Assessing the effectiveness of lifecycle (target-date) funds during the accumulation phase

John J. Spitzer

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Sandeep Singh
Department of Business Administration and Economics
College at Brockport
State University of New York
Brockport, NY, 14420 USA

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John J. Spitzer, Ph.D., is emeritus professor of economics at the State University of New York, Brockport, New York, where he taught courses in economics and statistics. His research interests include econometric modeling, asset allocation, and retirement issues. He can be reached at jspitzer@brockport.edu or (585) 225-8849.

Sandeep Singh, Ph.D., CFA, is professor of finance at the State University of New York, Brockport, New York, where he teaches courses in finance and investment analysis. His research interests include asset allocation, performance evaluation, and financial education. He can be reached at ssingh@brockport.edu or (585) 395-5519.

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Using bootstrap simulations, asset allocations that mimic real-world lifecycle fund behavior are shown to have lower accumulation efficiency than other available alternates. The better alternates include fixed stock/bond allocation with 80% or more in stocks and a set of adaptive strategies that attempt to protect gains against catastrophic loss. Lifecycle funds themselves are not as safe, reliable, or effective as implied.

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1. Introduction

Lifecycle (or alternately, target-date) mutual funds change the asset allocation of portfolios on a schedule based on an investor's age and place in the "life cycle." Each investor can contribute to a lifecycle fund that matches an anticipated retirement year and the mutual fund does the rest…the mutual fund industry's version of "cruise control asset management." Israelsen (2008) estimated that at the end of 2007, 229 distinct lifecycle funds with $177.7 billion in assets were under management. According to the Investment Company Institute (2009), lifecycle fund assets under management (AUM) reached $183 billion at the end of 2007 before declining to $164 billion by the end of 2008. The popularity of these funds is expected to increase since Department of Labor rules have designated them as one of the three Qualified Default Investment Alternatives (QDIAs).

The focus of this investigation is on a specific subset of lifecycle funds with target retirement dates in the 2040-2050 range. Lifecycle funds tend to reallocate funds to higher and higher concentrations of bonds as one approaches retirement. Such rebalancing strategies may result in a much lower accumulated balance at the end of 40 years than portfolios that maintain 50% or more in stock throughout the four decades. The empirical question of interest, then, is: "How effective are lifecycle accumulation schemes compared to some unmanaged constant allocations?"

2. Lifecycle Funds - A Synopsis

2.1 Literature Review

Because of the relatively recent introduction of lifecycle mutual funds, the available research on various aspects of these funds is limited. Nagengast, Bucci, and Coaker (2006) study the performance and structure of the retail lifecycle fund offerings of six major fund families. They rank the desirability of the funds on a weighted score of six major parameters: structure/strategy, expenses, allocation, performance and two measures of risk. They conclude that funds generally have performed in line with market returns. They observe that "the asset allocations of most of the fund families lack imagination." (p. 4)

Bodie and Trussard (2007) suggest integration of human capital risk in the optimization process. One of their conclusions is: "…people who are very risk averse and who have a high exposure to market risk through their labor income would experience a substantial gain in welfare from being offered a safe lifecycle fund rather than a risky one." (p. 47) They suggest that the transition from equities to debt in the lifecycle funds be less linear and more "humped."

Mitchell, Mottola, Utkus, and Yamaguchi (2007) study portfolio compositions before and after the existence of lifecycle funds. When lifecycle funds are available, the number of "all equity" or "all cash" portfolios in pension plans decreases. Lifecycle funds are found to change stock/bond allocations by age group probably in part due to the additional asset allocation opportunities provided in the lifecycle funds.

Spitzer and Singh (2008) use a bootstrap simulation to study the probability of running out of money (or shortfall risk) of target-date funds during the retirement years. They classify target-date funds into three types of glide paths: Steep, Gentle, and Fixed 25/75. They show that all three glide path strategies have higher shortfall risk than a constant 50/50 allocation. They urge the designers of target-date mutual funds to "rethink their asset allocation during retirement." (p. 151)

Vicera (2009) examines lifecycle funds in the context of portfolio theory. One of his conclusions is that when the default choices (in a QDIA) for a defined contribution plan are between a target fund and a money market fund, the lifecycle fund is preferable. He also recommends designing target date funds based on life expectancy and not on retirement dates.

Lauricella (2009), in the shadow of the current recession, questions the wisdom of a cookie cutter asset allocation approach of lifecycle funds. He reports a negative return in the range of 7 to 46 percent for the lifecycle funds and an average loss of 29 percent in 2008 for such funds.

