because of the amount of risk taken in this scenario. Anything between a 30% to 50% allocation to equities in a CW portfolio outperforms the DYNAMIC strategy and the TDF strategy with a 2% equity risk premium adjustment, although this may not be the case with the other adjustments. This is in comparison to no equity risk premium adjustment, in which the CW portfolio only outperforms both the DYNAMIC and TDF fund above a 40% equity allocation. We believe this occurs because of the lower average return on equities over the 84 year period with a 2% equity risk premium adjustment. Because of the lower equity returns of the portfolios, an investor will run out of money quickly.

4.3. Shortfall percentage and median value of terminal wealth tradeoff without equity risk premium adjustment

Smith and Gould (2007) develop a mean-variance analysis applicable to retirement planning, which is the tradeoff between shortfall probability (risk) and the median value of terminal wealth (return). We conduct a similar analysis in this study. The purpose of Table 4 is to display the median terminal values of the portfolios we use for our frontier. Fig. 2 illustrates the tradeoff between percentage of shortfalls and median terminal value of the portfolios. We use a variation of the Markowitz efficient frontier using shortfall as our

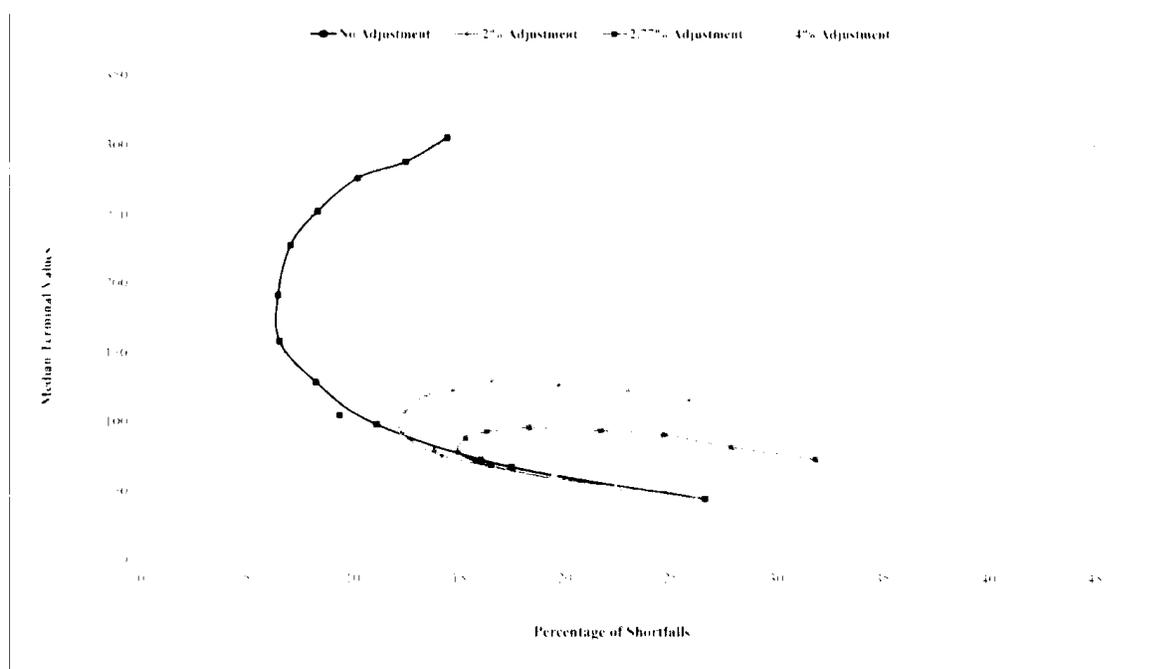


Fig. 2. Percentage of shortfalls and median terminal value tradeoff.

measure of risk, and median value of ending wealth as our measure of return. In Fig. 2, the horizontal axis represents the probability of shortfall, and the vertical axis represents the median value of terminal wealth. Each of the 13 points on the graph signifies a unique asset allocation strategy. The frontier describes the TDF strategy, CW strategies, and DYNAMIC strategy that provide the optimal trade-offs of risk and return over the 30 year time horizon. The frontier considers all possible combinations of securities, with all possible different weightings and keeps track of combinations that provide more return for less risk or the least risk for a given level of return.

