ESSAYS ON TARGET DATE FUNDS
AS A RETIREMENT PORTFOLIO CHOICE

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ABSTRACT

This two part dissertation evaluates target date funds (TDFs) as a portfolio choice for retirement savings. In the first part we analyze the fit of TDFs as the main retirement savings instrument for the utility maximizing investor who becomes more risk averse as he/she gets older. Using bootstrapping simulations, we show that TDFs lead to higher expected utility than the strategies that keep stock allocation fixed in the portfolio over the whole investment horizon. Incorporating the concept of loss aversion into the expected utility model, we find further proof that decreasing the weight of risky assets in the portfolio as the target retirement date nears will lead to higher expected utility and is therefore preferable to the utility maximizing investor.

In the second part of the dissertation we analyze the actual return dispersion of 2010 TDFs to indentify the sources of this performance. In the fall of 2008, the investors in these TDFs were about 2 years away from their planned retirement when some of those investors lost up to 40% of their accumulated wealth in the 2010 TDFs. According to the central tenet of TDFs, the funds that are close to target retirement year should have decreased their allocation to risky assets in their portfolios in order to protect the retirement savings. Instead, those underperforming TDFs fell short of providing a safe harbor for the retiring investors' funds. Though all 2010 TDFs were affected by the bear market, not all of them experienced extreme losses and the savings of some investors were affected minimally. We find that the worst returns were limited to only few renegade funds and that in general the asset allocation of 2010 TDFs protected investors as it was designed to do. The main source of underperformance of some of the 2010 TDFs was the poor security selection skills of the managers.

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CHAPTER 1. INTRODUCTION

In this paper, we evaluate if life-cycle portfolios or target date funds (TDFs) are a better fit as the main retirement savings instrument than life-style portfolios where the asset allocation is fixed[1]. When an investor's asset portfolio is a good match with his/her risk tolerance at the respective stage in life, there is less worry about welfare during golden years and therefore fewer sleepless nights. After all it is a well-known fact that the investor's risk tolerance is reflected in his ability to sleep at night. Using expected utility as a measure of performance allows us to account for the fit of the portfolio strategy with investor's risk aversion under uncertainty.

Today, as employers switch from offering defined benefit plan to defined contribution plan, more individuals than ever have the freedom to manage their retirement savings. Along with this freedom comes the responsibility to ensure their welfare during the retirement years. Unlike the bygone days of defined benefit pension plans when the employers made all of the contributions and investment management decisions, in the modern era, 401(k) defined contribution plan participants decide for themselves how much to save, what should be the composition of their portfolios, and they bear the investment risks. Thus along comes a greater need to be educated and informed about one's investment choices. Unfortunately, research suggests that this is a burden many pension plan participants may not be prepared to bear.

With the enactment of the Pension Protection Act (PPA) of 2006, the U. S. Department of Labor defined qualified default investment alternatives (QDIAs) for the retirement plan participants who fail to choose the vehicle for their retirement contributions. PPA does not identify specific investment products but aims to assure that an investment vehicle is appropriate and meets individuals' long-term retirement savings needs. One of the four mechanisms described in PPA says that the qualified default instrument should have a

[1] In this paper we use terms "life-cycle fund" and "target date fund (TDF)" interchangeably.

portfolio mix that takes into account an investor's age or retirement date (EBSA, 2009). Target date funds aim to do exactly that and can therefore be used by plan sponsors as a default option for participants who fail to choose the fund themselves. With the endorsement from the Department of Labor, the popularity of TDFs has increased remarkably in recent years. According to the Investment Company Institute (2012), in the end of the second quarter of 2012 the total assets of TDFs are $427 billion, which is about 13% of the total assets of defined contribution plans. This is a significant increase since 2007, when TDFs only had a 6.1% share of the defined contribution plans. Due to this surge in popularity of TDFs it is important to investigate the central tenet of TDFs that investors should gradually diminish the importance of risky assets in their retirement portfolios.

Table 1. TDFs and US private retirement market in billion USD, 2007 to 2012.

	2Q2012	1Q2012	2011	2010	2009	2008	2007
TDF assets in billion USD							
Total Net Assets	427	425	376	340	256	160	183
TDFs in DC Plans	305	305	270	245	189	119	131
TDFs in IRAs	83	82	73	65	48	32	39
Private retirement Assets							
TNA (billion USD)	12,250	12,522	11,773	11,736	10,650	9,040	11,751
TDF share in %	3.5%	3.4%	3.2%	2.9%	2.4%	1.8%	1.6%
Defined Contribution Plans							
TNA (billion USD)	3,290	3,360	3,120	3,070	2,746	2,208	2,984
TDF share in %	13.0%	12.6%	12.1%	11.1%	9.5%	7.2%	6.1%

Source: ICI (2012)

Life-cycle funds or TDFs are characterized by the target retirement date and a portfolio strategy that decreases the equity weight in the portfolio over the investment horizon, whereas life-style strategies keep the stock allocation fixed over the investment period. Superiority of decreasing stock allocation strategies over the fixed stock allocation strategies has been a topical question for a long time even before the emergence of TDFs. Financial planners have advocated that the weight of stocks in the individual investor's portfolio should be inversely related to the investor's age. The most common rule of thumb is that the percentage of wealth invested in stocks should be equal to 100 minus the investor's age (Ameriks & Zeldes, 2004; Damato, 1993; Jagannathan & Kocherlakota, 1996).

Following this rule the investor who is 45 years old should have no more than 55% of his wealth invested in stocks. Academic literature refers to this idea as the life-cycle risk aversion hypothesis (Bakshi & Chen, 1994).

Though financial planners seem to advise in unison the shift away from stocks and towards fixed income instruments as the investor nears retirement age, the academic community is not as unanimous on this point. The main arguments that have been discussed in the literature in support of decreasing equity allocation are: stocks are not as risky over a long investment horizon; stocks are essential to accumulate funds for different financial goals; younger people have more future labor income to help them recover potential losses and investors have a desire to ensure a terminal value at the end of the investment period (Jagannathan & Kocherlakota, 1996). The findings of this paper add one more reason to this list. As an investor's risk aversion increases with age the stock allocation in the portfolio needs to decrease in order to be optimal for the utility maximizing investor.

Risk aversion is directly related to investors' utility, an economic concept reflecting the satisfaction gained from goods or services. Unlike return on the investment or the final accumulated dollar amount, utility takes into account the cost of reached monetary goals – sleepless nights due to too high risks of the portfolio. Keeping large portions of wealth in risky assets when the investor's risk tolerance is low would lead to lower expected utility or in other words the investor would be disgruntled.

In this paper we use expected utility over different investment horizons as a measure to compare differences in life-cycle and life-style strategies and assume that investors are utility maximizers. We run simulations with a range of portfolio weights on stocks and bonds for both life-cycle and life-style strategies, with a range of representative investors with different risk aversion characteristics. Our investigation includes portfolio strategies that are more common among the funds offered by fund families. We find that for the investor whose risk aversion increases as he/she gets older, the life-cycle portfolio strategies lead to higher expected utility than strategies that keep stock allocation fixed over the whole investment horizon. Prior studies in the field of behavioral finance have concluded that investors have different attitude towards downside risk and are more sensitive to the negative changes to their wealth (Kahneman & Tversky, 1979). We incorporate the concept of loss aversion into the expected utility model. The results find further proof that investment strategy that decreases risky assets in the portfolio as the target retirement date nears, leads to higher expected utility and is preferable to the utility maximizing investor.

It is also important to remember that not all TDFs with the same target date are the same. Balduzzi and Reuter (2012) find increased heterogeneity among the TDFs offered in the market and conclude that this differentiation can lead to varying levels of performance and risk. Idzorek (2009) stresses that it is important to look past the target date and evaluate the fund strategy in more detail. The Morningstar Industry Survey (Charlson, Herbst, Liu, Pavlenko Lutton, & Rekenrthaler, 2009) reports that in 2008 the equity allocations for 2010 TDFs range from 26 percent to 72 percent. Due to this wide difference in glide paths, we consider a wide range of different life-cycle strategies, including different glide path lengths, gentle and steep descent glide paths (also referred to as glide paths with kink), as well as aggressive and conservative glide paths, and our results are robust.

In addition to including in our analysis a range of different life-cycle strategies, this paper contributes to the literature in that we compare the performance of life-cycle and life-style strategies by using expected utility and incorporating investor's increasing risk aversion and loss aversion into the utility model[2].

The rest of this paper is organized as follows. The next section gives an overview of prior research related to the need to decrease the portion of equity in total wealth as an investor ages, and to the life-cycle risk aversion hypothesis. Section III describes the model used in our analysis. The results are analyzed in Section IV, and the conclusions are drawn.

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[2] In this paper we focus on a representative investor who has failed to choose a fund for his/her contributions towards retirement, or who wants to make his/her contributions with minimal or no interference during the full investment period. This is an investor who is kept in mind in the PPA 2006 that defined QDIAs. This is also the investor who without this default choice would have made no or very few contributions toward his/her retirement welfare. It is therefore important to remember that an investor who actively manages his/her retirement portfolio may find other strategies more suitable for investing towards retirement.

CHAPTER 2. RELATED RESEARCH

1) Prior TDF literature

As the popularity of TDFs has increased as a simple investment strategy for retirement, researchers have also become more interested in the topic. Studies have been both critical of the life-cycle model as well as finding support for the suitability of TDF strategy for the retirement investing. The main focus in these studies has been on the accumulated wealth by the target retirement year and the appropriate asset allocation.

During the recent financial crises TDFs received a lot of criticism for not being sufficiently conservative in their strategy. Basu and Drew (2009) argue that TDFs reduce equity allocation at the wrong time, namely when investors have sufficient portfolio balances to reap the capital gains. They simulate the results of different investment strategies, and compare the life-cycle strategy with decreasing equity allocation to a contrarian strategy with the exactly opposite approach of increasing equity allocation, and conclude that a high equity allocation should be maintained in TDFs.

Liu, Chang, De Jong, and Robinson (2011) evaluate the performance of the two lifecycle funds with gentle and steep descent glide paths and seven lifestyle funds throughout accumulation and withdrawal phases using bootstrapping. They examine the total accumulated wealth at the retirement date and the sustainable success rates in the retirement stage of different strategies, and conclude that basic life-cycle strategies are beneficial to the investor, especially during the withdrawal phase.

Pfau (2011) performs similar simulation analysis as Basu and Drew (2009) with an expected utility framework to compare different strategies and consider more realistic lifecycle asset allocation strategies. He finds that the introduction of a reasonable degree of risk aversion and assuming diminishing utility from wealth, would give investors a reason to prefer the lifecycle strategy in spite of portfolio size effect. In his model, Pfau keeps representative investor's risk aversion constant throughout the investment period and does not discount the annual accumulated wealth to its present value.

Idzorek (2009) builds a model to estimate an optimal glide path for a representative investor. Using modern portfolio theory he incorporates in his model human capital and investor's risk preferences. In addition he uses several different asset classes in his hypothetical portfolio (e.g. TIPS, commodities and real estate). He suggests a glide path that starts out with allocations to international and small-cap stocks, and as the investor becomes older, increases the allocation to bonds and eventually to inflation-protected instruments.

2) Decreasing portfolio stock allocation as the investor gets older

Decreasing the allocation to risky assets over the investment period is the central tenet of TDFs. There are three main arguments that explain the importance of decreasing the equity weight in the investment portfolio throughout the lifetime of the investor. These reasons have been advocated by financial planners and studied by researchers.

The first argument used to support life-cycle investment strategies is the principle that stocks are less risky and outperform bonds over the long investment horizon (Bali, Demirtas, Levy, & Wolf, 2009 & Wolf, 2009; Malkiel, 2011). In his famous book, *Random Walk Down Wall Street*, Burton G. Malkiel states that "the longer the time period over which you can hold on to your investments, the greater should be the share of common stocks in your portfolio" (Malkiel, 2011, p. 364). Several other studies have also found that the longer the investment horizon, the lower the average variance of stock returns, and therefore the more heavily the investor can invest in stocks compared to investors with short investment periods (Latané, 1959; Markowitz, 1976). Barberis (2000) analyzes how the predictability of asset returns affects optimal portfolio choice and concludes that even after accounting for uncertainty of asset returns or estimation risk, the investor that has a long investment horizon would allocate more of his portfolio into equities than the investor with the short investment horizon.

The second argument relates to individuals' life cycle. Financial objectives are different from person to person and depend on what stage in life the investor is in. At a younger age it is necessary to save for the down payment of mortgage, in midlife it is essential to have money for the kids' education, and overall it is important to have accumulated sufficient funds to finance the retirement years and beyond. Samuelson (1989) concludes that the longer-term financial objectives, such as assuring income for themselves or desire to bequest, support the life-cycle investment strategy. Dynan, Skinner, and Zeldes (2002) show that the motive to assure own well-being and the bequest motive are indistinguishable as accumulated savings serve these goals simultaneously by providing for future financial needs as necessary, and if not depleted are then left for kids or for other worthy causes. Therefore in order to ensure a desired terminal value of savings or target level of wealth, either for covering expenses during the golden years or for leaving behind as inheritance, the portfolio weight in equity should be reduced as the target retirement year nears.

The third argument in support of decreasing equity allocation is the introduction of labor income that is often referred to as human capital. The younger the investor, the more future income from salaries he/she still has left to receive. This future income can be used to recover the potential losses caused by bear markets and economic downturns (Jagannathan & Kocherlakota, 1996). Young people have time as their ally in the quest for saving for retirement or as Bodie, Merton, and Samuelson (1992) put it, "future earning power is the most important asset of young people." Jagannathan and Kocherlakota (1996) consider future income as a risk-free asset, treating the expected salary over the working years as a constant. The investor therefore needs to balance his overall wealth portfolio and have a higher level of risky assets when he/she is young as the present value of future labor income is relatively high at a young age. In their bestselling book, Ayres and Nalebuff (2010) recommend that young investors should use leverage to increase their position in stocks as they consider future labor income to be equivalent to the low-risk fixed income assets and therefore decrease the share of risky assets of the present value of total wealth. When older, there are less working years left and the portion in equity should be decreased. In other words, the present value of future income is a decreasing function of age (Bajtelsmit &

Bernasek, 2001). Bodie et al. (1992) stress that riskiness of labor income determines the optimal portfolio choice and therefore ignoring human capital will lead to an 'omitted variable' problem. The more uncertain the future income is the less should be invested in risky assets, and as the target retirement year gets closer, the value of future income diminishes so the investor should become more conservative in his/her investment decisions. Bodie and Treussard (2007) provide evidence that the life-cycle strategy is optimal for the "natural" TDF holders who have conventional risk aversion and exposure to human capital risk.

3) Risk aversion and age

It has long been believed that age affects an individual's tolerance for risk. Common sense is that risk aversion increases with age. We see very few elderly people parachuting or taking other extraordinarily high risks. The worry about personal well-being during years of retirement could make investors less tolerant of financial risks. On the other hand, research has also shown that an individual's risk aversion decreases when wealth increases – when you are rich you have more wealth to risk as well as cover possible losses. Pratt (1964) and Arrow (1965) develop two measures of risk aversion: the absolute risk aversion that measures the dollar amount of risky assets in a portfolio; and a relative risk aversion that reflects the proportion of risky assets in individual's total wealth. Relative risk aversion can also be referred to as elasticity of marginal utility, which makes this measure of investor's risk tolerance appropriate for our study as we focus on the marginal utility derived from specific retirement investment strategies.

It is difficult to single out an investor's preferences, to know whether his/her risk aversion increases or decreases. No study so far has been able to map individual investor's risk preferences throughout different stages in his/her life. The overall consensus among the academic community is that absolute risk aversion decreases as individual's total wealth increases (e.g. Friend & Blume, 1975; Guiso & Paiella, 2008). According to Friend and Blume (1975), relative risk aversion for wealth, using the narrow definition provided by Arrow (1965) and Pratt (1964), is larger than one and slightly increasing or constant.

Demographics of individual risk aversion have been researched by experts in many different fields – psychology, economics, finance, and management, among others. Three main types of studies have been conducted to determine individual's risk aversion: analysis of actual holdings of risky assets, experimental studies looking at the participant's choice between risky alternatives, and more recently, studies that involve studying brain activity during decision-making that involves risk. In finance literature the most common are studies using information from different national databases analyzing the composition of household portfolios. One problem with the studies about actual holdings is that many households hold no stocks (e.g. Vissing-Jørgensen & Attanasio, 2003) but the findings provide some understanding about the risk attitudes of individual investors.

A longitudinal study by Bakshi and Chen (1994) tests the life-cycle risk aversion hypothesis by analyzing the changes in markets for real estate and stocks over the lifetime of baby boomers. They measure risk aversion as proportion of a household's assets held in the form of risky assets such as stocks. One of their findings is the increase in individual investors' risk aversion with age in the post-1945 period.

Pålsson (1996) uses the framework by Friend and Blume (1975) and analyzes the Swedish annual tax return data to examine risk taking by households. She includes both real and financial assets in the study. The estimated age coefficient in her study indicates that risk aversion increases with age.

Hartog, Ferrer-i-Carbonell, and Jonker (2002) conduct a survey by asking individuals for the amount they would be willing to pay for participation in a lottery. They calculate the Arrow-Pratt measure of absolute risk aversion and relate that to personal characteristics. They find that individuals are more risk averse as they grow older.

A cross-sectional study by Agnew, Balduzzi, and Sundén (2003) analyzes almost seven thousand retirement accounts from a single plan over the period of 1994-1998. The age range in their dataset is from 20 to 77. The average equity allocation in their sample is 37.5%. They find that age has a negative effect on the portfolio fraction held in equities. The equity allocation is highest among the 45-55 years old, whose mean allocation is 44%. For the next age group (55-65), the pre-retirement years, the mean equity allocation declines to 37.85%. According to the authors, an extra year translates into a lower allocation to stocks by 93 basis points.