Liu *et al.* (2009) utilize bootstrap simulations to compare the accumulation performance of a prototype glide path to constant allocation portfolios with differing exposure to equities ranging from 100 percent to 50 percent for accumulation periods ranging from 10 to 40 years. They find that "Portfolios that follow a glidepath strategy (i.e., decreasing equity and increasing bond allocations) during retirement tend to have lower probabilities of sustainability than portfolios that maintain a constant stock:bond allocation." (p. 12)

In a new approach, Branch and Qui (2009) calculate the size of an annuity that can be purchased at the end of the accumulation period by various lifecycle fund strategies. They use a novel methodology in the bootstrap to capture the serial correlation of asset returns. They find that,

> …the mean accumulations and annuity values rise monotonically with the percentage of the stock allocation and for the 50/50 and higher allocations favor the fixed over the target allocations. While the variability is greater for the fixed allocations, both the

Sharpe and Treynor ratios are substantially higher for the high concentration stock portfolios than they are for the target portfolios. These results pose a major challenge to the claims that the target date funds are an effective retirement planning vehicle. (p. 1)

2.2 Lifecycle Fund Diversity

Individuals in the 25-35 age range usually begin to contribute to a retirement plan or intend to do so soon. Lifecycle funds designated as “2050” to "2055" funds are usually deemed the appropriate funds for such individuals.

[Insert Table 1 about here]

Table 1 provides information about several “Target Date 2050" or “Target Date 2055" funds and similarly dated funds. For each fund family, the longest available target date fund is used. The starting allocation of stocks and bonds, the ending allocation of stocks and bonds, and the number of years it will take to get from the starting to the ending allocation (Time-to-Target) are noted in the table. Additional comments in the table are added as necessary. The T. Rowe Price Retirement 2055 Fund entry, for example, begins with a 90/10 stock/bond allocation and retains this allocation until 20 years prior to retirement. Subsequently, the asset allocation to equities is systematically reduced until it attains a 55/45 stock/bond allocation. (Equity exposure will generally continue to be reduced in retirement for all such lifecycle funds. The emphasis here is on the accumulation phase, not the post-retirement phase.) On the other hand, the American Century LIVESTRONG 2050 Portfolio begins with an 80/20 stock/bond allocation and immediately begins moving toward its terminal 45/55 stock/bond allocation. For simplicity in exposition, cash equivalents and preferred stocks are categorized as fixed income assets and included in the bonds portion. Similarly, REITs are treated as equity securities and included in the stock allocation.

[Insert Fig. 1 about here]

It is not the purpose of this paper to compare lifecycle funds, but rather to evaluate the performance of different lifecycle fund strategies. Two broad transparent asset allocation strategies can be culled from Table 1 and are illustrated in Fig. 1. The two strategies are composites or proxies for actual lifecycle funds.

"Late Descent" The percentage of stocks stays constant at 90 percent for the first 15 years and then begins to fall over the next 25 years until it reaches 50 percent.

"Early Descent" Beginning with 90 percent in equities, the percentage of stocks falls gradually to 50 percent over 40 years.

3. Models, Data, and Methods

In an earlier paper, Spitzer and Singh (2008) compared the efficiency in target date funds in the withdrawal phase during retirement. A similar methodology is used here with the focus on the accumulation phase.

Models

Fifteen allocation strategies (models) are studied. Table 2 contains descriptions, and comments where pertinent. The first 10 of the allocation strategies have fixed allocations. Models 11 and 12 represent the lifecycle proxies from Figure 1, while the last three are attempts at improving on the previous dozen.

Insert Table 2 about here

There are three available QDIA options: a money market fund, a large-cap index fund, and lifecycle funds. Model 1 is the first QDIA option at 100% cash, represented by U.S. Treasury bills. Model 2 is a composite of two QDIA choices with a 50/50 mixture of cash and stocks.

Models 3 through 10 are fixed stock/bond allocations: Model 3 is 30% stocks, Model 4 is 40% stocks…Model 10 is 100% stocks. Model 10 represents the second QDIA default option. Model 11 is the lifecycle proxy designated as "Late Descent" (constant 90% stock allocation for the first 15 years), and Model 12 represents "Early Descent." Both are examples of the third type of QDIA -- lifecycle funds.

Models 13 through 15 have the ability to adapt their behavior based on changing conditions and are simplistic attempts at refining outcomes. The three adaptive models are not intended as the best strategy, but merely a first naïve attempt in that direction. Here is how they work. In each instance, the portfolio maintains a 100% stock allocation until a target portfolio amount of 100, 200, or 300 times the annual contribution amount is reached. In many instances, the target portfolio amount may never be achieved, in which case the model continues to hold 100% in stock. If the target is obtained, the asset allocation immediately "jumps" to a 50%/50% stock/bond allocation. The intent is to lock in the portfolio balance and protect it from dramatic down-side movements.