Our graph of the trade-off between shortfall percentage (risk) and median terminal wealth (return) is analogous to the Markowitz mean-variance criterion. The four yellow dots highlight the TDF portfolio for each adjustment, and the optimal portfolio has the least shortfall risk. In Fig. 2, investors desire the portfolio that is positioned the farthest west because we are using shortfalls as our performance measure. Those portfolios that are toward the “north” have the highest median terminal wealth (return). Those lying to the “west” have the lowest shortfall percentage (risk). Just as in the Markowitz frontier, portfolio X dominates portfolio Y if all investors prefer X over Y. This is the case if X has a higher median terminal wealth (return) and a lower percentage of shortfalls (risk). Though, because we are using the minimum shortfall portfolio as the optimal portfolio, the point farthest to the left on the curve is the best one. Allocations that lie below the minimum shortfall portfolio are deemed inefficient as these portfolios are always rejected by the investor. Any portfolio on the downward sloping part of the curve is dominated by a portfolio right above it on the upward sloping part of the curve because it has an equal percentage of shortfall (risk) but a higher median terminal value (return).

Table 5 TDF and CW/DYNAMIC strategies: Statistical differences in shortfall rates

CW/DYNAMIC strategies	TDF strategy
0%/100% CW	
10%/90% CW	
20%/80% CW	ERP adjustment 4%: Significant at the 0.05 level
30%/70% CW	ERP adjustment 2%, 2.77% and 4%: Significant at the 0.10 level, the 0.10 level, and the 0.01 level, respectively
40%/60% CW	ERP adjustment 0% and 4%: Significant at the 0.10 level and the 0.05 level, respectively
50%/50% CW	ERP adjustment 0%: Significant at the 0.05 level
60%/40% CW	
70%/30% CW	
80%/20% CW	
90%/10% CW	
100%/0% CW	
DYNAMIC	ERP adjustment 4%: Significant at the 0.01 level

We can see the minimum-shortfall portfolio (minimum risk) without an equity risk premium adjustment is the 50/50 CW portfolio. Using the specific data from 1926 to 2009, this result is significant at the 0.05 level as seen in Table 5. We can also see from the graph that investors would reject the TDF as it lies to the right of the 50/50 CW portfolio. An investor would prefer to hold a 50/50 CW or 60/40 CW portfolio, although the TDF does dominate the DYNAMIC allocation.

4.4. Shortfall percentage and median value of terminal wealth tradeoff with equity risk premium adjustments

We conduct a similar analysis with equity risk premium adjustments. The minimum-shortfall portfolios with a 2%, 2.77%, and 4% equity risk premium adjustment are the 30/70 CW portfolio for the first two adjustments, and the DYNAMIC strategy for the 4% adjustment. The decrease in equity proportion for the adjusted minimum-shortfall portfolios occurs because there are lower equity returns. An investor would reject the TDF fund with the equity risk premium adjustments in terms of shortfall risk. The TDF point lies above the minimum-shortfall portfolio in all three cases, although positioned farther “east” so there is greater risk involved as well.

Because the DYNAMIC allocation lies on the downward sloping portion of the curve for the 2% and 2.77% adjustments, an investor would reject it and hold the 50/50 CW allocation or the TDF portfolio. The DYNAMIC allocation is the optimal allocation in terms of shortfall risk with a 4% adjustment. Perhaps the equity allocation of the DYNAMIC allocation decreases over time, so the 4% adjustment has less effect on the performance of the portfolio over time. Therefore, it begins to outperform a CW strategy with a constant exposure to this 4% adjustment.