Jianakoplos and Bernasek (1998) compare risk aversion among women and men, and also try to determine life-cycle effects. Their findings support life-cycle risk aversion hypothesis as younger women in their study are less risk averse than older women, and relative risk aversion increases with age. The newer article by Jianakoplos and Bemasek (2006) decomposes the effects of age, birth cohort, and calendar year on the financial risk taking by households by using two measures of risk taking. They look at portfolio holdings by participants and their willingness to take risk based on survey responses. The authors conclude that risk taking decreases with age and households take less risk in response to decreasing financial security over time.

Some newer studies in neuroeconomics have tested risk aversion over the life cycle by studying brain activity using the functional magnetic resonance imaging (fMRI). Deakin, Aitken, Robbins, and Bahakian (2004) use computerized gambling tasks in their experimental study with 177 participants in age range between 17 and 70. Using factor analysis they find that risk taking decreases with age suggesting older people are more risk averse. Lee, Leung, Fox, and Gao (2007) conduct an experiment with younger and older male participants, following their brain activity with the help of fMRI, while the participants are performing tasks that have risky gains. They conclude that when making risky decision, there may be possible neuropsychological mechanisms underlying the change in risk-taking behaviors when individuals age. In their study older subjects choose the risky option less often and when they do choose risky alternative, they perceive it as more risky compared to the younger participants.

However, when wealth is taken into account, some studies have shown that as investors get older and their wealth increases, their risk tolerance may not decrease (McInish, Ramaswami, & Srivastava, 1993; Wang & Hanna, 1997; Yoo, 1994). Siegel and Hoban (1982) find that by restricting the sample to higher wealth households and by defining wealth narrowly, patterns consistent with decreasing or constant relative risk aversion emerge. However, they show that there is an increasing relative risk aversion with wealth if a broader based sample and a more comprehensive measurement of wealth are used.

In fact it is hard to separate the age effect and wealth effect. Ameriks and Zeldes (2004) decompose the effects on risk aversion into time and cohort effects. Using pooled cross-sectional data from the Surveys of Consumer Finances and new panel data from TIAA-CREF, they examine the empirical relation between age and portfolio choice, focusing on the fraction of wealth held in stocks. They find that equity ownership has a hump-shape pattern in relation to age, with investors in both ends of the age spectrum holding less of their portfolio in stocks.

In his thesis Fagereng (2012, Chapter 1) uses a novel panel data from Norwegian administrative and tax records to study household life cycle portfolio choices. He separates age, time, and cohort effects on stock market participation, and shows that households gradually reduce their risky portfolio share beginning in mid-life before stabilizing the risky fraction around the age of retirement.

4) Risk aversion coefficient

Many papers have studied the value of the risk aversion coefficient using theoretical models and experimental frameworks, resulting in a wide range of results. The majority of the studies conclude that the value of a relative risk aversion coefficient is somewhere between 2 and 4. A seminal paper by Friend and Blume (1975) estimates the coefficient of relative risk aversion is about 2 assuming stock returns are the only stochastic component of wealth. Grossman and Shiller (1981) find the coefficient of relative risk aversion has to be at least 4 to explain the variability in stock prices. Pålsson (1996) finds the range for the coefficient of relative risk aversion is between 2 and 4. Halek and Eisenhauer (2001) use insurance data to estimate risk aversion, and find that the coefficient of relative risk aversion is highly skewed towards zero and has a median value of 0.89. Chetty (2003) includes price elasticity and income elasticity of labor supply in his theoretical model for relative risk aversion, and finds that the coefficient of relative risk aversion is very close to 1. Meyer and Meyer (2005) review prior literature on relative risk aversion and calculate the relative risk aversion coefficient using various wealth measures and conclude that for a narrowly defined Arrow-Pratt wealth measure, the coefficient is larger than one and slightly increasing. Azar (2006) concludes that in the expected utility framework in order to justify the market equity premium, the upper limit for the coefficient of relative risk aversion should be 4.5.

5) Investor's loss aversion

Economic analyses of investor's decisions under risk generally assume that people maximize expected utility. Empirical evidence has shown that people systematically violate expected utility theory. For example, studies in the field of behavioral finance have shown that investors have different attitudes toward risk. Namely investors are more sensitive to the negative changes to their wealth, therefore they are loss averse. Loss aversion describes an observed behavior which the investor avoids symmetric fifty-fifty bets (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). In the case of loss aversion utility, function is steeper for losses than gains (Schmidt & Zank, 2005; Thaler, Tversky, Kahneman, & Schwartz, 1997 & Schwartz, 1997).

How much more do the losses affect the investor compared to the gains? Tversky and Kahneman (1992) estimate the loss aversion parameter for the utility function is equal to 2.25. Other researchers have found the coefficient of loss aversion to be between 1.4 and 4.8. The differences in the results can be explained by the definition and framework used by the authors. The lowest value for the loss aversion coefficient is estimated by Schmidt and Traub (2002), who use the framework of cumulative prospect theory and find that the individual's average loss premium is positive and the loss aversion coefficient is 1.43. The highest value for loss aversion is 4.8, estimated by Fishburn and Kochenberger (1979).

CHAPTER 3. METHODOLOGY

The objective of this paper is to evaluate the life-time utility provided by portfolio strategies. In our analysis we assume first that the investor's risk aversion increases as he/she gets older. In the second model we also assume that the investor becomes more risk averse as he/she experiences losses. Based on these assumptions we look how the change in risk aversion over the investment horizon and the portfolio composition affect the investor's lifetime expected utility. More specifically, do life-cycle strategies yield higher expected utility compared to life-style strategies for the utility maximizing investor who becomes more risk averse as he/she gets older?

We use the lifetime expected utility to compare the differences between life-cycle and life-style strategies for a representative investor who becomes less risk tolerant as he/she gets older. At any month *t*, we express the utility of the representative investor using the mean-variance model adopted by Friend and Blume (1975):

$$U_t = E\left(R_{p,t}\right) - \frac{1}{2} A_t \sigma_{p,t}^2 \tag{1.1}$$

Where $R_{p,t}, \sigma_{p,t}$ are the return and variance of the portfolio that the investor holds, and A_t is Pratt's measure of relative risk aversion at year *t*.

This mean-variance model can be motivated by assuming quadratic utility for arbitrary distributions, or assuming that the return of the risky portfolio is normally distributed for arbitrary preferences (Huang & Litzenberger, 1988). We calculate annual expected utilities for the representative investor with different scales of risk aversion. These different risk aversion scales can have the risk aversion level from zero to 4 at the beginning of the investment period, and the level between zero and 6 at the target retirement year[3]. The expected utility for all these different risk aversion ranges is calculated for the finite number of portfolio strategies based on equity/bond mix. The lifetime expected utility for the whole investment period (e.g. 40 years from age 25 to age 65) is defined as the present value of all annual expected utilities.

$$E(U)=\sum_{t=1}^{T}\beta^{t}\left[E\left(R_{p,t}\right)-\frac{1}{2}A_{t}\sigma_{p,t}^{2}\right] \tag{1.2}$$

where β is the discount factor, T is the length of investment period in years, and t stands for a specific year. We use a discount factor of 0.99 and for robustness tests also made calculations with β of 0.95 and 0.90.

Expected portfolio return is calculated based on the portfolio mix for each strategy at the respective investment period. The life-cycle portfolios follow different glide path strategies that are characterized by the beginning equity allocation, ending equity allocation and the time point when the equity allocation starts to decrease in the portfolio (e.g. for the first ten years the weight of equity is kept at the maximum creating a kink in the glide path). Based on these parameters the portfolio allocations of life-cycle strategies change each year by decreasing the equity in equal increments but stay the same within the year[4]. Life-style strategies keep the equity allocation constant over the whole investment period. The monthly mean return of the portfolio for each strategy is calculated as follows:

$$E\left(R_{p,t}\right)=w_{bond,t}\times\bar{R}_{bond}+w_{eq,t}\times\bar{R}_{eq} \tag{1.3}$$

Where $w_{bond,t}$ is the weight of bond in the portfolio at time t and $w_{eq,t}$ is the weight of equity in the portfolio at time t. $\bar{R}_{bond}$ is the mean return of the bond and $\bar{R}_{bq}$ is the mean

[3] We assume that the relative risk aversion changes annually. Within each month during a year the investor's risk aversion is assumed to stay the same.
[4] As in Liu, Chang, De Jong, and Robinson (2011), we rebalance the portfolio annually in the beginning of each year. Therefore, within the year the level of equity in the portfolio is kept constant.

return of Diversified Equity Portfolio. The portfolio variance for each strategy is calculated for each investment year as follows:

$$\sigma_t^2\left(R_{p,t}\right)=w_{bond,t}^2\bar{\sigma}_{bond}^2+w_{eq,t}^2\bar{\sigma}_{bond}^2+2w_{bond,t}w_{eq,t}\bar{\sigma}_{bond}\bar{\sigma}_{eq}\rho_{bond,eq} \tag{1.4}$$

Where ρ is the correlation between the returns of the equity portfolio and the returns of the fixed income portfolio. In the simulations we use a Diversified Equity Portfolio for equity allocation with 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index, following (Liu, Chang, De Jong, & Robinson, 2009 and Robinson 2009). For the fixed income holding we use a 10-year U.S. Treasury Bond. The monthly return data for equity indices and Treasury bonds is retrieved from CRSP and Datastream. The sample period is from January 1970 to December 2010. Table 2 shows the descriptive statistics for the three equity indices: the S&P 500 Index, the Russell 2000 Index, and the MSCI EAFE Index, the 10 year U.S. Treasury Bonds, and the Diversified Equity Portfolio.

Table 2. Descriptive statistics for monthly returns for assets used in simulated strategies for the period from January 1970 to December 2010.

	10-year T-bond	S&P 500	Russell 2000	MSCI EAFE	Diversified Equity Portfolio*
Mean	0.00689	0.00896	0.00908	0.00755	0.00864
Median	0.00595	0.01202	0.01308	0.00978	0.01187
Standard Deviation	0.02357	0.04555	0.06392	0.05018	0.04417
Sample Variance	0.00056	0.00207	0.00409	0.00252	0.00195
Kurtosis	1.17384	1.97282	4.29705	1.08029	3.55604
Skewness	0.35503	-0.48217	-0.03284	-0.34430	-0.60492
Minimum	-0.06682	-0.21580	-0.30615	-0.20239	-0.22394
Maximum	0.09999	0.16811	0.39515	0.17874	0.21885

** Diversified Equity Portfolio is a equity portfolio with 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index*

Among the three equity indices that we use to combine the Diversified Equity Portfolio, the Russell 2000 Index has the highest average monthly return (0.908%). The MSCI EAFE Index has an average monthly return of 0.755% and the S&P 500 Index has the average return of 0.896%. The Russell 2000 Index also has the highest monthly standard deviation (6.392%). The standard deviation for the MSCI EAFE Index and the S&P 500 Index are 5.018% and 4.555%, respectively. The Diversified Equity Portfolio which has 45% invested in the S&P 500 Index, 30% invested in the Russell 2000 Index, and 25% invested in the MSCI EAFE Index, has an average return of 0.864% and standard deviation of 4.417%. As a proxy for the fixed income asset we use a 10-year U. S. Treasury bond, which has an average monthly return of 0.69% and standard deviation of 2.36% over the period from 1970 to 2010.

As Balduzzi and Reuter (2012) note, the fund families try to differentiate themselves from other TDFs offered in the market and therefore there are many different glide paths offered by the fund families. We therefore calculate the expected lifetime utility for a wide range of different glide paths. Each glide path can be characterized by its beginning equity level, ending equity level, and the steepness of the glide path or the presence of the kink in the glide path. We analyze glide paths that begin with equity allocation from 100% to 50% and end with the equity allocation from 70% to 0%. In addition we assume the glide path can be flat in the beginning of the investment period for 10, 20 or even 30 years, creating a kink into the glide path[5]. Given the different combinations between the beginning and ending equity and the kink in the glide path, we analyze well over 900 different portfolio strategies. In the framework of this paper we present the results for the more common strategies used by the fund families in the current market and also present the results for the best performing strategy. For the basic case we look at the representative investor who starts saving for retirement in the beginning of his/her professional career as a young person and has at least 40 years to accumulate funds to support his retirement years. Table 3 illustrates the characteristics of glide paths followed by the TDFs offered by fund families.

[5] The kinked glide path has also been referred to as steep glide path (Liu et al., 2011).

The most common beginning equity level among the TDFs offered currently in the market is 90% equity. The highest level of beginning equity in the glide path is 100%. On average the TDFs reach the level of 40 to 45% equity by the target year. The minimum level of equity at the target year is 20%. The most common combination is the glide path from 90% equity allocation 40 years prior to target year and 50% equity at target year. Five fund families follow this glide path strategy with their TDFs. The next most common combinations are 90%-to-40%, and 90%-to-30% equity. Among the more conservative strategies the common combination is from 80%-to-40% equity and 80%-to-30% equity. Among the TDF families, 57% have a kink in their glide path, meaning that they keep the equity at the maximum level for the first 5 to 30 years. Most commonly the glide path is flat for the first 10 years and starts decreasing 30 years prior to the target year.

Table 3. Summary statistics for the glide paths of TDFs offered by the mutual fund families.

The glide path of the TDF is characterized by two characteristics: length of the glide path and change in the asset allocation over the fund lifetime. TDFs change the asset allocation gradually from the high allocation into equity at the inception of the fund and low equity allocation as the target retirement year nears. More than half of the funds hold the equity level high for the period in the beginning of the funds life and start decreasing equity allocation on average 30 years before target year. We refer to the year before the target when the equity allocation starts decreasing as a kink of the glide path. 57% of TDF families have a kink in their glide paths. Length of the glide path is another characteristic that fund families use to differentiate their strategy from others. Most commonly the TDFs are founded 40 years before the target year. TDFs that continue the glide path after the target year are called "through" TDFs. On average the glide path continues 19 years past the target year and 66% of TDFs are "through" TDFs. The information about the glide paths of TDFs is collected from the prospectuses of TDFs as of September 2012.

	% of equity		Year of the kink before target year	Length of the glide path in years	
	40 years before target year	At target year		Before target year	After target year
Mean	91	42	30	43	19
Median	90	45	30	40	20
Mode	90	45	25	40	10
Min	80	20	10	40	0
Max	100	60	35	50	40
Market leaders					
Fidelity	90	20	N/A	45	0
Vanguard	90	50	25	50	5
T.Rowe Price	90	45	25	45	40
% of TDFs with					
kink in the glide path		57%			
continue past target year		66%			
Glide path longer than 40 years before target year		41%			

Basu and Drew (2009) focus on their study on four alternative life-cycle glide paths. All of these strategies have 100% equity at the beginning of the glide path 40 years before target date and decrease the equity allocation to no equity by the target date. These rather aggressive strategies are different in how long they keep the equity at the maximum level: 21, 26, 31 or 36 years before the target date. These kinked strategies are unrealistic and do not represent properly the glide paths employed by the TDFs offered in the market today. Pfau (2011) uses the glide paths studied by Basu and Drew (2009) but also incorporates couple of realistic glide paths using the actual TDFs of T. Rowe Price as basis. They call it a "realistic" strategy and it has a 90% equity allocation 40 years before target date, keeping it at the maximum level and decreases it to about 50% by target date.

We improve the analysis compared to Pfau (2011) by looking at an even wider range of realistic glide path strategies used by actual TDFs in the market. In our results we present the expected utility for the following more common life-cycle strategies: 90%-to-50%, 90%-to-40%, 90%-to-30%, 80%-to-40% and 80%-to-30%. In comparison we also present results to the more aggressive life-cycle strategy from 100% equity to 60% equity and one more conservative life-cycle strategy from 70% equity to 30%. Appendix 1 through 7 present the results for even wider range of glide paths including combinations of 20 different beginning equity levels and 20 different ending equity levels, starting at 100% equity to 0% equity with the interval of 5%.

In our expected utility model we assume the investor's relative risk aversion increases over his lifetime and that the investor can have different beginning risk aversion and ending risk aversion. In conventional literature the investor's risk aversion is most commonly assumed to be between 2 and 4. In our paper we use different risk aversion ranges starting with the investor's beginning risk aversion level at zero (risk neutral) and the maximum ending risk aversion of 6 at the target retirement date. We assume that the change in risk aversion is linear, but for robustness also examine cases where the investor's risk aversion stays constant for a certain period (e.g. first 10 years) and starts increasing closer to the target retirement year.

Behavioral finance studies have shown that investors are loss averse, meaning they are more sensitive to the negative changes to their wealth than gains (Thaler et al., 1997). In the second model we incorporate the concept of loss aversion into the original mean-variance utility model. We add to the expected utility function the loss aversion coefficient, λ, that increases the investor's risk aversion when the prior period's portfolio return was negative. The value of the loss aversion coefficient, λ, is determined based on the realized portfolio return in the previous month. Monthly portfolio returns are calculated based on 1,000 bootstrap samples for each portfolio glide path strategy. With the loss aversion coefficient the lifetime expected utility function is expressed as follows,

$$E(U)=\sum_{t=1}^{T}\beta^{t}\left[E\left(R_{p,t}\right)-\frac{1}{2}A_{t}\lambda_{t}\sigma_{p,t}^{2}\right] \quad (1.5)$$

Where

$$\lambda_t=\begin{cases}1 & when\ R_{p,t-1}^{s}\geq 0\\ 2.25 & when\ R_{p,t-1}^{s}<0\end{cases} \quad (1.6)$$

$R^{S}_{p,t-1}$ stands for the portfolio return for the month t-1. If during the previous month the portfolio return was negative, investor's risk aversion will increase 2.25 times. In case of positive portfolio return, investor's risk aversion does not deviate from the regular risk aversion that the investor normally has.

Similar to earlier analysis, we then run simulations for a range of portfolio strategies and for the different risk aversion levels after incorporating loss aversion.