Data

Annual total returns from 1926-2008 for Large Company Stock, Intermediate-Term Government Bonds, and U.S. Treasury Bills are obtained from Ibbotson (2009). The data are nominal returns; they have *not* been adjusted for inflation.

Methods

Which model(s) can reliably amass the largest portfolio at the end of 40 years? Assume that the savings/investment goal is to purchase the largest annuity possible with the proceeds of Models 1 through 15. Starting with a zero balance, $1 is added to each portfolio at the beginning of every year.[1] A "year" between 1926 and 2008 (inclusive) is randomly selected and the rates of return on stocks, bonds, and cash from that year are used to calculate the new portfolio balance based on the asset allocation rules in effect for each model. Rebalancing of the portfolio is implicit. For example, Model 5 is specified to be 50/50 in stocks and bonds. Let P(t-1) be the value of the portfolio at the end of the (t-1)-th year. Let the rates of return on stocks, bonds, and cash for the next (randomly selected) year, t, be $R_{s,t}$, $R_{b,t}$, and $R_{c,t}$ respectively. The value of Model 5's portfolio at end of the t-1 year is then calculated to be $P(t-1)(1+0.5*R_{s,t} + 0.5*R_{b,t}+ 0.0*R_{c,t})$. An additional dollar will be added to this calculation to represent the portfolio value at the start of the next year. The size of the portfolio will fluctuate over time as rates of return vary, additional contributions are added, and as the value of the portfolio holdings change. For each of the fifteen options, ten thousand 40 year sequences of accumulations are performed. The 10,000 ending balances for the 15 models are saved for further analysis. The distribution of (terminal) portfolio balances provides useful information on portfolio means, medians, ranges, standard deviations, and shapes. It is of special note that each of the portfolios is exposed to precisely the same rates of return on stocks, bonds, and cash in exactly the same order. Differences among the portfolio distributions are therefore attributable to asset allocation difference, not the stochastic returns themselves. The appendix provides a more complete algorithm for the bootstrap.

The $1 contribution amount has an interesting benefit: it is scalable. Real-world individuals may have vastly different annual contribution amounts. Those in 401(k) plans may

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[1] This study seeks to discover which models are likely to reliably attain large ending balances, in nominal terms. The constant $1 annual contribution is problematic, since in real life salary increases, bonuses, increases in contribution limits, etc. imply that contribution amounts will likely grow over time. The idea of a constant annual increase in the contribution amount was rejected on grounds that it is unrealistic. Promotions and contribution limits change sporadically, not regularly. In an attempt to mirror this behavior, a second set of bootstraps was done, where the contribution was increased by 10% after every 5 years – a series of steps or jumps rather than a smooth increase. Thus in year 6, the annual contribution was $1.10, in year 11 it increased again to $1.21, etc. The second set of estimates had larger ending balances, of course, but the relative differences among the 15 models did not change. The constant $1 contribution seems adequate to capture the differences among models.

contribute the (current) maximum of $16,500 each year. Alternately, those in an IRA may contribute their maximum of $5,000. Others may contribute only what they can comfortably afford, well below the limit. The scalability of the ending balances means that multiplying any balance statistic in this study by the actual annual contribution amount obtains a reasonable estimate of the statistic in a real context. For example, if the median ending balance for a portfolio in Model X (any of the 15 models) is $100, this corresponds to a $500,000 median balance for a person who contributes $5,000 per year. If a mean balance for Model Y is $500, then the corresponding mean balance for a $5,000 per year contributor would be $2.5M.

4. Results

The amount of summary data is considerable. In the spirit of parsimony, only three summary "views" of the data are provided; each allows its own distinct insight. First is a table of statistics, second a graphical depiction of the shapes of the distributions, and lastly, a glimpse at the relative likelihood of attaining a specific portfolio goal.