As illustrated in Table 5, we use a one-tailed z-test of two proportions to test the significance of our results given that the precise data points are the stock and bond returns

from 1926 to 2009. This test measures the difference between shortfall proportions of the TDF allocation and the CW allocation. The null hypothesis is: “The proportion of shortfalls for the CW strategy is greater than or equal to the proportion of shortfalls for the TDF strategy.” The alternative hypothesis is: “The proportion of shortfalls for the CW strategy is less than the proportion of shortfalls for the TDF strategy.” Any part of Table 5 that is filled with a specific equity risk premium adjustment means that the CW portfolio shortfall is statistically smaller than the TDF shortfall. Any part of Table 5 that is unfilled completely or is missing a particular equity risk premium adjustment means the CW portfolio shortfall is greater than or equal to the TDF portfolio shortfall.

In concordance with Spitzer and Singh (2008), the minimum shortfall risk portfolio with no equity risk premium adjustment is the 50/50 CW strategy. However, the minimum shortfall risk portfolios with a 2% adjustment, a 2.77% adjustment, and a 4% adjustment are the 30/70 CW portfolio for the first two adjustments, and the DYNAMIC strategy for the latter adjustment. The result for no equity risk premium adjustment is significant at the 0.05 level. The results for the 2% and 2.77% adjustment are each significant at the 0.10 level. The result for the 4% adjustment is significant at the 0.01 level. Therefore, the TDF strategy has a statistically greater chance of running out of money than the minimum shortfall risk portfolios for each adjustment.

A trend develops as the equity risk premium adjustment increases: the optimal portfolio in terms of shortfall risk shifts to a greater weight in bonds. Without an equity risk premium adjustment, the 50/50 CW strategy is the optimal shortfall risk portfolio and it outperforms the TDF strategy. With both the 2% and 2.77% equity risk premium adjustments, the 30/70 CW strategy is the optimal strategy and it outperforms the TDF strategy. Therefore, the shortfall risk of the TDF is greater than even a 30/70 CW asset allocation with any equity risk premium adjustment besides 0%. The result of a greater weight in bonds indicates that the adjustments increase the risk of the portfolios with a higher weight in equities significantly. If the investor withdraws 4% of the initial portfolio balance each year and also receives a lower return on equities, there is a large increase in shortfall risk for those portfolios with a greater weight in equities.

We witness the trend continue with the 4% equity risk premium adjustment. The DYNAMIC strategy has the best performance in terms of shortfall probability. This portfolio has an even lower weight in equities over 30 years than a 30/70 CW strategy does. However, there is enough weight in equities to provide the investor with a steady return. The DYNAMIC strategy begins with 35% in equities and drops to 5% in equities over the 30 year time horizon. We believe the TDF underperforms the DYNAMIC strategy with a 4% adjustment because with such a drastic downward shift in equity returns, risk begins to dominate expected return at a lower equity allocation. Therefore, the DYNAMIC strategy gets safer at a quicker rate over the 30 year period while risk dominates the TDF portfolio.

5. Conclusion

This study adds to the debate of asset allocation during retirement (decumulation phase) by comparing three different strategies: the target-date fund strategy (TDF), the constant-

weighting allocation strategies (CW), and the 100 minus age strategy (DYNAMIC). Spitzer and Singh (2008) illustrate that the target-date fund's performance is inferior to fixed strategies in terms of shortfall risk, as it underperforms a 50/50 fixed strategy. They conclude that the fund managers of target-date funds should "rethink their asset allocation during retirement."