CHAPTER 4. RESULTS

1) *Expected utility for the investor with 40-year investment period*

We first look at the case of a young investor who has at least 40 years to save up for his/her retirement year. We calculate the total investment period expected utility following equation [1] for a wide range of different portfolio strategies – both life-style and life-cycle. Table 4 summarizes the results for the more common strategies offered by the fund families. The TDFs strategies offered by the fund families start at the relatively high equity level of 90% to 80% and decrease the equity allocation to 50% to 40% by the target date.

In our base case the representative investor is a young person who has just entered the work force and is risk neutral (A=0) when he/she starts saving up for retirement, and becomes less risk tolerant as he/she gets older, with risk aversion level increasing in equal increments every year and reaching the level of 4 at target retirement year. Table 4 shows that our young investor would reach the highest level of expected utility (E(U)=3.4317) if he/she invests in the TDF portfolio that starts out with 100% equity allocation and diminishes the equity level to 25% by target date. The highest expected utility by life-style strategy is provided by the 50% equity portfolio (E(U)= 3.2768), but this is lower than the utility of any of the listed life-cycle strategies. Among the more common TDF strategies his/her best choice would be to start investing to the TDF with the glide path from 90% to 30% equity. As our investor is risk neutral when he/she is young the high equity level helps him speed up the accumulation of retirement funds by picking an aggressive TDF.

If the young investor becomes more risk averse as he/she gets older, reaching the risk aversion of 6 at target date, he/she will have higher expected utility over the 40 year period with a life-cycle strategy. Life-cycle strategy with the glide path from 100% equity to 10% equity at target date provides highest utility (E(U)=3.2089). The portfolio with 50% equity yields the expected utility of 3.0584 and is the best life-style strategy for our investor. This strategy does not outperform the more common life-cycle strategies.

Table 4. Expected utility for the investor with an investment horizon of 40 years.

The table shows the representative investor's total expected utility for the investment period of 40 years. The total expected utility is calculated as a sum of discounted annual expected utilities. (Though we calculate the expected utility for over 900 different portfolio strategies, this table summarizes the results for the more common life-cycle and life-style strategies offered in the mutual fund market. As we assume that our representative investor is a utility maximizer, the higher the total expected utility, the better.) Numbers in bold represent the highest utility achieved within a given risk aversion level among the strategies presented here.

Relative Risk Aversion	Life-Cycle Strategies									Life-Style Strategies					*Strategy with the highest E(U)*	
	Equity allocation in the portfolio															
	100% to 60%	*100% to 40%*	*90% to 50%*	*90% to 40%*	*90% to 30%*	*80% to 50%*	*80% to 40%*	*80% to 30%*	*70% to 30%*	*100%*	*80%*	*50%*	*30%*	*0%*	*Glide path*	*E(U)*
0 to 2	3.7540	3.7248	3.6992	3.6782	3.6497	3.6524	3.6288	3.5977	3.5428	3.7218	3.6778	3.4951	3.2954	2.8791	100/70	3.7572
0 to 3	3.5444	3.5688	3.5354	3.5381	3.5294	3.5044	3.5031	3.4906	3.4475	3.3594	3.4401	3.3859	3.2330	2.8284	100/40	3.5688
0 to 4	3.3347	3.4128	3.3717	3.3980	3.4091	3.3564	3.3775	3.3834	3.3521	2.9971	3.2024	3.2768	3.1706	2.7777	100/25	3.4317
0 to 5	3.1251	3.2568	3.2079	3.2578	3.2889	3.2084	3.2518	3.2763	3.2568	2.6347	2.9647	3.1676	3.1082	2.7270	100/15	3.3153
0 to 6	2.9154	3.1009	3.0441	3.1177	3.1686	3.0604	3.1261	3.1692	3.1614	2.2724	2.7270	3.0584	3.0457	2.6762	100/10	3.2089
1 to 3	3.2158	3.2760	3.2720	3.2905	3.2963	3.2827	3.2959	3.2964	3.2875	2.9438	3.1674	3.2607	3.1614	2.7702	80/35	3.2977
1 to 4	3.0062	3.1200	3.1082	3.1503	3.1760	3.1347	3.1702	3.1893	3.1921	2.5814	2.9297	3.1515	3.0990	2.7195	75/25	3.1937
1 to 5	2.7965	2.9640	2.9445	3.0102	3.0558	2.9867	3.0446	3.0822	3.0968	2.2191	2.6920	3.0424	3.0365	2.6688	75/20	3.1063
1 to 6	2.5869	2.8080	2.7807	2.8701	2.9355	2.8387	2.9189	2.9751	3.0014	1.8568	2.4543	2.9332	2.9741	2.6181	60/20	3.0283
2 to 4	2.6776	2.8272	2.8448	2.9027	2.9429	2.9131	2.9630	2.9952	3.0321	2.1658	2.6571	3.0263	3.0274	2.6613	50/30	3.0603
2 to 5	2.4680	2.6712	2.6810	2.7626	2.8227	2.7651	2.8373	2.8880	2.9368	1.8035	2.4193	2.9171	2.9649	2.6106	50/20	2.9875
2 to 6	2.2583	2.5152	2.5173	2.6225	2.7024	2.6171	2.7116	2.7809	2.8414	1.4411	2.1816	2.8079	2.9025	2.5599	45/20	2.9203
3 to 5	2.1394	2.3784	2.4176	2.5150	2.5895	2.5434	2.6301	2.6939	2.7768	1.3878	2.1467	2.7919	2.8933	2.5524	40/25	2.8983
3 to 6	1.9298	2.2224	2.2538	2.3748	2.4693	2.3954	2.5044	2.5868	2.6814	1.0255	1.9090	2.6827	2.8309	2.5017	40/20	2.8356

The higher the investor's beginning risk aversion the lower should be the equity allocation in the beginning of the investment period. For example the investor with risk aversion from 2 to 4 would be best to choose the TDF portfolio with the conservative glide path from 50% to 30% equity as this strategy is estimated to provide expected utility of 3.0603. High risk aversion (above 4) at target retirement year shifts the preference towards a more conservative glide path with lower beginning and ending equity level. If the investor's beginning equity level is higher than 2 the more common life-cycle strategies illustrated in Table 4 fail to outperform the life-style strategies with equity of 50% or 30%, but they do outperform the extreme life-style strategies with all equity or no equity.

Since we run our analysis for a wider range of strategies we find that even with higher levels of risk aversion, there exist life-cycle strategies that outperform life-style strategies although none of the currently offered TDFs have sufficiently conservative glide path. For example, for the investor with risk aversion from 2 to 6, the life-cycle portfolio strategy with equity allocation decreasing from 45% to 20% would yield an expected utility of 2.9203, which is higher than the utility for 30% life-style strategy. To the investor who has above average risk aversion already when he/she is young, we suggest finding a more conservative TDF that has a target year closer than the investor's planned retirement. The TDF with the closer target date has already decreased the equity allocation to the desired lower level. The investor needs to make sure that the TDF is so-called "through"-TDF and continues the glide path past the target date stated in its name, allowing investors to continue contributions to the fund. As stated in Table 3, 66% of the TDFs continue the glide path past the target date. By picking the TDF with the target date that does not match his/her desired target retirement year, the investor may find a fund with the glide path that matches his/her risk aversion and will maximize his/her expected utility.

2) Expected utility for the investor with the shorter investment period

So far we have assumed that a young person enters the work force, for example, after finishing his/her undergraduate education at around age 25 and immediately starts making contributions to the retirement savings plan. Quite often this is unfortunately not the case as young people do not take advantage of time as their ally in investing for retirement. We analyze whether target date funds would also be a good choice for the person who joins the defined contribution plan later in life, for example 30, 20 or even only 10 years before the desired target retirement date.

Panel A of Table 5 assumes that our young investor postpones saving for retirement by 10 years. We assume that our investor picks a TDF that has a target year similar to his/her planned year of retirement. In such a case the TDF that our investor starts making contributions to has already decreased the equity allocation for the first 10 years, assuming the smooth glide path. Appendix 8 illustrates the changes in the equity level for the glide path from 90% equity to 40% equity given different investment horizons. In our analysis we assume our investor's risk aversion is at its minimum when he/she starts making contributions into the retirement fund.

If risk aversion of the risk-neutral investor increases from 0 to the level of 4 over his 30-year investment horizon, he/she will reach higher utility with life-cycle portfolio strategies than life-style strategies. From the more common strategies listed in Table 5, all of the listed life-cycle strategies outperform all the life-style strategies in the context of total expected utility. The highest utility is reached with the strategy with the original glide path from 100% equity to 25% equity at the target date. This TDF would have decreased the equity allocation to about 81% when the investor starts to make contributions to his retirement plan, and it yields our investor a total expected utility of 2.6911 over the 30 year investment period.

If the investor is more risk averse and his/her risk aversion increases from 1 at 30 years before target year to 5 at target year, his/her best choice would be a portfolio strategy with original glide path from 75% equity to 20%. This more conservative strategy would yield him/her expected utility of 2.4380. A bit more aggressive strategies with the starting equity of 90% or 80% and ending equity of 40% or 30% also outperform all life-style

Table 5. Total expected utility for the investor with shorter investment horizon.

The table shows the representative investor's total expected utility for shorter investment periods. We assume the investor's risk aversion is at the minimum level when he/she starts making contributions towards retirement and starts increasing after that. The total expected utility is calculated as a sum of discounted annual expected utilities. The glide path for the strategies with highest E(U) given in the last two columns, states the equity level when the investor starts investing to TDF.

Relative Risk Aversion	Life-Cycle Strategies: *Original glide path*									Life-Style Strategies					*Strategy with the highest E(U)*	
	100/60	*100/40*	*90/50*	*90/40*	*90/30*	*80/50*	*80/40*	*80/30*	*70/30*	*100%*	*80%*	*50%*	*30%*	*0%*	*Glide path*	*E(U)*
Panel A. 30 year investment horizon																
	Approximate equity allocation 30 years before target date															
	90%	85%	80%	80%	75%	75%	70%	65%	60%	*100%*	*80%*	*50%*	*30%*	*0%*		
0 to 4	2.6091	2.6572	2.6314	2.6488	2.6423	2.6240	2.6288	2.6160	2.6012	2.3363	2.5648	2.5705	2.4896	2.1813	100/25	2.6911
1 to 5	2.2402	2.3769	2.3424	2.3891	2.4260	2.3554	2.4066	2.4328	2.4327	1.7246	2.1035	2.3862	2.3842	2.0957	75/20	2.4380
2 to 6	1.8713	2.0966	2.0535	2.1293	2.2097	2.0896	2.1844	2.2495	2.2641	1.1129	1.7021	2.2018	2.2788	2.0101	45/20	2.2927
Panel B. 20 year investment horizon																
	Approximate equity allocation 20 years before target date															
	80%	70%	60%	65%	60%	65%	60%	55%	50%	*100%*	*80%*	*50%*	*30%*	*0%*		
0 to 4	1.9859	1.9454	1.9306	1.9317	1.8995	1.9439	1.9176	1.8842	1.8685	1.9814	1.9799	1.9028	1.8014	1.5745	100/60	2.0269
1 to 5	1.9227	1.8997	1.8900	1.8903	1.8647	1.8891	1.8801	1.8528	1.8402	1.8706	1.9072	1.8694	1.7823	1.5590	100/50	1.9428
2 to 6	1.3649	1.5260	1.5116	1.5413	1.5813	1.4958	1.5542	1.5790	1.5947	0.7642	1.1814	1.5360	1.5917	1.4042	50/20	1.6014
Panel C. 10 year investment horizon																
	Approximate equity allocation 10 years before target date															
	70%	55%	60%	55%	45%	555	50%	45%	40%	*100%*	*80%*	*50%*	*30%*	*0%*		
0 to 4	0.9459	0.9484	0.9491	0.9484	0.9341	0.9446	0.9428	0.9341	0.9271	0.8432	0.9103	0.9397	0.9119	0.7992	100/25	0.9880
1 to 5	0.8433	0.8846	0.8707	0.8846	0.8860	0.8846	0.8838	0.8860	0.8826	0.6185	0.7682	0.8720	0.8732	0.7677	70/20	0.8937
2 to 6	0.7407	0.8207	0.7923	0.8207	0.8380	0.7989	0.8247	0.8381	0.8380	0.3938	0.6154	0.8043	0.8345	0.7363	50/20	0.8400

strategies listed in Table 5. Even if the investor is very risk averse with risk aversion increasing from 2 to 6, we still find that a conservative life-cycle strategy with original glide path from 45% equity to 20% reaches higher expected utility (2.2927) than that of the best life-style strategy (with utility of 2.2788).

If the investor postpones making contributions into a retirement account even longer and leaves only 20 years for contributing towards his/her retirement nest egg, the glide path of life-cycle strategies has brought the equity level in the portfolio even lower. The summary of expected utilities under the same assumptions is brought in Panel B of Table 5. If our risk-neutral investor is still risk-neutral towards risk when he starts saving for retirement and his risk aversion reaches the level of 4 when he retires, he is still better off with life-cycle portfolio strategy. Among the more common five life-cycle strategies the highest expected utility is reached with the original glide path strategy from 90% equity to 40% equity. This strategy would yield our investor a total investment period expected utility of 1.9317. The highest expected utility is reached with maximum equity in the portfolio, with equity changing from 100% to 60% along the glide path. Starting out with relatively high equity level at 20 years prior to target retirement might help the investor to catch up a little with the lost years of capital accumulation. But it is important to keep in mind that in case of periods of bear markets investors have less time left to recover the losses.

Less risk tolerant investor with risk aversion changing from 2 to 6 over his 20-year investment period, will benefit from more conservative life-cycle strategies. Among all the strategies he/she would reach highest utility (E(U) = 1.6014) with the life-cycle strategy with the glide path from 50% equity to 20% equity. Also the glide path with equity from 70% to 30% provides higher expected utility (E(U) = 1.5947) than that of the best performing life-style strategy (E(U) = 1.5917). This life-cycle strategy starts out at 70% equity 40 years before target date and reaches 50% level 20% years before the target date.

When the investor postpones making contributions to his/her retirement account even more and the investment period is only ten years, the glide paths of life-cycle strategies have brought the equity level down very close to the level at the target date. We find, though, from Panel C of Table 5 that for our representative investor who is risk-neutral when he/she starts investing towards retirement and reaches a risk aversion level of 4 at the retirement date, the life-cycle strategy with the original glide path from 100% equity to 25% equity yield the highest expected utility of 0.9880. For the investor whose risk aversion is 1 when he/she starts investing and reaches 5 by the target year, a more conservative strategy with original glide path from 70% equity to 20% equity provides the highest utility of 0.8937. It is interesting to note that even the more risk- averse investors with risk aversion increasing from 2 to 6 by the target year are better off with a life-cycle strategy in case of only a 10-year investment horizon. For them, the TDF with the original glide path from 50% equity to 20% equity would be the best choice (E(U) = 0.8400) and would outperform all the life-style strategies.

For most representative investors in our study the extreme life-style strategies, either 100% equity or no equity at all, perform poorly compared to the alternative strategies. With the shorter investment period it is important to remember that when picking the TDF that has the target year approximately equal to the desired retirement year, the equity level in the portfolio has already been decreased to a lower level. Shorter glide paths also decrease the difference between the expected utility derived from the best life-style portfolio and utility from the best life-cycle portfolio.

3) Expected lifetime utility of the loss averse investor

Prior research has concluded that investors have different attitude towards downside risk thus they are more sensitive to the negative changes to their wealth. Table 6 summarizes the results for the analysis that uses equation [5] which incorporates the representative investor's loss aversion in our model. Similar to Table 4, we assume an investment horizon of 40 years and lifetime expected utility is calculated as the sum of the present value of monthly utilities over the 40 years. In case the representative investor's portfolio strategy yields a loss during the given month, the investor is assumed to be more risk averse next month. We use the loss aversion of 2.25 as suggested by (Kahneman & Tversky, 1979).

Table 6. Expected utility for the investor who is loss averse and has a 40 year investment horizon.

The table shows the representative investor's total expected utility for the investment period of 40 years. The total expected utility is calculated as a sum of discounted annual expected utilities, following equation 3. Though we calculated the expected utility for over 900 different portfolio strategies, the table summarizes the results for the more common life-cycle and life-style strategies offered in the mutual fund market. As we assume that our representative investor is a utility maximizer, the higher the total expected utility, the better. Numbers in bold represent the highest utility achieved within a given risk aversion level among the strategies presented here.