Insert Table 3 about here

Table 3 provides raw statistics – mean, median, standard deviation, minimum, and maximum for the ending portfolio size of all models. The reader may use these numbers in their current form, or may reference them in relation to Figure 2, which will be discussed below. It is clear from these summary data that the "all cash" option of Model 1 has the least variation and also the smallest mean and median accumulation of money. Models 3 through 10 (fixed stock/bond percentages) show a clear pattern of rising mean and median balances as the stock percentage increases. As expected the spread increases with the stock percentage as well. Model 2, the composite cash/stock model, performs similarly to Model 3 (30% stocks, 70% bonds), having a slightly higher mean, median, and standard deviation. Model 2 performs poorly compared to any of the remaining models but significantly better than Model 1 (100% cash). The lifecycle proxies, Models 11 and 12, have higher means and medians than Models 3, 4, 5 or 6. However, models with 80% or more stock (Models 8 through 10) have larger means and medians than either of the lifecycle fund models. The lifecycle fund models could be forgiven their inferior performance if they offered significantly superior down-side protection, but as will be shown in the next two figures, they do not. Models 13 through 15 (the "jump" to 50% models) have larger median balance remaining than the lifecycle proxies. Model 13 has larger mean and median and smaller standard deviation than Model 7 (70% stock). Models 14 and 15 perform similarly with respect to Model 8 (80% stock).

Insert Figures 2 about here

Figure 2 is a series of boxplots which allow relative comparisons among the various models. Several aspects of each models' statistical personality are shown in the fifteen rectangles. The y-axis shows the ending balance scale. The diamond-shaped character in each rectangle designates the location of the median balance, and the circle shows the mean balance. All models exhibit right-skewness - the mean exceeds the median - and the distance between the mean and median increases as the amount of stock increases. The rectangle itself represents the middle 80% of the distribution of ending balances. Consequently, 10% of the ending balances in each Model will be larger than the top of the rectangle, and 10% will be smaller than the bottom. For example, Model 5 with 50/50 stock/bond has a 10th percentile value of $148, a 50th percentile (diamond shape) at $275 and a 90th percentile of $508. The mean (circle) is at $308. (The mean and median numbers correspond to those found in Table 2. The percentile numbers are not shown in Table 2 and are used here to help in the interpretation of the boxplots.) Ten percent of the Model 5's ending balance will be less than $148, 50% will be less than $275, and

90% will be less than $508. The median and mean balance both increase as the stock percentage in the portfolio increases. Model 1, the all cash portfolio, has extremely poor performance compared to all other options. Model 2, the mixture of stocks and cash does about as well as the 30% stock portfolio, Model 3. Model 10, 100% stock, has the largest median, the largest mean, and the largest variance. There is a dashed horizontal line at $331 at the median for Model 12, Early Descent. Using this reference line, it is easily seen that Model 12 performs on a par with Model 7 on the basis of median. Neither lifecycle model performs as well as Models 8, 9, 10, 13, 14, or 15 as measured by the median. Based on Figure 2, the lifecycle models have mediocre median performance and limit potential maxima. The bottoms of each rectangle (except for the All Cash model) have fairly similar values, indicating that the lifecycle funds do not provide greatly superior down-side protection. As will be shown next in Figure 3, the worst-case scenarios are remarkably similar for all the models (except the unremarkable All Cash)

Insert Figures 3 about here

Another perspective is offered in Figure 3, where the probability of achieving a specific portfolio goal is shown. There are 5 clusters in the figure. Cluster 1 shows the probabilities in each of the 15 models of attaining at least a $100 ending balance. Clusters 2 through 5 show the probabilities in each of the 15 models of attaining at least a $200, $300, $400, and $500 balance respectively. The two cross-hatched rectangles are the lifecycle proxies of Models 11 and 12. In Cluster 1, all models except Model 1 are likely to attain at least a $100 ending balance with probability exceeding 93%. Model 1 attains a $100 ending balance only about 17% of the time. Since all models (except All Cash) provide at least 93% probability of achieving the $100 target (a return of about 4.25%), the assertion that the lifecycle funds do not demonstrate superior down-side protection is strengthened. If the lifecycle funds had smaller medians than fixed allocation models but assured that their worst-case outcomes were much better, there would be strong advocacy for their use. Unfortunately, there is little support for an argument that they are "safer" and little evidence that they provide as large an ending balance as Models 8 through 10.

As the ending balance size increases, the probability of success decreases, in some instances very rapidly. For example, for Model 5 (50/50 Stocks/bonds) the probability of attaining a $100 balance is 98%, but drops to 75% at $200, 43% at $300, 22% at $400, and 11% at $500. Although not apparent on the graph, Model 1 disappears for ending balances of $200 or more! That is, it is virtually impossible to attain an ending balance of $200 by using Model 1 as an investment strategy.

The lifecycle models do about the same as models 3, 4, and 5 in attaining a minimum $100 ending portfolio. These models slightly out-perform models 7 through 10 by 1-3%. The advantage is short-lived however. The probability of attaining ending balances of $200, $300, $400, and $500 falls faster for the lifecycle models than for either the Jump models or for models 8, 9, and 10. All of the "Jump" models are more likely to surpass the lifecycle models for the $200 Cluster and all higher clusters shown. Models 8 through 10 perform equivalently to the lifecycle models at $200, but begin to outperform them at higher ending balance targets. For ending balance amounts of $600 or more (not shown), Model 10 (100% stocks) pulls away from the pack. One can refer back to Table 3 and observe the size of the maximum balance achieved by Model 10. These unlikely results will eventually ensure that Model 10 is capable of attaining a large ending balance that no other model can approach, though with accompanying volatility.