We find that the conclusion from Spitzer and Singh (2008) is warranted even when using various equity risk premium adjustments, and six more years of stock and return data. Using a frontier of the tradeoff between shortfalls and median value of terminal wealth, we find that the target-date fund strategy is never the minimum-shortfall risk portfolio, and is always outperformed by a 50/50 CW strategy. However, the optimal shortfall risk portfolio with equity risk premium adjustments moves toward a greater weight in bonds. With the 2% and 2.77% equity risk premium adjustments, investors desire a 30/70 CW strategy, and would want an even greater portion in bonds with a 4% adjustment (DYNAMIC strategy). As the equity risk premium adjustment increases, the investor desires a less risky portfolio, and would put less money in equities. For instance, the target-date fund dominates the DYNAMIC strategy for every equity risk premium adjustment except for a 4% adjustment. If the DYNAMIC strategy is usually outperformed by the target-date fund in terms of shortfall risk, it begs the question: Is it worth the trouble for an investor to personally reallocate the portfolio during retirement? The answer would be no if future equity returns stay in line with past returns. Though, the 100 minus age strategy may work if future stock market returns significantly underperform past returns because investors would prefer a portfolio more heavily weighted in bonds.

It would be true to say that an investor with the goal of the least risk of running out of money would rather hold the self-managed portfolios rather than the target-date fund. However, it would be false to say that an investor will always prefer to hold the minimum-risk portfolio. The particular risk preference of an investor must be taken into consideration to find the optimal portfolio in terms of risk-return tradeoff. A person may choose a portfolio farther to the "north east" on our frontier, but that person would also be accepting increased shortfall risk with a chance for higher median terminal wealth. Though, using the frontier, we can say that those portfolios lying below the minimum shortfall risk portfolio will always be inefficient regardless of how the investor defines optimal.

Historical performance of stocks and bonds do provide direction for future returns of these assets. However, on a macro level, the past century has been one in which the United States has won most wars, has developed various technological advances, and has been the leader of production for these advances. To replicate a century such as this would be remarkable if not impossible. Siegel (1992); Campbell, Diamond, and Shoven (2001); Carlson, Pelz, and Wohar (2002); and Ilmanen (2003) are among the authors who believe that the future equity risk premium will shrink. Therefore, we believe it is highly unlikely future stock returns will replicate past stock returns. To illustrate this belief, we use different equity risk premium adjustments for the bootstrap simulation.

The findings in this study have relevant implications for those in retirement. Suppose a retiree has accumulated enough money to retire at age 65. The question of how to best minimize the shortfall risk of the portfolio in a time of uncertain stock market performance is explored here. A significant risk that an investor faces is an unlucky turn for the worse in

the stock market while withdrawing money from the portfolio. We account for this risk by adjusting the equity risk premium. Despite a fund manager's assistance, a self-managed portfolio outperforms a target-date fund. If future equity returns shrink, then a self-managed portfolio with a greater weight in bonds will be desirable. Retirees should reconsider using target-date funds as an all-inclusive investment to provide a comfortable retirement lifestyle whether market conditions replicate past performance or not.

Notes

1. The Social Security Administration reports that in 1985, there were about 114,000 defined benefit plans. As of 2009, there were about 28,000 insured defined benefit plans. Furthermore, in 2009, 39.6 million people were 65 years of age or older. The Administration on Aging reports that in 2030, this number is expected to almost double, as is it estimated that about 72.1 million people will be part of the elderly population. The Social Security Trustees estimate all funds will be dissipated by 2041. This leaves future retirees with about 30 more years of retirement benefits, at which point no more future benefits will be paid out.
2. The definition of the equity risk premium is one that is universally accepted. However, the magnitude of the equity risk premium differs greatly depending on the estimation method and the risk-free rate used.
3. Spitzer and Singh (2008) use a sample of 131 active target-date funds to develop target-date fund strategies for their bootstrap and rolling period simulations. They develop three strategies: The first target-date strategy is referred to as "Gentle Descent," the second is referred to as "Steep Descent," and the third is referred to as "FIXED 25/75." Our TDF strategy is analogous to their Gentle Descent strategy. For a description of target-date funds by fund family, starting allocation, ending allocations, and time-to-target, refer to Spitzer and Singh (2008).
4. Our study contributes to the previous literature by exploring asset allocation of target-date funds during the distribution phase (post-retirement). Other studies that have explored the distribution phase (post-retirement) include Spitzer and Singh (2008) and Pye (2009). Studies that have explored the accumulation phase (pre-retirement) include Spitzer and Singh (2009) and Dolvin, Templeton, and Rieber (2010).
5. The survey in Graham and Harvey (2010) spans from the third quarter of the year 2000 to the third quarter of the year 2010. With 13,368 responses, the study suggests that there is a weak negative correlation between past returns and the level of the long-run risk premium.
6. Cooley, Hubbard, and Walz (1998) concluded that retirees who anticipate long payout periods should plan on lower withdrawal rates, and portfolios heavily allocated to stocks can afford higher withdrawal rates. In essence, more fixed income may reduce risk of a portfolio at the expense of a lower withdrawal rate during retirement.
7. Milevsky and Robinson (2000) and Spitzer and Singh (2008) are among the studies that measure shortfalls as the probability of running out of money before death (real