Relative Risk Aversion	Life-Cycle Strategies									Life-Style Strategies					*Strategy with the highest* E(U)	
	Equity allocation in the portfolio															
	100% to 60%	*100% to 40%*	*90% to 50%*	*90% to 40%*	*90% to 30%*	*80% to 50%*	*80% to 40%*	*80% to 30%*	*70% to 30%*	*100%*	*80%*	*50%*	*30%*	*0%*	*Glide path*	*E(U)*
0 to 2	2.9084	2.9259	2.9119	2.9141	2.9112	2.8985	2.8996	2.8955	2.8774	2.7879	2.8573	2.8519	2.7745	2.5439	100/40	2.9259
0 to 3	2.7419	2.7995	2.7808	2.7997	2.8112	2.7786	2.7960	2.8056	2.7964	2.4983	2.6698	2.7628	2.7140	2.4692	100/30	2.8144
0 to 4	2.5754	2.6730	2.6497	2.6853	2.7111	2.6588	2.6923	2.7156	2.7154	2.2087	2.4823	2.6737	2.6535	2.3944	85/20	2.7238
0 to 5	2.4088	2.5466	2.5186	2.5710	2.6110	2.5389	2.5887	2.6257	2.6344	1.9191	2.2948	2.5845	2.5930	2.3197	75/20	2.6437
0 to 6	2.2423	2.4202	2.3875	2.4566	2.5109	2.4191	2.4851	2.5357	2.5534	1.6295	2.1073	2.4954	2.5325	2.2450	65/20	2.5705
1 to 3	2.4768	2.5639	2.5707	2.6020	2.6243	2.5996	2.6280	2.6482	2.6661	2.1625	2.4524	2.6597	2.6451	2.3845	60/30	2.6744
1 to 4	2.3102	2.4375	2.4396	2.4876	2.5242	2.4798	2.5244	2.5582	2.5851	1.8729	2.2649	2.5706	2.5846	2.3097	50/30	2.6047
1 to 5	2.1437	2.3111	2.3085	2.3732	2.4241	2.3599	2.4208	2.4683	2.5041	1.5833	2.0774	2.4815	2.5241	2.2350	45/25	2.5411
1 to 6	1.9771	2.1846	2.1774	2.2589	2.3241	2.2401	2.3172	2.3783	2.4230	1.2937	1.8899	2.3923	2.4636	2.1602	45/25	2.4786
2 to 4	2.0451	2.2020	2.2295	2.2899	2.3374	2.3007	2.3565	2.4009	2.4547	1.5371	2.0475	2.4676	2.5157	2.2250	40/30	2.5237
2 to 5	1.8785	2.0755	2.0984	2.1755	2.2373	2.1809	2.2529	2.3109	2.3737	1.2475	1.8600	2.3784	2.4552	2.1503	45/25	2.4610
2 to 6	1.7120	1.9491	1.9673	2.0611	2.1372	2.0610	2.1493	2.2210	2.2927	0.9597	1.6725	2.2893	2.3947	2.0755	35/25	2.3995
3 to 5	1.6134	1.8400	1.8883	1.9778	2.0504	2.0019	2.0850	2.1535	2.2434	0.9117	1.6426	2.2754	2.3863	2.0656	35/25	2.3886
3 to 6	1.4469	1.7136	1.7572	1.8634	1.9503	1.8820	1.9813	2.0636	2.1624	0.6221	1.4551	2.1862	2.3258	1.9908	35/25	2.3291

Our results show that for the investor who is risk-neutral when he/she starts contributing towards the retirement portfolio, life-cycle strategies yield higher expected lifetime utility than the life-style strategies. Specifically for the risk-neutral investor who reaches a risk aversion of 4 by the target year and is loss averse, the best portfolio strategy is the life-cycle portfolio with the glide path from 70% equity to 20% equity. Such a portfolio strategy will yield him/her a total investment period expected utility of 2.7231. The more common TDF strategies with glide paths from 90%-to-50% and 80%-to-40% also outperform the life-style strategies in terms of expected utility and yield the representative investor a total expected utility of 2.6497 and 2.6923 respectively.

For the investor who is more risk-averse when he/she is young and has a risk aversion of at least 2 when he/she starts investing towards retirement and reached risk aversion level of 4 by retirement the life-cycle strategy with equity decreasing from 70% to 10% over the investment period, yields the highest expected utility (E(U) = 2.3352). The more common life-cycle strategies fail to outperform the 30% equity life-style strategy and our investor needs a more conservative glide path. As suggested before, this can be accomplished if our investor picks a TDF with the target date closer to today than his/her desired retirement year. He/she only needs to make sure that the chosen TDF is a "through"-TDF that allows the investor continue making contributions to the fund past the target date.

We find that even when loss averse investor postpones making contributions into the retirement account, life-cycle strategies yield higher expected utility and are more beneficial to the investor. If investor postpones making contributions into a retirement account and leaves 30 years for contributing towards his/her retirement nest egg, the glide path of life-cycle strategies has brought the equity level in the portfolio even lower. The summary of expected utilities under the same assumptions is brought in Panel A of Table 7. If our risk-neutral investor is still risk-neutral towards risk when he/she starts saving for retirement and his/her risk aversion reaches the level of 4 when he retires, he is reaches higher expected utility with life-cycle portfolio strategy. Among the more common five life-

Table 7. Total expected utility for the investor who is loss averse and has a shorter investment horizon.

The table shows the representative investor's total expected utility for shorter investment periods. We assume the investor's risk aversion is at the minimum level when he/she starts making contributions towards retirement and starts increasing after that. The total expected utility is calculated as a sum of discounted annual expected utilities. The glide path for the strategies with highest E(U) given in the last two columns, states the equity level when the investor starts investing to TDF.

Relative Risk Aversion	Life-Cycle Strategies									Life-Style Strategies					*Strategy with the highest E(U)*	
	Original glide path															
	100/60	*100/40*	*90/50*	*90/40*	*90/30*	*80/50*	*80/40*	*80/30*	*70/30*	*100%*	*80%*	*50%*	*30%*	*0%*	*Glide path*	*E(U)*
Panel A. 30 year investment horizon																
	Approximate equity allocation 30 years before target date															
	90%	85%	80%	80%	75%	75%	70%	65%	60%	*100%*	*80%*	*50%*	*30%*	*0%*		
0 to 4	1.5202	1.6069	1.5892	1.6208	1.6442	1.6035	1.6341	1.6550	1.6628	1.1922	1.4432	1.6419	1.6514	1.4737	60/30	1.6650
1 to 5	1.2859	1.4272	1.4042	1.4582	1.5013	1.4357	1.4882	1.5278	1.5494	0.7989	1.1868	1.5204	1.5689	1.3713	45/25	1.5728
2 to 6	1.0515	1.2474	1.2191	1.2955	1.3584	1.2678	1.3424	1.4006	1.4359	0.4055	0.9304	1.3988	1.4864	1.2690	35/25	1.4872
Panel B. 20 year investment horizon																
	Approximate equity allocation 20 years before target date															
	80%	70%	60%	65%	60%	65%	60%	55%	50%	*100%*	*80%*	*50%*	*30%*	*0%*		
0 to 4	0.9096	0.9798	0.9597	0.9866	1.0070	0.9669	0.9942	1.0123	1.0163	0.6181	0.8254	0.9947	1.0138	0.8931	60/30	1.0170
1 to 5	0.7826	0.8892	0.8590	0.9012	0.9352	0.8714	0.9143	0.9454	0.9535	0.3716	0.6652	0.9172	0.9605	0.8266	45/25	0.9620
2 to 6	0.6556	0.7985	0.7583	0.8159	0.8634	0.7759	0.8344	0.8784	0.8908	0.1251	0.5049	0.8398	0.9072	0.7601	45/25	0.9088
Panel C. 10 year investment horizon																
	Approximate equity allocation 10 years before target date															
	70%	55%	60%	55%	45%	55%	50%	45%	40%	*100%*	*80%*	*50%*	*30%*	*0%*		
0 to 4	0.4566	0.5050	0.4867	0.5070	0.5182	0.4897	0.5089	0.5189	0.5194	0.2449	0.3848	0.5008	0.5188	0.4498	60/30	0.5197
1 to 5	0.3961	0.4656	0.4389	0.4688	0.4867	0.4434	0.4717	0.4882	0.4894	0.1107	0.2982	0.4593	0.4906	0.4142	50/30	0.4909
2 to 6	0.3357	0.4262	0.3911	0.4305	0.4553	0.3971	0.4345	0.4575	0.4593	-0.0233	0.2117	0.4178	0.4624	0.3785	45/25	0.4629

cycle strategies the highest expected utility is reached with the original glide path strategy from 70% equity to 30% equity. This strategy would yield our investor a total investment period expected utility of 1.6628. The highest expected utility is reached with the more conservative strategy, with equity changing from 60% to 30% along the glide path. Less risk tolerant investor with risk aversion changing from 2 to 6 over his 30-year investment period will benefit from even more conservative life-cycle strategy with equity changing from 45% to 25%.

In case our investor's investment period is only twenty years, the glide paths of life-cycle strategies have brought the equity level closer to the level at the target date. We find, though, from Panel B of Table 7, that for our representative investor who is risk-neutral when he/she starts investing towards retirement and reaches a risk aversion level of 4 at the retirement date, the life-cycle strategy with the life-cycle glide path from 60% equity to 30% equity yield the highest expected utility of 1.0170. For the investor whose risk aversion is 1 when he/she starts investing and reaches 5 by the target year, a more conservative strategy with original glide path from 45% equity to 25% equity provides the highest utility of 0.9620.

Loss averse investor with the 10 year investment period will still benefit from the life-cycle strategies. Investor, who is risk neutral in the beginning of the investment period and reaches risk aversion level of 4 by target retirement age, will benefit the most from the strategy with the glide path from 60% equity to 30% equity. This strategy would provide the expected utility of 0.5197. More risk averse investors would benefit from more conservative glide path strategies.

4) TDF glide paths with the kink

So far we have looked at so-called smooth glide path strategies in comparison to constant equity strategies. Poterba and Samwick (1997) study the age and cohort effects on investor portfolio allocation and find that households start decreasing equity in their overall portfolio after age 43. Many TDFs also keep the equity allocation at maximum in the beginning of the investment period for 5 to 15 years thus creating a kink into the glide path.

Table 8. Expected utility for the glide path strategies with the kink at 30 years before target year for the investor with 40 year investment period.

This table illustrates the total investment period expected utility for the investor whose risk aversion changes linearly starting from the beginning of the investment period. The investment strategies shown in the table on the other hand have a kink in their glide path and the equity allocation in the portfolio is kept at the maximum level for the first 10 years and starts to decrease 30 years before the target retirement year. The glide path with the kink in it 30 years before target retirement is the most common among the glide paths with the kink.

Relative Risk Aversion	Life-Cycle Strategies									Life-Style Strategies					*Strategy with the highest E(U)*	
	Equity allocation in the portfolio															
	100% to 60%	*100% to 40%*	*90% to 50%*	*90% to 40%*	*90% to 30%*	*80% to 50%*	*80% to 40%*	*80% to 30%*	*70% to 30%*	*100%*	*80%*	*50%*	*30%*	*0%*	*Glide path*	*E(U)*
0 to 2	3.7778	3.7684	3.7291	3.7189	3.7024	3.6774	3.6648	3.6459	3.5849	3.7218	3.6778	3.4951	3.2954	2.8791	100/60	3.7778
0 to 3	3.5460	3.5831	3.5462	3.5565	3.5574	3.5163	3.5230	3.5204	3.4765	3.3594	3.4401	3.3859	3.2330	2.8284	100/30	3.5877
0 to 4	3.3141	3.3978	3.3633	3.3941	3.4125	3.3553	3.3813	3.3948	3.3682	2.9971	3.2024	3.2768	3.1706	2.7777	100/15	3.4323
0 to 5	3.0823	3.2126	3.1804	3.2317	3.2675	3.1942	3.2396	3.2693	3.2598	2.6347	2.9647	3.1676	3.1082	2.7270	95/10	3.2930
0 to 6	2.8505	3.0273	2.9975	3.0694	3.1225	3.0332	3.0978	3.1438	3.1514	2.2724	2.7270	3.0584	3.0457	2.6762	80/10	3.1795
1 to 3	3.1794	3.2367	3.2495	3.2687	3.2778	3.2724	3.2872	3.2919	3.2927	2.9438	3.1674	3.2607	3.1614	2.7702	75/35	3.2940
1 to 4	2.9476	3.0514	3.0666	3.1063	3.1328	3.1114	3.1455	3.1664	3.1843	2.5814	2.9297	3.1515	3.0990	2.7195	65/25	3.1887
1 to 5	2.7158	2.8661	2.8837	2.9439	2.9878	2.9503	3.0038	3.0409	3.0759	2.2191	2.6920	3.0424	3.0365	2.6688	60/20	3.1003
1 to 6	2.4839	2.6808	2.7008	2.7816	2.8428	2.7893	2.8620	2.9153	2.9676	1.8568	2.4543	2.9332	2.9741	2.6181	55/20	3.0219
2 to 4	2.5811	2.7050	2.7699	2.8185	2.8531	2.8675	2.9097	2.9380	3.0005	2.1658	2.6571	3.0263	3.0274	2.6613	45/30	3.0591
2 to 5	2.3492	2.5197	2.5870	2.6561	2.7082	2.7064	2.7680	2.8124	2.8921	1.8035	2.4193	2.9171	2.9649	2.6106	45/25	2.9863
2 to 6	2.1174	2.3344	2.4041	2.4937	2.5632	2.5454	2.6262	2.6869	2.7837	1.4411	2.1816	2.8079	2.9025	2.5599	40/20	2.9185
3 to 5	1.9827	2.1733	2.2903	2.3683	2.4285	2.4625	2.5322	2.5840	2.7083	1.3878	2.1467	2.7919	2.8933	2.5524	35/25	2.8979
3 to 6	1.7509	1.9880	2.1074	2.2059	2.2835	2.3015	2.3904	2.4585	2.5999	1.0255	1.9090	2.6827	2.8309	2.5017	35/25	2.8360

Basu and Drew (2009) study only the so-called kinked life-cycle strategies that keep the equity level at the maximum for 21, 26, 31 or even 36 years. We have found that among the TDFs offered in the market 57% do have a kink in their glide paths. The TDFs offered to investors today usually do not have the kink as far out (or as close to the target date) as assumed by Basu and Drew (2009). In our analysis we calculate expected utility for glide path strategies with the kink at 30, 20, and 10 years before the target year.

First, we examine the life-cycle strategies with the kink at 30 years before the target year in comparison to the same set of life-style strategies as in our previous analysis. We do not make changes to the assumptions about the investor's risk aversion and assume it changes linearly and starts increasing right when he/she starts making contributions to his/her retirement account. Table 8 summarizes the results.

We find that when the investor's beginning risk aversion is relatively low (from 0 to 1) he/she finds the best portfolio strategy among the life-cycle strategies. The higher his/her ending risk aversion, the more conservative should be his/her strategy, keeping both the beginning and ending equity allocation at lower levels. For the investor whose risk aversion in the beginning of the investment period is 2 or higher, although the more common life-cycle strategies do not yield higher expected utility in comparison with the 30% equity life-style strategy, the very conservative life-cycle strategy is able to outperform this constant equity strategy. For example, to the investor with risk aversion increasing from 2 to 4, the best strategy is to invest in the 45%-to-30% glide path fund.

We next look at the expected utility for the investor whose risk tolerance does not start decreasing right when he/she enters the work force and begins making contributions to the chosen retirement plan. In the beginning of the investment horizon the accumulated capital is still small and worries about potential losses is low. Certain changes in life can change the investor's risk tolerance – like for example starting a family. Agnew et al. (2003), find that investor's risk aversion is low even up to age 45 to 55 and starts increasing after that. Among their sample group the age group in their pre-retirement years (55 to 65) decreases the allocation to equity in their portfolio by about 38%. Table 9 shows the expected utilities for investor whose risk aversion starts increasing 20 years before target retirement year. The strategies listed in the table have a smooth glide path or in other words start decreasing the equity allocation in the portfolio right away.

As our representative investor's risk aversion starts increasing only later in life, his/her average risk aversion over the investment period is relatively higher. Therefore in general this investor reaches higher utility with more aggressive strategies compared to the investor whose risk aversion starts increasing right away. More specifically our investor who is risk neutral when he/she is young and starts saving for retirement and whose risk tolerance starts decreasing 20 years before retirement reaching the level of 4 by target date, would reach the highest total expected utility when investing in the target date fund that has 100% equity in the beginning and decreases it to the level of 55% equity by target date. The more risk averse investor whose risk aversion changes from 2 to 4, would benefit from choosing a life-cycle strategy with the glide path from 60% equity to 25% equity. If investor's risk aversion is constant for a period and starts increasing later in life, the life-cycle strategies still provide higher expected utility than life-style strategies.

Table 9. Expected utility for the investor with 40 year investment period and risk aversion starting to increase 20 years before target year.

This table illustrates the total investment period expected utility for the investor whose risk aversion changes linearly starting from the beginning of the investment period. The investment strategies shown in the table on the other hand have a kink in their glide path and the equity allocation in the portfolio is kept at the maximum level for the first 10 years and starts to decrease 30 years before the target retirement year. The glide path with the kink in it 30 years before target retirement is the most common among the glide paths with the kink.

Relative Risk Aversion	Life-Cycle Strategies									Life-Style Strategies					*Strategy with the highest E(U)*	
	Equity allocation in the portfolio															
	100% to 60%	*100% to 40%*	*90% to 50%*	*90% to 40%*	*90% to 30%*	*80% to 50%*	*80% to 40%*	*80% to 30%*	*70% to 30%*	*100%*	*80%*	*50%*	*30%*	*0%*	*Glide path*	*E(U)*
0 to 2	4.0032	3.9271	3.8962	3.8545	3.8073	3.8242	3.7815	3.7335	3.6592	4.0906	3.9198	3.6063	3.3590	2.9307	100/100	4.0906
0 to 3	3.9182	3.8722	3.8309	3.8025	3.7659	3.7621	3.7322	3.6943	3.6221	3.9127	3.8031	3.5527	3.3283	2.9058	100/80	3.9316
0 to 4	3.8331	3.8174	3.7657	3.7505	3.7245	3.7000	3.6829	3.6551	3.5849	3.7348	3.6864	3.4990	3.2977	2.8809	100/55	3.8332
0 to 5	3.7480	3.7625	3.7004	3.6985	3.6831	3.6379	3.6336	3.6158	3.5478	3.5569	3.5696	3.4454	3.2670	2.8560	100/45	3.7639
0 to 6	3.6630	3.7077	3.6351	3.6465	3.6417	3.5758	3.5843	3.5766	3.5106	3.3789	3.4529	3.3918	3.2364	2.8311	100/35	3.7087
1 to 3	3.4650	3.4783	3.4690	3.4667	3.4540	3.4546	3.4486	3.4322	3.4039	3.3126	3.4094	3.3718	3.2249	2.8218	100/45	3.4789
1 to 4	3.3800	3.4234	3.4037	3.4147	3.4126	3.3925	3.3993	3.3930	3.3667	3.1347	3.2927	3.3182	3.1943	2.7969	100/35	3.4260
1 to 5	3.2949	3.3686	3.3385	3.3627	3.3711	3.3304	3.3500	3.3538	3.3296	2.9568	3.1760	3.2646	3.1636	2.7720	100/25	3.3821
1 to 6	3.2098	3.3137	3.2732	3.3108	3.3297	3.2683	3.3007	3.3146	3.2924	2.7789	3.0593	3.2110	3.1330	2.7471	100/20	3.3432
2 to 4	2.9268	3.0295	3.0418	3.0790	3.1006	3.0849	3.1157	3.1310	3.1485	2.5347	2.8990	3.1374	3.0909	2.7130	60/35	3.1540
2 to 5	2.8418	2.9746	2.9765	3.0270	3.0592	3.0228	3.0664	3.0917	3.1114	2.3567	2.7823	3.0838	3.0603	2.6881	60/30	3.1180
2 to 6	2.7567	2.9198	2.9113	2.9750	3.0178	2.9607	3.0171	3.0525	3.0742	2.1788	2.6656	3.0302	3.0296	2.6632	60/25	3.0853
3 to 5	2.3886	2.5807	2.6146	2.6912	2.7472	2.7152	2.7828	2.8297	2.8932	1.7567	2.3887	2.9030	2.9569	2.6041	45/30	2.9686
3 to 6	2.3036	2.5258	2.5493	2.6392	2.7058	2.6531	2.7335	2.7905	2.8560	1.5788	2.2719	2.8494	2.9262	2.5792	45/25	2.9389

CHAPTER 5. CONCLUSIONS

Prior literature has examined several reasons why investors should follow the conventional wisdom of switching their investment portfolio gradually into safer assets when they get older. This paper adds investors' increasing risk aversion to this list and shows that for the investors who become less risk tolerant over their lifetime, life-cycle strategy employed by TDFs is a choice that would yield higher expected utility than a constant allocation strategy.