5. Summary and Conclusion

Lifecycle (or target-date) funds are a relatively new tool with which retirement savings maybe be amassed. Sellers of such funds provide systematic rebalancing of a retirement portfolio to which the employee (and often the employer) makes regular contributions. Typically, the stock portion of the lifecycle portfolio diminishes over time so that the portfolio becomes increasingly conservative as the owner nears a (target) retirement date. This paper compares the effectiveness of these funds to other choices. Fifteen different asset allocation strategies (models), including two lifecycle examples, are evaluated in a bootstrap simulation to see which models reliably attain the largest ending balance at the end of 40 years.

Many results echo those found elsewhere. The findings confirm those in Vicera (2009), that lifecycle funds are a better choice than an "all cash" portfolio. Branch and Qui's (2009) findings that the average ending balance increases monotonically with the proportion of stock are also confirmed. In contrast to Branch and Qui, however, present results do not confirm that fixed portfolios of 50%, 60%, or 70% stocks are better than the lifecycle funds. Only fixed portfolios of 80% or more stocks are found here to outperform lifecycle funds. When measuring the likelihood that a particular model will achieve a specific goal (100, 200, 300, 400, or 500 times the annual contribution size), the lifecycle funds performed well for the smallest goal; both variants of lifecycle funds attained the smallest goal about 96% of the time. However, portfolios of 80% or more stock begin to equal and then exceed the lifecycle fund performance as the ending balance goal goes beyond $100.

Three adaptive models proved to be surprisingly effective. Except for the smallest goal, all of the adaptive models had a higher probability of attaining a specific ending balance amount than the lifecycle funds or any of the fixed allocation funds.

Spitzer and Singh (2008) found the performance of target date funds during the withdrawal phase (that is, during retirement) to be inferior to alternative fixed allocations. The present study strongly suggests that lifecycle funds are strongly inferior during the accumulation period as well. Employees are likely to amass more money by their retirement date by either investing in fixed proportion portfolios with at least 80% stock (the more the better!) or by implementing some adaptive strategy along the lines suggested here.

In light of its very poor performance, the All Cash default option (Model 1) needs revisiting. A significant improvement would be an additional default option similar to Model 2, a 50/50 cash/equity portfolio. The proposed option is transparent to buyers and will likely have lower costs than the lifecycle fund option.

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Appendix-Bootstrap Algorithm

Let

$B_{m,t}$	=	the portfolio balance of the m-th model at the beginning of the t-th year
W	= $1	the annual contribution
$\lambda_s, \lambda_b, \lambda_c$	=	the proportion of stocks, bonds, and cash respectively specified by the allocation rule for the m-th portfolio
$R_{s,t}, R_{b,t}, R_{c,t}$	=	Rates of return on stocks, bonds, and cash in the t-th year.

(No model holds all three assets. Only models 1 and 2 contain Cash. Asset proportions are not constant for models 11 through 15.)

The value of $B_{m,t}$ at the end of the t-th year is calculated as:

$$B_{m,t} [1 + \lambda_s R_{s,t} + \lambda_b R_{b,t} + \lambda_c R_{c,t}]. \quad [A1]$$

The value of the portfolio at the beginning of the next year will contain an additional annual contribution, W. Hence,

$$B_{m,t+1} = B_{m,t} [1 + \lambda_s R_{s,t} + \lambda_b R_{b,t} + \lambda_c R_{c,t}] + W. \quad [A2]$$

Models 11 through 15 will have changing values of the λs over time.

For each iteration:

a. Set $B_{m,1}$ = $1, W = $1. Set a "year" counter to 0.

b. Using a uniform random number generator, generate a random number between 1926 and 2008 (inclusive) to represent the "year". Obtain the rates of return on stocks, bonds, and cash for this randomly selected year from the historical data.

c. Calculate the appreciated value of each portfolio using Eq A1 and A2.

d. Increment the "year" counter. If the year counter = 40, store the ending balance amounts for all the models for later analysis, otherwise, return to step b.

The above steps describe a single iteration of 40 years of accumulation. This process is repeated 10,000 times. When completed, there will be 10,000 ending balance amounts for each of the 15 models.