wealth is zero). We will use the same definition of shortfalls here: A 100% fall in real wealth in any given year is a shortfall. Other studies such as Smith and Gould (2007) have explored different levels of shortfalls such as 50% and 75%.

8. Bootstrapping is a particular Monte Carlo simulation. Bootstrapping involves sampling with replacement from a set of data to generate outcomes (the data is assumed to be the distribution). In contrast, Monte Carlo simulation involves sampling from a distribution with parameters to generate outcomes.

Acknowledgment

This thesis' framework draws greatly upon the methodology of Spitzer and Singh (2008). I thank John J. Spitzer and Sandeep Singh for their comments and guidance. I also appreciate the substantial help provided by Dr. Michael A. Kelly, Dr. Joseph Liebner, and Dr. David Stifel at Lafayette College.

Appendix A: bootstrap algorithm

$$A_{z,m+1} = A_{z,m} [1 + \lambda_z(R_{s,m} - ERP) + (1 - \lambda_z)R_{b,m}] - F$$

A_z = z-th portfolio balance. Starting value at the beginning of year 1 is $b = \$100$ for all models

λ_z = z-th stock proportion

$\lambda_z = [0.50, 0.25]$ for TDF model where λ is decremented by 0.00833 each year.

$\lambda_z = [0.00, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1.00]$ for CW models.

$\lambda_z = [0.35, 0.05]$ for DYNAMIC model where λ is decremented by 0.01 each year.

F = annual withdrawal amount at \$4 (constant) made at the end of each year.

$R_{s,m}$ and $R_{b,m}$ are historical rates of return in year m on large company stocks and long-term government bonds, respectively.

ERP means equity risk premium adjustment (no adjustment, 2%, 2.77%, or 4%).

If $A_{z,m+1} \leq 0$, its value is set to zero because the portfolio has run out of money and a shortfall has occurred.

Note

1. The values of 1926 to 2009 are not sequential (randomly generated).
2. There are 10,000 sequences of 30 year withdrawals.
3. Each of the 13 portfolio types is exposed to the same rates of return on stocks and bonds in exactly the same order.

Appendix B: equity risk premium adjustment calculation

The 2.77% equity risk premium adjustment is calculated from the Graham and Harvey (2010) survey using the arithmetic average difference between historical stock and bond

returns from 1926 to 2009. We then subtract this number from the 10-year average equity risk premium of 3.40%. In formulaic terms:

$$\text{Yearly Historical Stock Return Adjustment} = [\text{AVERAGE}(R_s) - \text{AVERAGE}(R_b)] - 3.40\% = 2.77\%$$

where:

1. R_s and R_b are the historical rates of return on Large Company Stocks and Intermediate-Term Government bonds, respectively, from 1926 to 2009 from Ibbotson (2010). We use Intermediate-Term Government bonds because this risk premium is estimated over a 10 year time horizon.
2. $[\text{AVERAGE}(R_s) - \text{AVERAGE}(R_b)] = 6.17\%$.

No equity risk premium adjustment, 2% equity risk premium adjustment and 4% equity risk premium adjustment are other values tested to see how adjustments above and below our calculation affect the shortfall risk of various portfolios.

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