For investors who start saving for retirement early and have 40 years to accumulate wealth to support their golden years, the best choice for the retirement plan depends on their risk aversion. To the investors who are less risk averse when young and become moderately risk averse by the time they plan to finish working, the best fit would be the plan that is relatively aggressive starting the portfolio glide path at a high level of equity (close to 100%) and decreasing it over the investment horizon but keeping it relatively high (e.g. 60-50%) even at the target date. Investors, who are more risk averse and become even less risk tolerant throughout their life, should pick a more conservative life-cycle fund. For them, the more conservative version of the professional rule of thumb is a good idea and they should have in their portfolio a portion of bonds that is about equal to their age.

If the investor's risk tolerance starts decreasing later in life, for example 20 or 10 years before their planned retirement, life-cycle strategies will still provide a higher expected utility over the investment horizon than the constant allocation strategy. For them, it is good idea to pick a target date fund that keeps equity level constant for a number of years and starts decreasing stock allocation in the portfolio closer to the target date. In other words they should find a TDF that has a kink in the glide path.

Procrastinators who leave saving for retirement later in life are also better off with investment strategies that have a glide path with decreasing stock allocation over time. In most cases they would still be better off picking the target date fund that matches their planned retirement year. But for investors who have a relatively low level of risk aversion when joining the retirement saving plan, it would be a better idea to find a more aggressive fund that potentially needs to have a target date later than their desired retirement year.

Even after incorporating the investor's loss aversion, our results show that life-cycle investment strategies provide higher expected lifetime utility than strategies with constant equity allocation. Among the investment scenarios we have analyzed, the investor who has a relatively low risk aversion when he/she is young and whose risk aversion increases over his/her lifetime, the highest utility is provided by the portfolio that starts at about 80% equity and lowers the stock allocation to about one third of the portfolio by the retirement date.

We find it important to remember that TDFs are not a one-size-fits-all solution. Investors should look at the TDFs strategy a bit closer than just the target date. Financial advisors should determine investors' risk aversion characteristics prior to suggesting the appropriate TDF. Though it is hard to predict an investor's future risk tolerance, his/her beginning risk aversion can give at least some indication for the starting point of the glide path of the portfolio strategy.

Regulators should demand more transparency from the mutual fund companies that are offering TDFs, so the investor will have a clearer picture about the future allocation (glide path) of the TDF. Though fund families are eager to differentiate themselves from other TDFs offered in the market, it is also in their interest to provide the best match for the investor's risk tolerance. TDF fund managers should therefore provide investors with detailed information about how the TDF's glide path changes over the fund's lifetime.

PART 2. DETERMINANTS OF RETURN VARIATION AMONG THE 2010 TARGET DATE FUNDS

CHAPTER 6. INTRODUCTION

The recent financial crisis had a negative impact on some investors in 2010 target date funds (TDFs). In the fall of 2008, the investors in 2010 TDFs were about 2 years away from their planned retirement when some of those investors lost up to 40% of their accumulated wealth in the 2010 TDFs (Maxey, 2009). According to the central tenet of TDFs, the funds that are close to target retirement year should have decreased their allocation to risky assets in their portfolios in order to protect the retirement savings. Instead, those underperforming TDFs fell short of providing a safe harbor for the retiring investors' funds. The extreme losses of some TDFs raised a question of suitability of TDFs as a qualified default investment alternative (QDIA), leading to special hearing at the U.S. Department of Labor in summer 2009. Though all 2010 TDFs were affected by the bear market, not all of them experienced extreme losses and the savings of some investors were affected minimally. We analyze the actual return dispersion of 2010 TDFs to indentify the sources of this performance. We find that the worst returns were limited to only few renegade funds and that in general the asset allocation of 2010 TDFs protected investors as it was designed to do.

The portfolio strategy of 2010 TDFs should have considered the similar age, retirement year, and risk tolerance of their target investors, and therefore assured a relatively safe strategy so close to the target retirement year. TDFs should pay special attention to their investors as many of them have not made the choice to invest in these funds themselves. As Qualified Default Investment Alternatives (QDIAs) TDFs can be used by defined contribution plan sponsors in case the plan participant fails to make their choice for enrollment in the 401(k) plan. The Employee Benefit Research Institute found that employees who were automatically enrolled in a 401(k) plan were most likely investing in TDF and for most of these investor TDF was their only allocation (Copeland, 2009). Despite the fact that someone else picked the plan for the worker, he/she is the one who bears the investment risk. The Pension Protection Act (PPA) of 2006 aims to assure that an investment vehicle chosen by a plan sponsor is appropriate for the individual investor's long-term retirement savings needs. PPA states that the portfolio mix of QDIAs should take into account investor's age or retirement date and risk aversion (EBSA, 2009). 2010 TDFs should have considered that their investors were only 2 years away from retirement and have no time to recover possible losses.

If TDFs adhered to the objective to protect the investors' accumulated funds close to retirement, the returns of the peer group should not have been so dispersed. TDFs with the 2010 target year had cumulative returns ranging from -12.38% to -39.69% during the months from September 2008 to March 2009. The average cumulative return of 2010 TDFs was negative 22.89% during the crisis months. As can be seen from Table 10 the geometric average monthly return of all TDFs was -5.14% during the same period. But all the other TDFs had much more time until the target retirement and investors who are just in the beginning of the investment period have time to recover the losses.

Table 10. Descriptive statistics of monthly returns for the sample TDFs.

Annualized geometric mean monthly returns are reported for all periods one year and longer. The return for the crisis period from September 2008 to March 2009 reflect the holding period return for these 7 months.

	Mean	Max	Min	Std.Dev.
Full period (January 2006 to December 2010)				
All TDFs	2.48%	7.31%	-3.74%	1.79%
2010	3.08%	6.01%	-3.74%	1.94%
Pre-Crisis Period (January 2006 to August 2008)				
All TDFs	1.47%	8.65%	-11.05%	3.55%
2010	2.35%	8.14%	-3.33%	2.42%
Crisis Period (September 2008 to March 2009)				
All TDFs	-30.63%	-3.91%	-40.93%	6.38%
2010	-22.89%	-12.38%	-39.69%	5.60%
Post-Crisis Period (April 2009 to December 2010)				
All TDFs	29.02%	45.09%	7.11%	5.43%
2010	22.79%	28.67%	14.81%	3.69%

Understandably all 2010 TDFs are not the same and to differentiate themselves from the competition, fund managers can compose their portfolios using a different asset allocation policy or by selecting different types of assets under each asset class. During 2008 fall, the proportion of equity holdings varied greatly within the 2010 TDF peer group. During the 2006 to 2010 period on average about 50.2%of the holdings of the 2010 TDFs were equity funds and 49.8% were fixed income funds. The maximum level of equity held by the 2010 TDFs in our sample during that period was 76.2%. This seems like a much too aggressive portfolio strategy for a passive investor who has almost no time to recover losses in case of a bear market. The most conservative equity allocation was 23 percent. The top 3 market leaders, had an equity allocation that was a bit above the average – 53.7%. The 2010 TDFs with the highest level of equity in their portfolio were among the smallest funds with the standard deviation of equity holdings being also highest among the smaller funds. Table 11 summarizes the proportions of asset classes in the 2010 TDFs from 2006 to 2010.

Table 11. Summary of the holdings of 2010 TDFs, January 2006 – December 2010.

The table illustrates the average allocation of equity holdings and fixed income holdings for the 2010 TDFs included in our sample. The top 3 and the remaining funds are determined by the funds market share based on their total net assets as of December 2010. The top 3 TDFs include Fidelity, Vanguard and T.Rowe Price 2010 TDFs. The next 7 include TIAA-CREF, American Funds, ING, Vantagepoint, American Century, JP Morgan and Principal.

	Level of Equity Holdings				**Level of Fixed Income Holdings**			
	Average	**Max**	**Min**	**St.Dev.**	**Average**	**Max**	**Min**	**St.dev.**
All	50.3%	76.2%	0.0%	13.1%	49.8%	109.9%	23.8%	13.3%
Top 3	53.7%	67.1%	46.8%	5.3%	46.3%	53.2%	32.9%	5.3%
Next 7	51.0%	65.4%	30.8%	8.8%	48.2%	69.2%	34.8%	8.6%
The rest	47.8%	76.2%	0.0%	17.4%	52.3%	109.9%	23.8%	17.7%

Our objective in this paper is to analyze the return dispersion among 2010 TDFs and determine if it was the differences in the proportion of risky assets in the portfolio or the choices of individual securities in each asset class that affected the monthly returns of the 2010 TDFs. Using monthly returns of TDFs we determine the proportion of returns due to policy, due to timing, and due to security selection. Timing and security selection are part of active portfolio management strategies and the returns due to these factors reflect portfolio manager's skill or lack of it. We also analyze if the extreme negative performance was prevalent among all funds or was it more characteristic to the certain group of funds.

The rest of this paper is organized as follows. The next section gives an overview of prior research related to portfolio return attribution. Section III describes the data we use. Section IV explains the model we used for our analysis. The results are analyzed in Section V, and finally, the conclusions are drawn.

CHAPTER 7. RELATED RESEARCH

The literature looking into the performance of TDFs is limited as the funds are relatively new in the market. The first TDF was founded in 1994 and therefore no TDF has really lived through the whole 40-year investment horizon that investor would have to go through from the point he/she enters work force and starts saving for retirement to the year he/she retires. Therefore the main stream of TDF performance literature is made up of simulation studies that focus on the proper asset allocation policy by testing which strategy leads to the most accumulated funds or highest expected utility given the assumptions. The second stream of literature focuses on the performance of TDFs relative to other funds looking for reasons for difference in returns in the securities held by the TDFs.

Using accumulated wealth and expected utility as a measure of performance many studies compare so called life-cycle strategies employed by TDFs with the life-style strategies[6]. Liu, Chang, De Jong, and Robinson (2011) evaluate the performance of the life-cycle funds in comparison to life-style focusing in terms of accumulated wealth at the retirement date. They conclude that basic life-cycle strategies are beneficial to the investor, especially during the withdrawal phase. Pfau (2011) performs simulation analysis in the expected utility framework to compare different constant asset allocation and life-cycle strategies. He finds that the introduction of a reasonable degree of risk aversion and assuming diminishing utility from wealth, would give investors a reason to prefer the lifecycle strategy in spite of portfolio size effect. Unlike our paper these two studies do not also analyze the actual TDF returns but use hypothetical portfolios. They do not state what should be the optimal asset class weight for the TDFs that are close to the target retirement year, like 2010 TDFs were during the 2008 bear market, just that the proportion of risky assets in the portfolio should be lower close to retirement and higher when the investor starts investing towards retirement.

[6] Life-cycle strategy adjusts the allocation of risky assets in the portfolio over the lifetime of the fund by decreasing the proportion of risky assets as the target year nears. Life-style strategies keep the asset class proportions constant over the lifetime of the fund.

Lipton and Kish (2011) evaluate more specifically the monthly return performance of TDFs. The authors find that TDFs in their sample underperform compared to the market benchmarks both in terms of risk adjusted and non-risk adjusted returns. They offer as the reason for the underperformance the two layered structure of fees of TDFs – fees for TDF management and fees for underlying funds. Authors note that it is hard to evaluate the performance of TDFS as there is lack of disclosure among TDFs. Authors do not look if some TDFs perform better than others or what would be what would be the reasons for different returns. Compared to Lipton and Kish (2011) our objective is to explain why the returns are so different among the 2010 TDF peer group.

Like Lipton and Kish, Sandhya (2011) examines the return performance of TDFs relative to other funds. Focusing on the agency problems in fund management the author analyzes the flow-performance relation in TDFs and finds that under-performance of TDFs relative to balanced funds is due to TDFs investing in funds with high expense ratios and due to low performance within the fund family. She does not look how the policy decision about the asset allocation influences the returns.

In a sense our paper combines the two streams of TDF performance literature as we look at the effect of asset allocation and the effect of security selection together. By using the holding returns and holding based benchmark, like suggested by Wermers (2006), we are able to analyze the fund performance before expenses and trading costs, therefore excluding the two-tier fees as one reason for underperformance. We are interested if the variation in 2010 TDFs was due to differences in asset allocation policy or due to the selected holdings within asset classes.

When evaluating the portfolio performance and investigating the causes for variability in return, portfolio return can be measured against a benchmark which gives the analyst a frame of reference. With the help of benchmark comparisons portfolio's total return can be decomposed into three main components – market return, return due to asset allocation return, and return from active portfolio management (e.g. Solnik & McLeavey, 2009, pp. 541-542). Early work on performance attribution comes from Fama (1972) who was the first to suggest a finer breakdown of performance – return due to manager's ability to pick good securities and the return due to manager's ability to predict market price movements. This theoretical model is one way to test how well the portfolio managers do their security analysis and how well they pick the holdings to the fund portfolio.

Brinson, Hood and Beebower's (1986) study is the seminal work on portfolio performance attribution and a basis for our model for determining the causes for return variability among the 2010 TDFs. Similar to our study Brinson et al. focused on portfolios used for retirement savings. Their time-series of total returns is from 91 large U.S. pension plans from 1974 to 1983. They decompose portfolio return into policy, timing and selection effect in order to determine the importance of active management relative to policy. They find that asset allocation policy has more than 90 percent explanatory power for the total time-series return variations. They also find that active portfolio management has a negative effect on portfolio return, costing on average 1.1% per year. In the context of 2010 TDFs it would mean that their investment policy about the proportion of portfolio invested in each asset class determines the return variability across time and the decisions about individual assets in the portfolio affect the return minimally. In fact the later paper by Brinson, Singer, and Beebower (1991) updates the first study and confirms that over 90 percent of the variation in quarterly returns is explained by investment policy. In other words, fund managers choose a long-term strategic target that establishes a "normal asset class weights" in the portfolio (Brinson et al., 1991, p. 40) and this policy explains much of the variability in the pension fund returns.

Several other papers have since then confirmed the findings of Brinson et al. by using different benchmarks to gauge performance (e.g. Blake, Lehmann, & Timmermann, 1999; Hensel, Ezra, & Ilkiw, 1991). Majority of these studies find that investment policy explains bulk of the return variation but they disagree on how much exactly asset allocation explains of the return. This can be due to the different benchmarks they choose. These papers do not say that security selection or timing should be ignores, and though it is less important than policy, active management does merit attention as can have an adverse effect on the return.

The focus in the Brinson et al. (1986) paper and the papers following the methodology, is on explaining the return variation within a fund over a certain time period. In our study the objective is not so much to explain the time variation but the variation in returns among TDFs with the same target year. Couple of studies have extended the model by Brinson et al. (1986) and used it to explain return variation between different funds. By separating return variation across time and variation between funds, the studies have found that explanatory power of asset allocation policy is lower for the return variation among funds.

One of the studies that distinguishes between time variation and among fund variation is the paper by Ibbotson and Kaplan (2000) who study monthly returns for 94 balanced U.S. funds and quarterly returns of 58 pension funds. The authors find that asset allocation explains about 90 percent of the variability of returns for pension the funds over time and a little less for the balanced funds, concluding that on average pension fund managers engage less active management. By regressing each fund's returns against S&P 500 Index they find that market return explains a bulk of the return variability and funds just "participate in capital markets in general." Their results of cross-sectional regression find that asset allocation policy explains about 40 percent of the variation of returns among funds. The findings of Ibbotson and Kaplan (2000) would imply that the return variability of 2010 TDFs over the time period from 2006 to 2010 was mostly due to the variability in market returns and about 40% of the variability in performance of 2010 TDFs during the crisis is due to policy. We extend the Ibbotson and Kaplan (2000) study by also determining how much of the return variability during the volatile months can be attributed to active management, especially security selection.

Using return-based style analysis developed by Sharpe (1992) and employed by Ibbotson and Kaplan (2000) the Vardharaj and Fabozzi (2007) and Xiong, Ibbotson, Idzorek, and Chen (2010) evaluate in more detail the among-fund return variation and across-time return variation. Vardharaj and Fabozzi (2007) extend the study by analyzing the importance of allocation by economic sector, size, style and geographic region in stock portfolios, finding that allocation policy explains 30 to 60 percent of among fund variation in returns and nearly 90 percent of across-time variation in returns. Xiong et al. (2010) has similar objectives as our study as they aim to explain the importance of asset allocation policy relative to active portfolio management among a peer group of funds. They find that market return dominates asset allocation policy return in excess of the market return, and the return due to active portfolio management. After the authors separate the market returns from the total portfolio returns they find that within a peer group, asset allocation policy return in excess of market return and active portfolio management are equally important.