Table 1. Description of Lifecycle Funds by Fund Family, Starting Allocation, Ending Allocation, and Time-to-Target

Fund Family	Fund Name	Ticker	Starting and Ending Stock/Bond Allocation2	Time-to-Target	Comments
Alliance Bernstein	All-Bern 2055 Retirement Strategy	LTWAX	95/5 65/35	45 Years	Relatively unchanged allocation up to 25 years prior to retirement. Equity exposure continuously reduced during retirement.
American Century	LIVESTRONG 2050 Portfolio	ARFVX	80/20 45/55	40 Years	Some managerial discretion on asset allocation permitted. Gradually reducing equity exposure.
American Funds	American Funds Target Date Ret 2050	AALTX	95/5 30/70	40 Years	Constant allocation up to 20 years prior to retirement. Up to 20 percent of equity exposure may be invested in balanced funds.
Columbia Funds	Columbia Retirement 2040	BFHAX	95/5 70/30	30 Years	Monotonically declining glide path. Allocation to fixed income accelerates during retirement.
Goldman Sachs	Goldman Sachs Ret Strategy 2050	GRPAX	90/10 45/55	40 Years	Gradually reducing exposure to equities.
Guidestone	MyDestination 2045	GMFZX	100/0 40/60	35 Years	Gradually reducing equity exposure.
Fidelity	Fidelity Freedom 2050 Fund	FFFHX	90 to 100/10 to 0 45 to 90/55 to 10	40 Years	Relatively unchanged allocation up to 20 years prior to retirement. Retirement target reached two years around retirement date.
Franklin Templeton	Franklin Templeton 2045 Retire Target		100/0 60/40	35 Years	Constant allocation up to 30 years prior to retirement. Declining equity exposure until 5 years into retirement.
Hartford	Hartford Target Retirement 2050	HTPRX	95/5 60/40	40 Years	Gradually reducing equity exposure
John Hancock Funds	Lifecycle Retirement Portfolio	JLJAX	100/0 50/50		Relatively unchanged allocation up to 25 years prior to retirement. Gradually reducing equity exposure after that.

[2] REITs are treated as stocks and included in the stock allocation. Cash equivalents are treated as Fixed Income securities and included in the bond allocation.

Fund Family	Fund Name	Ticker	Starting and Ending Stock/Bond Allocation2	Time-to-Target	Comments
JP Morgan Chase	JP Morgan Smart Retirement 2050 Fund	JTSAX	None Provided	40 Years	Discretionary asset allocation
Manning & Napier	Manning & Napier Target 2050	MTYCX	None Provided	40 Years	Discretionary asset allocation
Mutual Fund Series	MFS Lifetime 2040	MLFJX	95/5 25/75	30 Years	Relatively unchanged allocation up to 20 years prior to retirement. Monotonically sloping path up to retirement.
Principal	Principal Lifetime 2050 Fund	PPEAX	None Provided	40 Years	Discretionary asset allocation
Putnam	Putnam Retirement Ready 2045 Fund	PRVYX	None Provided	35 Years	Discretionary asset allocation
Seligman Funds	TargETFund 2045	STQAX	None Provided	35 Years	"Typically, Funds with 20 years or more to their target dates will have similar asset allocations."
Scudder	DWS LifeCompass 2040 Fund	TGTAX	None Provided	30 Years	Discretionary asset allocation
State Farm	State Farm Lifepath 2050 Fund	NLPAX	None Provided	40 Years	Barclays proprietary asset allocation model.
TIAA-CREF	Lifecycle 2050 Fund	TLFRX	90/10 50/50	40 years	Relatively unchanged allocation up to 20 years prior to retirement. Monotonically sloping path up to retirement. Allowed discretionary change of ± 10%.
T. Rowe Price	T. Rowe Price Retirement 2055 Fund	TRRNX	90/10 55/45	45 Years	Relatively unchanged allocation up to 20 years prior to retirement. Monotonically sloping path up to 30 years into retirement.
Vanguard	Vanguard Target 2050 Fund	VFIFX	90/10 50/50	40 Years	Relatively unchanged allocation up to 20 years prior to retirement. Monotonically sloping path up to 5 years into retirement.

Fund Family	Fund Name	Ticker	Starting and Ending Stock/Bond Allocation2	Time-to-Target	Comments
Vantagepoint	Vantagepoint Milestone 2040 Funds	VPKRX	90/10 65/35	40 Years	Relatively unchanged allocation up to 25 years prior to retirement. Gradually reducing equity exposure after that, Constant allocation 10 years into retirement.
Wells Fargo	Wells Fargo Advantage Dow Jones 2040 Fund	STFRX	90/10 30/70	40 Years	Relatively unchanged allocation up to 30 years prior to retirement. Gradually reducing equity exposure after that, Constant allocation 10 years into retirement.