Though the prior studies don't straight out say that active portfolio management is useless, does the dominance of asset allocation policy in explaining return variation mean that in an attempt to differentiate their fund from other TDFs the portfolio managers do not add value when they engage in security selection? Wermers (2000) is focused on the security selection ability of the fund managers. He finds that though managers hold stocks that outperform the market, the fund's net returns still underperform the market. This small part of that underperformance is due to the performance of non-stock holdings, and due to the expenses and transaction costs. Wermers (2000) concludes that fund managers "pick stocks well enough to cover their costs" and that active fund management does provide value to the investor.

CHAPTER 8. DATA

We draw our sample of TDF funds and their holdings from the Morningstar U.S. Mutual Fund Database and the monthly returns of the holdings from CRSP database. As one focus in our paper is return variation during the recent financial crisis we exclude from our sample the TDFs that were terminated before January 2007. We also exclude TDFs that have an inception date later than 1st of January 2007 so that the funds in our sample would have returns for the whole crisis period and also that the possible post inception policy and investment changes would not affect our results. We also exclude TDFs that are index funds or exchange traded funds as their investment policy is very specific. Some of the TDFs hold only one or two balanced funds in their portfolio, making it hard for us to divide their assets into two distinct assets classes – equity and fixed income – without taking our analyzing the holdings of holdings. We therefore also exclude from our sample the TDFs that hold only one or two balanced funds. This leaves us with 16 fund families of TDFs. As our focus is only 2010 TDFs we are left with 859 fund month observations.

Table 12. Total Net Asset Value in million USD for the sample of TDFs as of the end of each year for the period of 2004 to 2010.

Fund Family	2006	2007	2008	2009	2010
Fidelity	59,054.9	82,510.7	63,452.9	88,872.2	94,659.5
Vanguard	15,586.5	30,124.7	31,633.8	53,427.7	74,920.6
T. Rowe Price	15,411.2	26,202.0	20,621.1	33,669.2	43,983.9
TIAA-CREF	424.5	1,337.3	1,815.3	3,100.9	5,132.3
American Funds		690.8	1,126.7	2,097.1	2,989.6
ING	282.5	1,006.9	971.7	1,536.8	1,867.2
Vantagepoint	298.1	533.1	519.6	876.1	1,645.7
American Century	365.2	518.1	492.1	990.7	1,154.6
JPMorgan	303.6	592.1	498.0	780.2	1,138.8
Principal Funds	330.5	598.3	536.4	851.6	944.3
GuideStone	0.5	379.4	348.8	575.1	721.8
Russell	37.6	104.9	99.0	241.3	322.6
MassMutual	487.2	549.4	282.7	264.0	261.8
Oppenheimer		24.6	53.1	124.9	227.3
John Hancock	0.8	9.7	18.6	73.7	162.5
Hartford	8.1	41.2	38.4	57.5	115.8
Putnam	465.3	422.4	195.9	221.3	93.2
Columbia	25.4	59.0	53.7	61.5	26.0

TDF market is highly concentrated in the hands of a few large funds with the three market leaders holding about 90 percent of the market share. The remaining 10% of the market share is divided by many smaller funds. The total number of fund families offering TDFs is around 40. Our sample includes the three leaders in the TDF market – Fidelity, Vanguard and T. Rowe Price. Table 3 illustrates the market shares of the TDF funds from 2006 to 2010.

In order to decompose the monthly return of the TDFs into separate policy and active management components according to the methodology in Brinson et al. (1986), we first need to classify the holdings of the TDFs in our sample into two asset classes – equity as a higher risk asset class and fixed income holdings as a lower risk asset class. All stock holdings are classified as equity. In case of mutual funds held by TDFs we rely on the Lipper classification code provided by CRSP. In case the Lipper classification is missing for the security, we check for the classification of the fund from Moriningstar.com. In case the holding is a balanced fund, we use the 50% cutoff point so that balanced funds with 50% and higher level of equity are classified as equity and balanced funds with less than 50% equity are grouped with fixed income holdings. A few TDFs also hold real estate and commodity funds and we classify these holdings as risky assets and group them with equity holdings.

Table 13. Descriptive statistics of the holdings of the 2010 TDFs included in the sample.

The table shows the average monthly return of the holdings for the 2010 TDFs included in our sample. The top 3 and the remaining funds are determined by the market share based on the total net assets as of December 2010. The funds are put in sub groups by their market share illustrated in previous table.

	Average	**Max**	**Min**	**Std.Dev.**
Equity Holdings				
All	0.3%	12.4%	-21.6%	5.5%
Top 3	0.4%	11.6%	-19.6%	5.6%
Next 7	0.4%	12.1%	-19.3%	5.3%
The rest	0.2%	12.4%	-21.6%	5.6%
Russell 3000 Index	0.2%	10.4%	-17.8%	5.3%
Fixed Income Holdings				
All	0.4%	5.5%	-17.8%	1.7%
Top 3	0.5%	3.7%	-5.9%	1.3%
Next 7	0.4%	3.0%	-7.0%	1.3%
The rest	0.3%	5.5%	-17.8%	2.1%
Barclay's US Aggregate	1.0%	4.9%	-2.3%	1.4%

Table 13 summarizes the mean monthly returns of the holdings of 2010 TDFs and. The average monthly return of equity holdings during the 2006 to 2010 period was 0.3% with the standard deviation of 5.5%. This return is a bit higher than the monthly return of the Russell 3000 Index. The equity holdings of top three TDFs averaged the monthly return of 0.4% and the smallest TDFs averaging the monthly equity holding return of 0.2%. Similarly the fixed income holdings of the top three TDFs outperformed the fixed income holdings of the smaller funds. Standard deviation of the return of the fixed income holdings was also higher for smaller funds compared to the market leaders. Fixed income holdings of the 2010 TDFs underperformed the Barclay's US Aggregate Index return. The underperformance of fixed income holdings was even more extreme during the bear markets of fall 2008 and spring 2009, when the Index had an average monthly return of 1.2% and the holdings of all 2010 TDFs averaged a monthly return of -1.1%.

CHAPTER 9. METHODOLOGY

We use the model of return attribution developed by Brinson et al. (1986) to evaluate the reasons the returns within the 2010 TDF peer group differed so drastically during the recent financial crisis. Brinson et al. (1986) decompose the return of the fund into the return due to policy, return due to market timing, and return due to security selection. Policy return is the return of the fund if it used mean asset class weight and the mean return.

In order to decompose the performance into return due to policy and due to active management we need a benchmark. The two main types of benchmarks are market based benchmarks, like for example Russell 3000 Index, and benchmarks based on the funds included in the sample. We use a benchmark based on the holdings of the TDFs included in our sample. Holdings based benchmark allows us to analyze the fund performance before expenses and trading costs. Using a holdings based benchmark is superior to market proxies as each security holding reflects the fund manager's ability to manage the funds that are the focus of our study. The calculation steps for the benchmark return and weight for both asset classes are explained in the Appendix 10.

TDFs generally split their allocation between the equity and fixed income asset, though some funds do include other types of assets in their portfolio. As majority of TDFs use two main asset classes and prior TDF literature has focused on the relationship between equity and fixed income, we also focus in our analysis on just two asset classes – equity and fixed income.

Active management of portfolio holdings involves two main strategies. First, deciding what proportion of the portfolio to invest in each asset class, and second, deciding what securities to choose under each asset class. Brinson et al (1986) refer to the first as timing and he defines it as under or overweighting asset class relative to benchmark. The effect of timing shows the value added by choosing the different asset class weight from the benchmark. Timing or asset allocation effect is calculated as follows:

$$Timing: \left(w_{fi\_t} \times \bar{R}_{i\_t}\right) - \left(\bar{w}_{i\_t} \times \bar{R}_{i\_t}\right) \quad (2.1)$$

Selection effect shows the value added of the portfolio manager's choices of securities. If the manager is good at picking securities the portfolio return will benefit from the active management of securities, if the managers skills are not good at security selection relative to the benchmark, the chosen securities will lead to the lower return relative to the benchmark and therefore hurt the portfolio return. The effect of security selection is calculated as follows:

$$Security\ selection: \left(\bar{w}_{i\_t} \times R_{fi\_t}\right) - \left(\bar{w}_{i\_t} \times \bar{R}_{i\_t}\right) \quad (2.2)$$

The total active management return is the combined effect of timing and selection and the possible interaction effect between the two. The total active management effect can also be expressed as a difference between the benchmark return and the actual portfolio return. We calculate the active management return effect as follows

$$Total\ active\ return: \left(w_{fi\_t} \times R_{fi\_t}\right) - \left(\bar{w}_{i\_t} \times \bar{R}_{i\_t}\right) \quad (2.3)$$

Brinson et al. (1986), we analyze how much of the average return variation is explained by each effect by calculating the coefficient of determination, also called R squared, for the regression model where the actual portfolio return is the dependent variable and return effects are independent variables. R square explains what proportion of the variation in portfolio return is explained by each return effect. We find R square for equity and fixed income return effects separately, in order to determine active management of which asset type explained more of the variation in the actual TDF returns. Similar to Brinson et al (1986) we report the average R square for each effect.

Our analysis covers the period from January 2006 to December 2010. We also report the results for the pre-crisis, during crisis, and post-crisis period. We are specifically interested in how the allocation and selection effects explain the return variation during the months with most severe losses from September 2008 to March 2009. In addition to presenting the results for the sample for 2010 TDFs, we also look at the performance of the top three market leaders, the next seven medium size funds, and the smallest funds.

CHAPTER 9. RESULTS

The variation in the return of 2010 TDFs during the 2008 and 2009 bear markets was extreme. Investors in some 2010 TDF lost as much as 40% of their accumulated assets just 2 years before they should have been able to start withdrawing from their retirement nest egg in order to enjoy the golden years. But not all TDFs in the 2010 peer group suffered as much. In fact we find that this extreme negative performance was limited to the few renegade funds. Decomposing the return of the 2010 TDFs into return into return effects due to timing and selection we find that in general the asset allocation of 2010 TDFs benefitted the funds as it was designed to do. On average active management had no effect on the performance of 2010 TDFs over the period from 2006 to 2010. But the smaller funds were hurt by active management. Security selection strategies of smaller TDFs cost them on average 24 basis points.

1) Effect of active portfolio management

One step in portfolio management is deciding the proportion of the portfolio invested in each asset class. TDFs that are close to the target retirement year should allocate the assets so that the weight of risky assets does not jeopardize investor's accumulated funds. Under or over weighting the asset class can either hurt or benefit portfolio return. During the period from 2006 to 2010, the timing of equity holdings on average hurt the return of the 2010 TDFs and timing of fixed income holdings benefited the return of these funds. On average the loss to the portfolio return due to the over or under weighting equity holdings was 9 basis points. The losses due to timing were higher for the smaller funds with the maximum loss due timing of equity holdings being as high as 8% per month. The top three funds suffered from active management the least (4 basis points) and small funds suffered most from equity security selection (13 basis points). Actively managing fixed income holdings had the most positive benefits for the top three funds (10 basis points) and least to the smaller funds (8 basis points). The small funds though were really playing a gamble with actively managing the holdings with the cost of 8.01% per month for equity selection and the cost of 7.94% per month for fixed income holding selection.

Table 14. Mean monthly returns for the holdings of 2010 TDFs.

The table illustrates the portion of returns due to portfolio management.
Panel A focuses on the return effects in combination with the policy return. Passive selection and passive timing represents the benchmark return for both equity and fixed income holdings (quadrant I in Brinson et al. (1986) article). Passive selection and actual timing represents returns due to policy and timing (quadrant II), where timing refers to the strategic under or overweighting of an asset class relative to its benchmark weight. Actual selection and passive timing represents the return effect of due to policy and security selection (quadrant III), where security selection means active selection of investments within an asset class. Actual timing and actual selection represents the average actual monthly returns of the equity and fixed income holdings during the period from 2006 to 2010.

<table>
<tr><th rowspan="3"></th><th rowspan="3"></th><th rowspan="3"></th><th colspan="4">Selection</th></tr>
<tr><th colspan="2">Actual</th><th colspan="2">Passive</th></tr>
<tr><th>Equity</th><th>FI</th><th>Equity</th><th>FI</th></tr>
<tr><td rowspan="8">Timing</td><td rowspan="4">Actual</td><td>All</td><td>0.12%</td><td>0.21%</td><td>0.12%</td><td>0.23%</td></tr>
<tr><td>Top 3</td><td>0.19%</td><td>0.22%</td><td>0.19%</td><td>0.21%</td></tr>
<tr><td>Next 7</td><td>0.17%</td><td>0.20%</td><td>0.16%</td><td>0.22%</td></tr>
<tr><td>The rest</td><td>0.05%</td><td>0.20%</td><td>0.06%</td><td>0.24%</td></tr>
<tr><td rowspan="4">Passive</td><td>All</td><td>0.21%</td><td>0.10%</td><td>0.21%</td><td>0.12%</td></tr>
<tr><td>Top 3</td><td>0.24%</td><td>0.13%</td><td>0.21%</td><td>0.12%</td></tr>
<tr><td>Next 7</td><td>0.27%</td><td>0.11%</td><td>0.21%</td><td>0.12%</td></tr>
<tr><td>The rest</td><td>0.15%</td><td>0.09%</td><td>0.21%</td><td>0.12%</td></tr>
</table>

Over or under weighting fixed income holdings benefited the monthly returns of 2010 TDFs. On average the decision of 2010 TDFs managers to choose a different weight for fixed income holdings than our benchmark weight, benefitted the funds monthly return by 11 basis points. Though on average the smaller funds benefitted from timing the fixed income holdings even more, some of the small funds picked so different fixed income weight that it hurt them even as much as 3.24% a month. This extreme negative fixed income timing effect was in the Putnam 2010 TDF in October 2008. The funds fixed income allocation during that months was relatively high – 77% of the total portfolio. Therefore we can conclude that at least in this specific case overweighting fixed income holdings relative to the benchmark hurt fund's performance.

Table 15. Mean monthly active management returns of the 2010 TDFs, January 2006 – December 2010.

Table summarizes the returns due to active portfolio management represented by timing, security selection and total active management.

	Equity				Fixed Income				Total
	Mean	**Max**	**Min**	**Std.Dev.**	**Mean**	**Max**	**Min**	**Std.Dev.**	**Mean**
Timing									
All	-0.09%	9.83%	-8.01%	1.49%	0.11%	2.13%	-3.24%	0.39%	0.02%
Top 3	-0.05%	5.10%	-2.50%	1.17%	0.09%	0.82%	-1.68%	0.30%	0.04%
Next 7	-0.08%	5.72%	-3.88%	1.34%	0.10%	1.19%	-1.88%	0.35%	0.02%
The rest	-0.12%	9.83%	-8.01%	1.73%	0.12%	2.13%	-3.24%	0.45%	0.00%
Security Selection									
All	0.00%	4.46%	-5.00%	0.57%	-0.02%	1.27%	-4.15%	0.26%	-0.02%
Top 3	0.01%	0.86%	-0.94%	0.27%	0.01%	1.27%	-0.79%	0.16%	0.00%
Next 7	0.03%	2.35%	-1.80%	0.54%	-0.02%	0.96%	-0.53%	0.18%	0.01%
The rest	0.03%	4.46%	-5.00%	0.71%	-0.03%	0.70%	-4.15%	0.33%	0.00%
Other									
All	0.00%	2.60%	-2.33%	0.22%	0.00%	1.90%	-4.71%	0.27%	0.00%
Top 3	0.00%	0.34%	-0.26%	0.08%	0.01%	0.99%	-0.58%	0.13%	0.01%
Next 7	-0.02%	0.52%	-0.85%	0.17%	-0.01%	1.13%	-0.50%	0.17%	-0.03%
The rest	0.02%	2.60%	-2.33%	0.29%	-0.01%	1.90%	-4.71%	0.37%	0.01%
Total Active Return									
All	-0.09%	10.01%	-8.01%	1.56%	0.09%	4.73%	-7.94%	0.64%	0.00%
Top 3	-0.04%	4.87%	-2.57%	1.11%	0.10%	1.91%	-1.47%	0.32%	0.06%
Next 7	-0.06%	6.58%	-3.49%	1.46%	0.08%	1.47%	1.54%	0.36%	0.02%
The rest	-0.13%	10.01%	-8.01%	1.83%	0.08%	4.73%	-7.94%	0.87%	-0.05%

An alternative active management strategy for the portfolio manager is to pick different securities under each asset class. This strategy requires from the manager the skill of being able to identify good securities. Our results show that relative to the first strategy of deciding on the asset class weight, selection of individual securities does not have as strong effect on the returns of 2010 TDFs. On average the selection of equity securities had no effect on the monthly returns of 2010 TDFs and selection of fixed income securities cost the funds 2 basis points – much less than the loss due to equity timing (11 basis points). The top three leading funds gained from equity security selection on average by 1 basis point. The next seven larger funds benefited from the equity selection 3 basis points. For smallest TDFs also benefited on average from the selection of equity securities but also had the highest standard deviation of the effect (0.71%). For the small funds the selection of fixed income securities also cost 3 basis points, whereas for the larger TDFs fixed income selection had no negative effect on average. It is interesting to note that the small funds were also the ones who took the biggest hit due to selection of fixed income holdings – 4.15% loss. This loss due to fixed income holdings is almost as high as the loss effect of equity security selection (-5%).

Our results show that some portfolio managers are better at timing and selecting securities than others. Active management of holdings can lead to extreme negative effects also. As can be seen from Table 15, the magnitude of timing effect is larger than the magnitude of the selection effect. In the context of the 2010 TDFs it means that the individual securities the fund managers had included in the portfolio did not affect the portfolio return as much as the chosen asset class allocation. By under or over weighting the asset class the managers could both improve or hurt the portfolio return. We also find similar to Brinson et al. (1986) that for the 2010 TDFs though security selection may add some value, the effect is small relative to policy returns..

2) Relative return variation

Brinson et al. (1986) use unadjusted R squared as a measure to evaluate what is the relative amount of variation in return explained by each effect. He found that investment policy return explained 93.6 percent of the total return variation. We calculated average unadjusted R squared for the equity and fixed income effects separately. We find that equity holding returns explain relatively less of the return variation in the 2010 TDFs than the fixed income holding returns. Similarly the active management of equity holdings explained less of the return variation than the management of fixed income holdings. The results are illustrated in Table 16.

Compared to Brinson et al. (1986) we find that both equity and fixed income policy return explains less of the monthly return variation. On average equity policy, using benchmark equity weight and benchmark return, explains 58%. Understandably on average fixed income policy explains more - 86% of the return variation – on average 2010 TDFs are more heavily invested in fixed income assets. Timing does not explain more of return variation. We find that selection of fixed income holdings in combination weight policy weights has on average the highest explanatory power for the return variation as the R squared increase to 93.7% compared to the 86%.

Table 16. Percentage of total return variation explained by fund investment activity, 2006 to 2010.

			Selection			
			Actual		**Passive**	
			Equity	***FI***	***Equity***	***FI***
Timing	**Actual**	All	56.43%	94.00%	55.81%	85.78%
		Top 3	61.43%	92.27%	61.69%	85.71%
		Next 7	51.90%	92.36%	49.85%	86.63%
		The rest	56.16%	96.03%	55.88%	85.30%
	Passive	All	58.53%	93.70%	57.97%	85.66%
		Top 3	61.85%	92.34%	62.12%	85.82%
		Next 7	52.69%	91.31%	50.90%	86.74%
		The rest	60.06%	95.96%	59.74%	84.91%

3) Crisis vs. non-crisis period

Comparing pre- and during crisis periods we find that the importance of both equity and fixed income timing effect increases during the months when the funds experienced severe losses (September 2008 to March 2009). This means that the manager's decision to deviate from the benchmark asset class weight had a stronger effect on the monthly return. Considering that the proportion of risky assets in the 2010 TDFs ranged from about 20% to little over 70%, this deviation from the mean weight is the main factor that hurt the monthly returns. Table 17 summarizes the results for the timing and selection effects for the period from September 2008 to March 2009.

Intuition would say that overweighting risky assets is to blame for the negative returns. But we find that the 2010 TDFs actually benefited from the timing of equity holdings and suffered from timing the fixed income holdings. For example the Putnam 2010 fund had a relatively low equity allocation in October 2008 but timing effect was negative 3.2%. On average timing of fixed income holdings hurt the smallest funds by 22 basis points during the bear market months from September 2008 to March 2009. Effect of equity timing on the return variation of individual 2010 TDFs was on average positive 1.45%. The top three funds had a lower benefit from equity timing and the smallest funds had a 1.51% benefit from equity timing during the most severe bear market months.

Table 17. Returns due to active management for the 2010 TDFs during the pre-crisis, crisis and post-crisis period

	Timing			***Selection***		
	Equity	*FI*	*Total*	*Equity*	*FI*	*Total*
Pre-Crisis Period *(January 2006 – August 2008)*						
All	-0.06%	0.08%	0.02%	0.00%	-0.01%	-0.01%
Top 3	-0.05%	0.07%	0.02%	-0.01%	0.01	0.00%
Next 7	-0.08%	0.08%	0.00%	0.03%	-0.02%	0.01%
The rest	-0.06%	0.08%	0.02%	-0.01%	-0.01%	0.00%
During Crisis *(September 2008 – March 2009)*						
All	1.45%	-0.21%	1.24%	0.03%	-0.06%	-0.03%
Top 3	1.33%	-0.20%	1.13%	-0.11%	0.11%	0.00%
Next 7	1.46%	-0.20%	1.26%	0.19%	0.11%	0.30%
The rest	1.51%	-0.22%	1.29%	0.01%	-0.25%	-0.24%
Post-Crisis Period *(April 2009 – December 2010)*						
All	-0.64%	0.26%	-0.38%	-0.03%	-0.02%	-0.05%
Top 3	-0.51%	0.21%	-0.30%	0.06%	-0.03%	0.03%
Next 7	-0.58%	0.24%	-0.34%	-0.02%	-0.06%	-0.08%
The rest	-0.74%	0.29%	-0.45%	-0.08%	0.01%	-0.07%

The choice of individual securities under each asset class did not affect the 2010 TDFs as much as timing and this return effect did not increase also significantly compared to the whole period from 2006 to 2010. The security selection effect for equity holdings of

2010 TDFs was zero pre-crisis months and increased to an average 3 basis points during September 2008 to March 2009. The medium size funds benefitted the most from equity security selection with 19 basis point positive effect. Fixed income selection effect had an average 6 basis point negative effect on the 2010 TDFs. The smallest funds were hit the hardest due to fixed income selection with negative 25 basis point effect..

CHAPTER 10. CONCLUSIONS

During the recent financial crisis the investors in some 2010 TDFs suffered losses of up to 40% over the period from September 2008 to March 2009. Those underperforming TDFs fell short of providing a safe harbor for the funds of investors who were only 2 years away from retirement. We analyzed the variation of returns among the 2010 TDFs and indentified the sources of this performance. We find that the worst returns were limited to only few renegade funds and that in general the asset allocation of 2010 TDFs protected investors as it was designed to do.

We find that active management in general does not add or take away from the performance of 2010 TDFs. But looking closer at the we find that the top three market leaders benefited from actively managing their holdings and it added on average 6 basis points to their return. On the other hand small funds were not good at active management and it cost them on average 5 basis points.

During the extreme bear market from September 2008 to March 2009 the asset allocation of 2010 TDF benefited their returns. 2010 TDFs that on average had higher proportion of fixed income holdings in their portfolio fulfilled their designed mission in providing the safer harbor to the funds of the investors who were about to retire. In general security selection hurt 2010 TDFs by 3 basis points during the crisis months, but the smaller funds had much higher cost of selection (on average 24 basis points). This shows that smaller funds are on average not as skilled at selecting securities as the managers of larger funds.

In order to understand better the sources for returns of 2010 TDFs further analysis needs to be made. The further research should look into additional benchmarks for both asset allocation policy and security selection.

APPENDIX A. EXPECTED UTILITIES FOR REPRESENTATIVE INVESTORS WITH DIFFERENT RISK AVERSION CHARACTERISTICS AND INVESTMENT HORIZONS

Table 18. Expected utility for the representative investor with the 40-year investment period and the risk aversion ranging from 0 to 4.

The table illustrates the present value of the total investment period expected utility for different portfolio allocation strategies. The column labels in the table state the beginning equity allocation for each strategy and row labels state the ending equity allocation for each strategy. The green cells illustrate higher expected utilities.

		Beginning Equity Allocation																				
		100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Ending Equity Allocation	100%	2.997																				
	95%	3.053	3.060																			
	90%	3.104	3.110	3.115																		
	85%	3.152	3.157	3.161	3.163																	
	80%	3.196	3.200	3.202	3.203	3.202																
	75%	3.236	3.239	3.240	3.239	3.238	3.234															
	70%	3.273	3.274	3.274	3.272	3.269	3.264	3.258														
	65%	3.306	3.306	3.304	3.301	3.296	3.291	3.283	3.275													
	60%	3.335	3.333	3.330	3.326	3.320	3.313	3.304	3.294	3.283												
	55%	3.360	3.357	3.353	3.347	3.340	3.332	3.322	3.311	3.298	**3.284**											
	50%	3.381	3.377	3.372	3.365	3.356	3.347	3.335	3.323	3.309	3.294	3.277										
	45%	3.399	3.394	3.387	3.378	3.369	3.358	3.345	3.331	3.316	3.299	3.281	3.262									
	40%	3.413	3.406	3.398	3.388	3.377	3.365	3.351	3.336	3.320	3.302	3.282	3.261	3.239								
	35%	3.423	3.415	3.405	3.395	3.382	3.369	3.354	3.337	3.319	3.300	3.279	3.257	3.234	3.209							
	30%	3.429	3.420	3.409	3.397	3.383	3.368	3.352	3.334	3.315	3.295	3.273	3.249	3.224	3.198	3.171						
	25%	**3.432**	3.421	3.409	3.396	3.381	3.365	3.347	3.328	3.307	3.285	3.262	3.237	3.211	3.184	3.155	3.125					
	20%	3.430	3.419	3.405	3.390	3.374	3.357	3.338	3.317	3.296	3.272	3.248	3.222	3.194	3.166	3.135	3.104	3.071				
	15%	3.425	3.412	3.398	3.382	3.364	3.345	3.325	3.303	3.280	3.256	3.230	3.203	3.174	3.144	3.112	3.079	3.045	3.009			
	10%	3.417	3.402	3.386	3.369	3.350	3.330	3.308	3.285	3.261	3.235	3.208	3.179	3.149	3.118	3.085	3.051	3.015	2.978	2.940		
	5%	3.404	3.388	3.371	3.352	3.332	3.311	3.288	3.264	3.238	3.211	3.182	3.152	3.121	3.088	3.054	3.019	2.982	2.944	2.904	2.863	
	0%	3.388	3.371	3.352	3.332	3.311	3.288	3.264	3.238	3.211	3.183	3.153	3.122	3.089	3.055	3.020	2.983	2.945	2.905	2.864	2.822	2.778

Table 19. Expected utility for the representative investor with the 40-year investment period and the risk aversion ranging from 0 to 6.

The table illustrates the present value of the total investment period expected utility for different portfolio allocation strategies for the investor who is risk-neutral when he starts investing in his retirement portfolio and has a risk-aversion level of 4 at his/her target retirement date. The column labels in the table state the beginning equity allocation for each strategy and row labels state the ending equity allocation for each strategy. The green cells illustrate higher expected utilities and red cells lowest expected utilities. The highest total expected utility for this representative investor is reached with the strategy that starts at 100% equity when investor is young and decreases the level of equity in the portfolio to about 10% at the target retirement year.

		Beginning Equity Allocation																				
		100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Ending Equity Allocation	100%	2.272																				
	95%	2.373	2.404																			
	90%	2.467	2.496	2.523																		
	85%	2.556	2.583	2.608	2.631																	
	80%	2.639	2.664	2.687	2.708	2.727																
	75%	2.717	2.740	2.761	2.780	2.797	2.811															
	70%	2.789	2.810	2.829	2.846	2.861	2.874	2.884														
	65%	2.855	2.874	2.891	2.906	2.919	2.930	2.939	2.945													
	60%	2.915	2.933	2.948	2.961	2.972	2.981	2.988	2.992	2.995												
	55%	2.970	2.986	2.999	3.010	3.019	3.026	3.031	3.033	3.034	**3.032**											
	50%	3.019	3.033	3.044	3.053	3.060	3.065	3.068	3.069	3.067	3.064	3.058										
	45%	3.063	3.074	3.084	3.091	3.096	3.099	3.100	3.099	3.095	3.090	3.082	3.073									
	40%	3.101	3.110	3.118	3.123	3.126	3.127	3.126	3.123	3.118	3.110	3.101	3.089	3.075								
	35%	3.133	3.141	3.146	3.149	3.151	3.150	3.147	3.141	3.134	3.125	3.113	3.100	3.084	3.066							
	30%	3.160	3.165	3.169	3.170	3.169	3.166	3.161	3.154	3.145	3.134	3.120	3.105	3.087	3.068	3.046						
	25%	3.180	3.184	3.186	3.185	3.182	3.177	3.171	3.162	3.150	3.137	3.122	3.104	3.085	3.063	3.039	3.013					
	20%	3.196	3.197	3.197	3.194	3.190	3.183	3.174	3.163	3.150	3.135	3.117	3.098	3.077	3.053	3.027	2.999	2.969				
	15%	3.205	3.205	3.202	3.198	3.191	3.183	3.172	3.159	3.144	3.127	3.107	3.086	3.063	3.037	3.009	2.980	2.948	2.914			
	10%	**3.209**	3.207	3.202	3.196	3.187	3.177	3.164	3.149	3.132	3.113	3.092	3.068	3.043	3.015	2.986	2.954	2.920	2.884	2.846		
	5%	3.207	3.203	3.197	3.188	3.178	3.165	3.150	3.134	3.115	3.094	3.070	3.045	3.018	2.988	2.957	2.923	2.887	2.849	2.809	2.767	
	0%	3.200	3.194	3.185	3.175	3.162	3.148	3.131	3.112	3.092	3.069	3.043	3.016	2.987	2.955	2.922	2.886	2.848	2.809	2.767	2.722	2.676

Table 20. Expected utility for the representative investor with the 40-year investment period and the risk-aversion ranging from 1 to 4.

The table illustrates the present value of the total investment period expected utility for different portfolio allocation strategies for the investor who is risk-neutral when he starts investing in his retirement portfolio and has a risk-aversion level of 4 at his/her target retirement date. The column labels in the table state the beginning equity allocation for each strategy and row labels state the ending equity allocation for each strategy. The green cells illustrate higher expected utilities and red cells lowest expected utilities. The highest total expected utility for this representative investor is reached with the strategy that starts at 75% equity when investor is young and decreases the level of equity in the portfolio to about 25% at the target retirement year.

	Beginning Equity Allocation																				
Ending Equity Allocation	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
100%	2.581																				
95%	2.649	2.684																			
90%	2.712	2.745	2.776																		
85%	2.771	2.803	2.832	2.858																	
80%	2.827	2.856	2.883	2.908	2.930																
75%	2.878	2.906	2.931	2.954	2.974	2.992															
70%	2.925	2.951	2.975	2.996	3.014	3.030	3.044														
65%	2.967	2.992	3.014	3.034	3.051	3.065	3.077	3.086													
60%	3.006	3.029	3.050	3.068	3.083	3.095	3.105	3.113	3.118												
55%	3.041	3.062	3.081	3.097	3.111	3.122	3.130	3.136	3.139	3.140											
50%	3.071	3.091	3.108	3.123	3.135	3.144	3.151	3.155	3.156	3.155	3.152										
45%	3.098	3.116	3.131	3.144	3.155	3.162	3.167	3.170	3.170	3.167	3.161	**3.153**									
40%	3.120	3.136	3.150	3.162	3.170	3.176	3.180	3.180	3.179	3.174	3.167	3.158	3.145								
35%	3.138	3.153	3.165	3.175	3.182	3.186	3.188	3.187	3.184	3.178	3.169	3.158	3.144	3.127							
30%	3.152	3.165	3.176	3.184	3.189	3.192	3.192	3.190	3.185	3.177	3.166	3.153	3.138	3.120	3.099						
25%	3.162	3.174	3.183	3.189	3.193	**3.194**	3.192	3.188	3.181	3.172	3.160	3.145	3.128	3.108	3.086	3.061					
20%	3.168	3.178	3.185	3.190	3.192	3.191	3.188	3.182	3.174	3.163	3.149	3.133	3.114	3.093	3.069	3.042	3.013				
15%	3.170	3.178	3.184	3.187	3.187	3.185	3.180	3.173	3.163	3.150	3.135	3.117	3.096	3.073	3.047	3.019	2.988	2.954			
10%	3.168	3.174	3.178	3.179	3.178	3.174	3.168	3.159	3.147	3.133	3.116	3.096	3.074	3.049	3.022	2.992	2.959	2.924	2.886		
5%	3.161	3.166	3.168	3.168	3.165	3.160	3.151	3.141	3.127	3.111	3.093	3.072	3.048	3.021	2.992	2.961	2.926	2.889	2.850	2.808	
0%	3.151	3.154	3.155	3.153	3.148	3.141	3.131	3.119	3.104	3.086	3.066	3.043	3.017	2.989	2.959	2.925	2.889	2.851	2.810	2.766	2.719

Table 21. Expected utility for the representative investor with the 40-year investment period and the risk-aversion ranging from 1 to 6.

The table illustrates the present value of the total investment period expected utility for different portfolio allocation strategies for the investor who is risk-neutral when he starts investing in his retirement portfolio and has a risk-aversion level of 4 at his/her target retirement date. The column labels in the table state the beginning equity allocation for each strategy and row labels state the ending equity allocation for each strategy. The green cells illustrate higher expected utilities and red cells lowest expected utilities. The highest total expected utility for this representative investor is reached with the strategy that starts at 60% equity when investor is young and decreases the level of equity in the portfolio to about 20% at the target retirement year.