Table 2. Asset Allocation Strategies used in the Bootstrap Simulations.

Model Number	Portfolio Composition	Comment
1	100% Cash	Represents one of the three QDIA default options
2	50% Cash/ 50% Stocks	Represents a combination of two QDIA default options
3	30% Stocks/ 70% Bonds	
4	40% Stocks/ 60% Bonds	
5	50% Stocks/ 50% Bonds	
6	60% Stocks/ 40% Bonds	
7	70% Stocks/ 30% Bonds	
8	80% Stocks/ 20% Bonds	
9	90% Stocks/ 10% Bonds	
10	100% Stocks	Represents one of the three QDIA default options
11	Late Descent	A lifecyle fund proxy
12	Early Descent	A lifecyle fund proxy
13	100 Jump	Experimental: 100% Stock until portofolio balance gets to $100, then 50%
14	200 Jump	Experimental: 100% Stock until portofolio balance gets to $200, then 50%
15	300 Jump	Experimental: 100% Stock until portofolio balance gets to $300, then 50%

Table 3. Various Statistics for Ending Portfolio Balances for selected accumulation strategies after 40 years based on 10,000 iterations

	Model Number and Description														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Cash Only	Cash/ Stocks	30% Stock	40% Stock	50% Stock	60% Stock	70% Stock	80% Stock	90% Stock	100% Stock	Late Decent	Early Descent	100-Jump	200-Jump	300-Jump
	Statistic Values in Dollars														
Mean	90	242	223	262	308	363	429	506	598	707	453	405	445	510	552
Median	89	219	212	242	275	310	346	380	414	447	353	331	378	424	460
StDev	11	117	74	108	156	223	315	441	613	847	358	281	292	364	417
Minimum	59	44	65	58	50	41	34	28	22	18	38	42	18	18	18
Maximum	151	1,133	677	999	1,527	2,515	4,117	6,697	10,811	17,313	4,924	3,580	3,285	3,783	4,407