	Beginning Equity Allocation																				
Ending Equity Allocation	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
100%	1.857																				
95%	1.969	2.027																			
90%	2.075	2.131	2.183																		
85%	2.176	2.229	2.279	2.326																	
80%	2.270	2.321	2.369	2.413	2.454																
75%	2.358	2.407	2.452	2.494	2.533	2.569															
70%	2.440	2.487	2.530	2.570	2.606	2.640	2.670														
65%	2.517	2.561	2.602	2.639	2.673	2.704	2.732	2.756													
60%	2.587	2.629	2.667	2.703	2.735	2.763	2.789	2.811	2.829												
55%	2.651	2.691	2.727	2.760	2.790	2.816	2.839	2.859	2.875	2.888											
50%	2.709	2.747	2.781	2.811	2.839	2.863	2.883	2.901	2.915	2.926	2.933										
45%	2.762	2.797	2.828	2.857	2.882	2.904	2.922	2.937	2.949	2.957	2.962	2.964									
40%	2.808	2.841	2.870	2.896	2.919	2.938	2.954	2.967	2.977	2.983	2.986	2.985	2.981								
35%	2.848	2.879	2.906	2.930	2.950	2.967	2.981	2.991	2.999	3.002	3.003	3.000	2.994	**2.985**							
30%	2.883	2.911	2.936	2.957	2.975	2.990	3.001	3.010	3.014	3.016	3.014	3.009	3.001	2.989	2.974						
25%	2.911	2.937	2.959	2.978	2.994	3.007	3.016	3.022	3.024	3.024	3.020	3.012	3.002	2.988	2.970	2.950					
20%	2.933	2.957	2.977	2.994	3.007	3.018	3.024	3.028	**3.028**	3.025	3.019	3.009	2.996	2.980	2.960	2.937	2.911				
15%	2.950	2.971	2.989	3.003	3.014	3.022	3.027	3.028	3.026	3.021	3.012	3.000	2.985	2.966	2.944	2.919	2.891	2.859			
10%	2.960	2.979	2.994	3.007	3.016	3.021	3.023	3.022	3.018	3.010	2.999	2.985	2.968	2.947	2.922	2.895	2.864	2.830	2.792		
5%	2.964	2.981	2.994	3.004	3.011	3.014	3.014	3.011	3.004	2.994	2.981	2.964	2.944	2.921	2.895	2.865	2.832	2.795	2.755	2.712	
0%	2.963	2.977	2.988	2.996	3.000	3.001	2.999	2.993	2.984	2.972	2.956	2.937	2.915	2.890	2.861	2.829	2.793	2.754	2.712	2.667	2.618

Table 22. Expected utility for the representative investor with the 40-year investment period and the risk-aversion ranging from 2 to 4.

The table illustrates the present value of the total investment period expected utility for different portfolio allocation strategies for the investor who is risk-neutral when he starts investing in his retirement portfolio and has a risk-aversion level of 4 at his/her target retirement date. The column labels in the table state the beginning equity allocation for each strategy and row labels state the ending equity allocation for each strategy. The green cells illustrate higher expected utilities and red cells lowest expected utilities. The highest total expected utility for this representative investor is reached with the strategy that starts at 50% equity when investor is young and decreases the level of equity in the portfolio to about 30% at the target retirement year.

		Beginning Equity Allocation																				
		100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	5%	0%
Ending Equity Allocation	100%	2.166																				
	95%	2.245	2.307																			
	90%	2.320	2.380	2.436																		
	85%	2.391	2.449	2.503	2.553																	
	80%	2.457	2.513	2.565	2.613	2.657																
	75%	2.519	2.573	2.622	2.669	2.711	2.749															
	70%	2.576	2.628	2.676	2.720	2.760	2.797	2.829														
	65%	2.629	2.679	2.725	2.767	2.805	2.839	2.870	2.897													
	60%	2.678	2.725	2.769	2.809	2.845	2.878	2.906	2.931	2.952												
	55%	2.722	2.767	2.809	2.847	2.881	2.912	2.938	2.961	2.980	2.995											
	50%	2.761	2.805	2.845	2.881	2.913	2.941	2.966	2.987	3.004	3.017	3.026										
	45%	2.796	2.838	2.876	2.910	2.940	2.967	2.989	3.008	3.023	3.034	3.041	3.045									
	40%	2.827	2.867	2.903	2.935	2.963	2.987	3.008	3.025	3.038	3.047	3.052	3.054	3.051								
	35%	2.854	2.891	2.925	2.955	2.981	3.004	3.022	3.037	3.048	3.055	3.058	3.058	3.054	3.045							
	30%	2.875	2.911	2.943	2.971	2.995	3.016	3.032	3.045	3.054	3.059	3.060	3.058	3.051	3.041	3.027						
	25%	2.893	2.927	2.956	2.982	3.005	3.023	3.038	3.048	3.055	3.058	3.058	3.053	3.045	3.033	3.017	2.997					
	20%	2.906	2.938	2.965	2.989	3.010	3.026	3.039	3.047	3.052	3.053	3.051	3.044	3.034	3.020	3.002	2.980	2.954				
	15%	2.915	2.944	2.970	2.992	3.010	3.025	3.035	3.042	3.045	3.044	3.039	3.031	3.018	3.002	2.982	2.958	2.931	2.899			
	10%	2.919	2.946	2.970	2.990	3.006	3.019	3.027	3.032	3.033	3.030	3.023	3.013	2.999	2.980	2.958	2.933	2.903	2.870	2.832		
	5%	2.918	2.944	2.966	2.984	2.998	3.008	3.015	3.018	3.017	3.012	3.003	2.991	2.974	2.954	2.930	2.902	2.871	2.835	2.796	2.753	
	0%	2.914	2.937	2.957	2.973	2.985	2.994	2.998	2.999	2.996	2.989	2.978	2.964	2.945	2.923	2.897	2.868	2.834	2.797	2.755	2.710	2.661

Table 23. Expected utility for the representative investor with the 40-year investment period and the risk-aversion ranging from 2 to 6.

The table illustrates the present value of the total investment period expected utility for different portfolio allocation strategies for the investor who is risk-neutral when he starts investing in his retirement portfolio and has a risk-aversion level of 4 at his/her target retirement date. The column labels in the table state the beginning equity allocation for each strategy and row labels state the ending equity allocation for each strategy. The green cells illustrate higher expected utilities and red cells lowest expected utilities. The highest total expected utility for this representative investor is reached with the strategy that starts at 50% equity when investor is young and decreases the level of equity in the portfolio to about 30% at the target retirement year.

		Beginning Equity Allocation																				
		100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	**45%**	40%	35%	30%	25%	20%	15%	10%	5%	0%
Ending Equity Allocation	100%	1.441																				
	95%	1.565	1.650																			
	90%	1.683	1.766	1.844																		
	85%	1.795	1.875	1.950	2.021																	
	80%	1.900	1.977	2.050	2.118	2.182																
	75%	1.999	2.074	2.144	2.209	2.270	2.326															
	70%	2.092	2.164	2.231	2.294	2.352	2.406	2.455														
	65%	2.178	2.247	2.312	2.372	2.428	2.479	2.525	2.567													
	60%	2.258	2.325	2.387	2.444	2.497	2.546	2.590	2.629	2.664												
	55%	2.332	2.396	2.455	2.510	2.560	2.606	2.647	2.684	2.716	2.744											
	50%	2.399	2.461	2.517	2.569	2.617	2.660	2.699	2.733	2.762	2.787	2.808										
	45%	2.460	2.519	2.573	2.623	2.668	2.708	2.744	2.775	2.802	2.825	2.842	2.856									
	40%	2.515	2.571	2.622	2.669	2.712	2.749	2.783	2.811	2.836	2.855	2.8707	2.881	2.888								
	35%	2.564	2.617	2.666	2.710	2.749	2.785	2.815	2.841	2.863	2.880	2.8925	2.901	2.904	2.903							
	30%	2.606	2.656	2.702	2.744	2.781	2.813	2.841	2.865	2.884	2.898	2.908	2.913	2.914	2.911	2.903						
	25%	2.642	2.689	2.733	2.772	2.806	2.836	2.861	2.882	2.898	2.910	2.917	2.9201	2.918	2.912	2.901	2.886					
	20%	2.671	2.716	2.757	2.793	2.825	2.852	2.875	2.893	2.907	2.916	**2.9203**	2.9203	2.916	2.907	2.893	2.875	2.853				
	15%	2.694	2.737	2.775	2.808	2.837	2.862	2.882	2.898	2.909	2.915	2.917	2.914	2.907	2.896	2.879	2.859	2.834	2.804			
	10%	**2.711**	2.751	2.786	2.817	2.844	2.866	2.883	2.896	2.904	2.908	2.907	2.902	2.892	2.878	2.859	2.836	2.808	2.776	2.739		
	5%	2.722	2.759	2.792	2.820	2.844	2.863	2.878	2.888	2.893	2.895	2.891	2.883	2.871	2.854	2.832	2.806	2.776	2.741	2.701	2.657	
	0%	2.726	2.760	2.790	2.816	2.837	2.854	2.866	2.873	2.876	2.875	2.869	2.858	2.843	2.824	2.799	2.771	2.738	2.700	2.658	2.611	2.560

APPENDIX B. GLIDE PATH CHANGE OVER THE LIFETIME OF THE TDF.

The figure illustrates how the glide path of the TDF has a downward slope meaning the equity allocation in the portfolio will decrease over the lifetime of the fund. For the investor who picks the TDF with his/her target retirement year but who has only 30, 20 or 10 years until retirement, the equity level in the portfolio is not anymore at the maximum level. For example for the investor who has 30 years until target retirement and who picks a TDF with the matching target date and glide path from 90% equity to 40% equity, the level of equity in the portfolio is at about 78% when he/she starts making investments into this fund. Similarly the investor who has only 20 years until retirement and picks the same TDF, starts investing into a fund that has already decreased the equity level to about 66%. Therefore the investors with the shorter investment period who pick the TDF with the matching target date will miss out on the benefits from high level of equity for the portfolio accumulation.

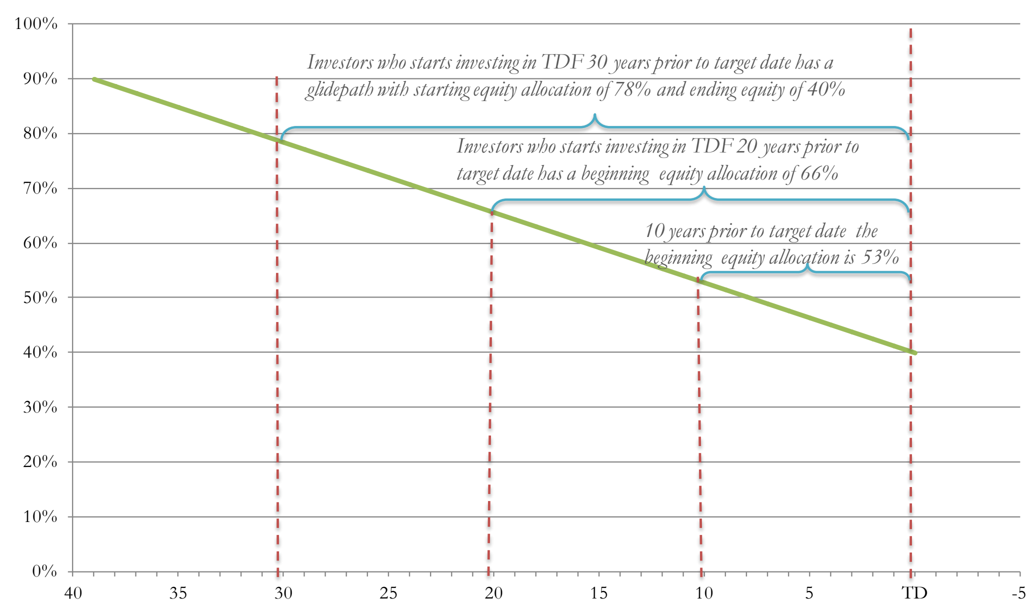

Figure 1. Equity allocation at different points in time over the lifetime of the TDF.

APPENDIX C. COMPARISON OF TDF GLIDE PATHS WITH AND WITHOUT THE KINK.

TDFs can have a kinked steep glide path or a smooth glide path. Kinked glide is often also called steep glide path and it keeps the equity allocation constant for a certain period of time in the beginning of funds lifetime. The most commonly the equity is kept constant for the first 5 to 10 years of the investment period, but some funds keep the equity allocation at the maximum level even longer. Smooth glide paths start decreasing equity allocation right away. Figure 1 illustrates how the glide paths with same beginning and ending equity can still be very different depending if they start decreasing equity allocation immediately or closer to the target year.

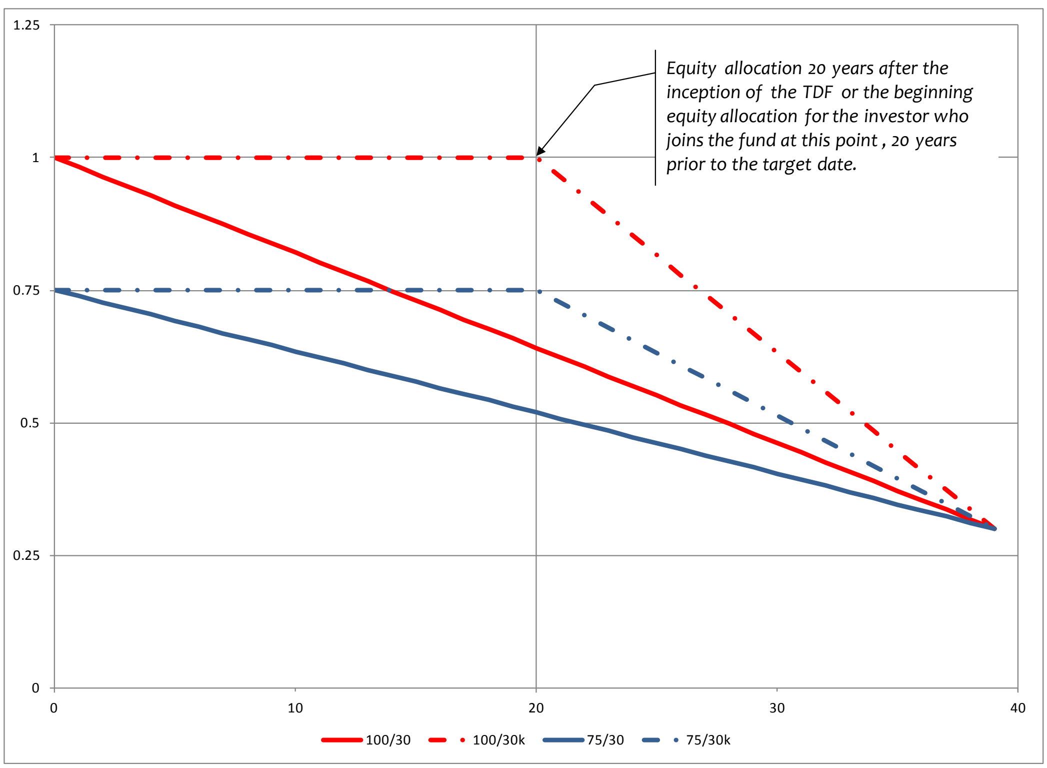

Figure 2. Comparison with and without the kink.

APPENDIX D. METHODOLOGY FOR CALCULATING THE RETURN EFFECTS BASED ON BRINSON ET AL. (1986).

As our original data from Morningstar Mutual Fund Database gives individual holdings we need to calculate the asset class weights for each TDF at each portfolio date as the sum of weights of holdings in each asset class as follows:

$$w_{fi\_t} = \sum_{h=1} w_{fih\_t} \tag{2.4}$$

Where *f* stand for specific TDF, *i* stands for the specific asset class, *h* stands for specific holding, and *t* for portfolio date.

We also need the return for each asset class for each fund. The asset class weight for individual TDFs is determined by the individual assets picked by the fund managers into that asset class. The monthly return for each asset class is the weighted average of the monthly returns of the securities in the same asset class and is calculated as follows:

$$R_{fi\_t} = \frac{\sum R_{fih\_t} w_{fih\_t}}{w_{fi\_t}} \tag{2.5}$$

The value of an investment decision can be measured by comparing the performance with the outcome of an alternative decision. For example, the portfolio return can be compared to the return that would have been earned had the funds been invested in the alternative portfolio instead. The difference represents the value added or lost due to the judgments made by the portfolio manager. As an alternative strategy we create internal benchmarks based on the performance of the funds in our sample. First, the average weight for each asset class:

$$\overline{w}_{i\_t} = \frac{\sum_{f=1}^{F} w_{fi\_t}}{F} \tag{2.6}$$

where F is the number of TDFs at that portfolio date. In case the TDF does not hold the specific asset class we assume the weight of that asset class is zero and for calculation purposes assign to it the average return of the respective asset class at that portfolio date.

Next we calculate the benchmark asset class return as an equally weighted average for both the equity and fixed income holdings at each date[7]:

$$\bar{R}_{i\_t} = \frac{\sum_{f=1}^{F} R_{fi\_t}}{F} \tag{2.7}$$

Brinson et al. (1986) use a framework where they put the effects into quadrants.

		Selection	
		Active	Passive
Timing	Active	Quadrant IV: Actual Return $w_{fi,t} \times R_{fi,t}$	Quadrant II: Policy and Timing $w_{fi,t} \times \bar{R}_{i,t}$
	Passive	Quadrant III: Policy and Selection $\bar{w}_{i,t} \times R_{fi,t}$	Quadrant I: Policy $\bar{w}_{i,t} \times \bar{R}_{i,t}$

Figure 3. Framework and computations for return accountability.

[7] The benchmark return and weight is calculated based on all TDFs of the fund families included in our sample and not only based on the sub sample of 2010 TDFs.

Quadrant I in represents the policy or benchmark return. As we separate the holdings of TDFs into equity and fixed income holdings we have a benchmark or policy return for both equity and fixed income, and it is calculated using the following equation:

$$Policy : \overline{w}_{i\_t} \times \overline{R}_{i\_t} \tag{2.8}$$

Quadrant II represents the effect of policy and timing. Brinson et al. (1986) define timing as a "under or overweighting of an asset class relative to its normal weight, for purposes of return enhancement and/or risk reduction." Christopherson, Carino, and Ferson (2009) refer to this effect as allocation effect. Combined policy and timing effect is calculated also for both asset classes as follows:

$$\textit{Policy and timing} : w_{fi\_t} \times \overline{R}_{i\_t} \tag{2.9}$$

Quadrant II represents the combined effect of policy and security selection. Brinson et al. (1986) define security selection as "active management of assets within asset class." The effect is calculated for both asset classes as follows:

$$\textit{Policy and security selection} : \overline{w}_{i\_t} \times R_{fi\_t} \tag{2.10}$$

Quadrant IV represents the actual return of TDF holdings for the period. We calculated the actual return also for both equity and fixed income holdings as follows:

$$\textit{Actual asset class return} : w_{fi\_t} \times R_{fi\_t} \tag{2.11}$$

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