Figure. 1. Late Descent and Early Descent Lifecycle Strategies

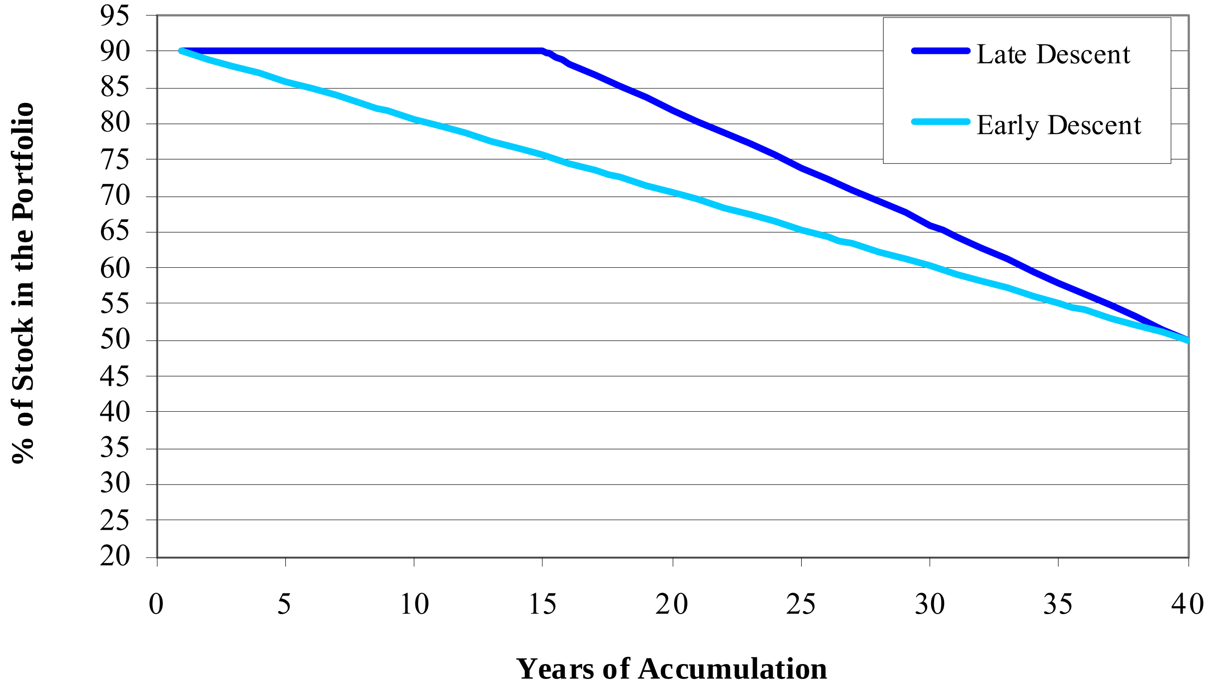
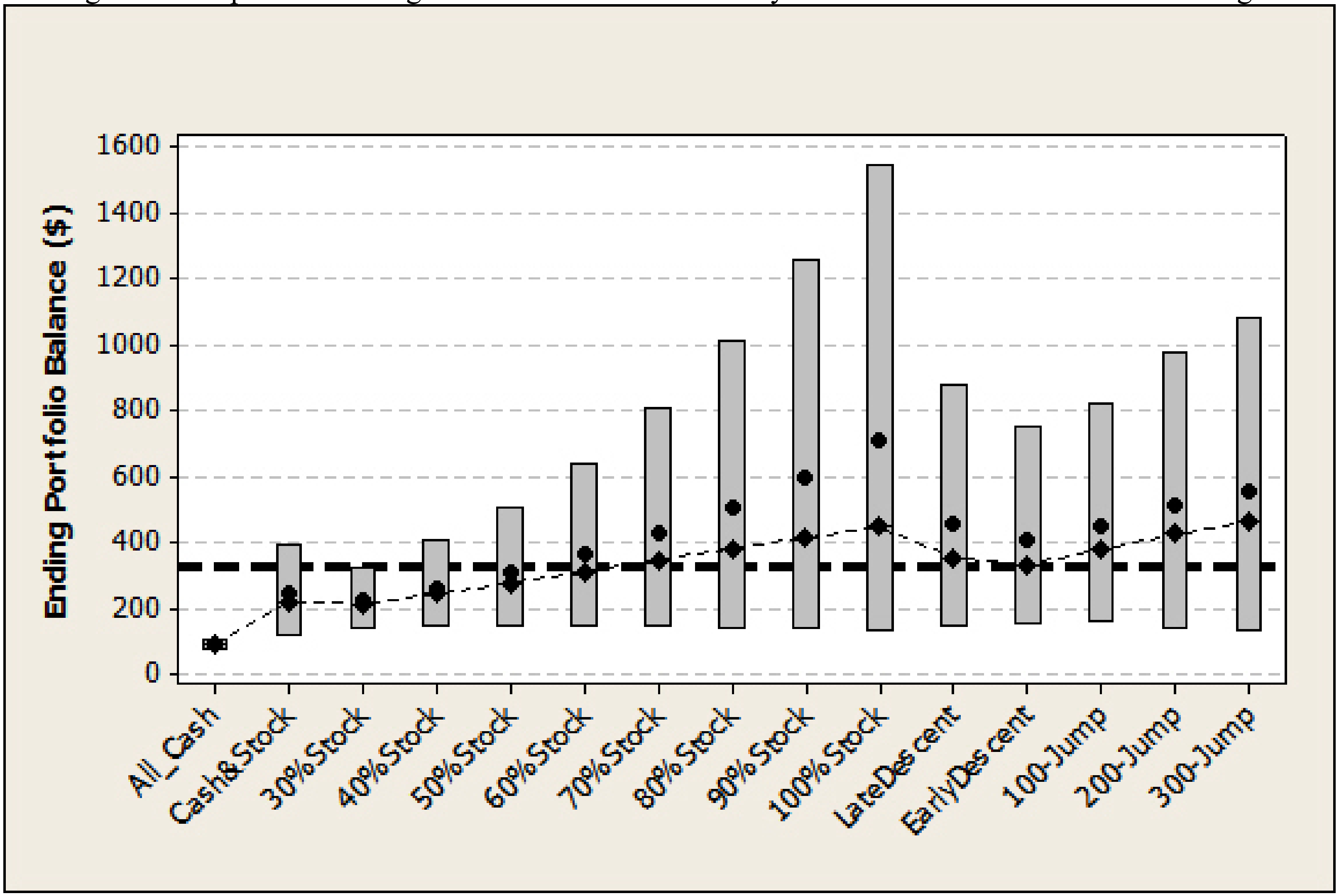


Figure 2. Boxplots of Ending Portfolio Balances after 40 years for selected accumulation strategies



● - Designates the location of the mean. ◆ - Designates the location of the median. The rectangle shows the middle 80% of the Distribution of Ending Balances.

Figure 3. Probability of having a $100, $200, $300, $400, or $500 Ending Portfolio Balance after 40 years for selected Accumulation Strategies (Numbers on the horizontal axis correspond to Model numbers in Table 2)