Title: Zero Bias in Target Retirement Fund Choice

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Abstract:

Using data of approximately 33,000 people who hold Target Retirement Funds, we find a strong "zero" bias in that investors exhibit a strong preference for TRFs which end with zeros (2030, 2040) as compared to TRFs that end with five (2035, 2045). In particular, the bias manifests for people born in years ending between 8 and 2 (e.g., 1968-1972), with people with birth years ending in 0,1 or 2 selecting TRFs that imply they intend to retire at 70 whereas those born in years ending in 8 and 9 select TRFs aspiring to retire at 60. The bias is costly as it impacts the wealth accumulated by influencing the amount people contribute towards their retirement and exposing them to inappropriate levels of risk.

Main Text:

"When do you intend to retire?" As part of financial planning goals, this question has to be addressed by approximately half of the American population, those who save for retirement using a defined contribution plan such as 401(K) or 403(b) (*1*). Sound planning entails making several estimates including the time horizon to retire, benefits of diversification, and costs of borrowing and fees. Errors in these estimations can profoundly impact the amount of wealth accumulated (*2*, *3*). Using data from choices of Target Retirement Funds (TRFs), an increasingly popular investment vehicle, we observe a systematic "zero" bias in individuals' retirement investment decisions.

We find that many people base their choices of TRFs not on the age of 65 at which they are likely to retire but rather on a zero ending calendar year. This bias is not all-encompassing but more provincially manifests itself based on the year an individual is born. In particular, people born with years ending in 8 or 9 have a tendency to make choices as if they are aiming to retire when they are 60 whereas the choices of those born in years ending in 0, 1 and 2 suggest that they intend to leave the labor force when they are 70. We find this propensity to select TRFs with round ending calendar years leads to disproportionate levels of the amount contributed towards retirement, incompatible exposure to risk, and thereby to the total wealth accumulated.

The data we use are investors' choices of TRFs, funds named for a target retirement date. For example, assets in a 2030 TRF shift gradually from riskier (potentially high return) equities today to a low-risk portfolio consisting of cash and bonds in 2030. For those opting to invest in TRFs, the choice of TRFs is between alternatives with year endings in 0 (e.g. 2030, 2040) or endings in 5 (e.g., 2035, 2045). TRFs are widely held: assets in TRFs have grown from $116 billion in 2005 to $763 billion in 2015 (*4*). TRFs are frequently the default investment for participants who are automatically enrolled in a 401(k) plan and do not specify investment choices (*5*). In 2014, recently hired 401(k) plan participants held 41% of their 401(k) plan assets invested in TRFs, with Vanguard reporting that 40% of their clients are invested entirely in TRFs (*6*).

The data shows a strong preference for selecting TRFs with year ending “0” as compared to year ending “5”. Prior research has observed that people tend to utilize round numbers as a reference point against which to judge performance. For example, SAT takers set goals at round scores like 1300, professional baseball players aim for batting averages at round numbers like 0.300 (*7*) and marathon runners choose full hours (e.g., four hours) as completion time (*8*). In contrast to the use of round numbers as a goal towards which people exert effort, the affinity for using a round ending calendar year as a time to retire appears to be a rounding bias. Findings in computational estimation show that individuals use rounding-down or rounding up strategies to arrive at approximate solutions to simple arithmetic problems (*9*, *10*). The effect we document demonstrates the use of specific rounding strategies even in central decision making that significantly influences financial well-being.

We use data from a global financial investment management company which offers retirement plans. Our data includes 84,600 accounts from defined contribution plans. Nearly half of the people (33,876) invest in TRFs (e.g., Vanguard Target Retirement 2050 Investment Fund). In total, our data contains 91 different TRFs from six fund providers.

We observe a “zero bias” in that investors choose more TRFs with year ending in zero than those ending with five. As shown in Figure 1, the number of investors (blue line) who choose any of the 2020/2030/2040/2050 TRFs is much higher than the number of investors who opt for any of the 2025/2035/2045/2055 TRFs.

Assuming the typical retirement age of 65, we use each investor's birth year to calculate their "predicted" retirement year, hence the associated TRF. Then we compare the observed number of investors who choose TRFs of specific target dates with the predicted numbers. The orange line in Figure 1 reveals that the distribution of investors' predicted target retirement year is almost uniform, ranging from 2020 to 2050. However, the observed number of investors for each TRF shows a strong zigzag pattern, as displayed by the blue line. This pattern suggests that zero-ending TRFs are over-bought while five-ending TRFs are under-bought.

To decipher the cause of this zigzag pattern in Figure 1, we depict the choices made by investors of each birth year in Figure 2 – 5. The different colors in Figure 2 – 5 represents TRFs with different target dates while the height of the bar represents the number of investors. For example, for those investors born in 1958, 307 choose the 2020 TRF (orange), 545 selected the 2025 TRF (gray) and 73 picked the 2030 fund (yellow).

Figure 2 plots the choice of TRF for each investor born between 1953 and 1962. Three patterns emerge from Figure 2. First, majority of the investors choose TRFs that reflect the target retirement age of 65. For example, most investors born in 1955 choose the 2020 TRF as it is the year that matches their retirement age of 65. (1955+65=2020). Given that TRFs only have zero-ending and five-ending alternatives, investors with birth year not ending with zero or five are required to perform computations that involve some form of rounding. For example, investors born in 1953 ought to plan to retire in 2018 (at age 65) and choose the 2020 TRF by rounding up. Accordingly, Figure 2 shows that majority of investors born in 1953 do choose the 2020 TRFs which is appropriate for their target retirement age.

For easy exposition, we group birth years that normatively should select the same TRF. For example, people born in the 1955 birth group {1953,1954,1955,1956,1957} should select the

2020 TRF whereas those in the 1960 birth group {1958,1959,1960,1961,1962} should select the 2025 TRF. Our second observation is that the zero bias is not universal: it originates primarily from investors born in the zero-ending birth groups – those who should choose the "5" ending appropriate TRFs: instead of choosing the normative five-ending TRFs, they select the zero-ending ones. For example, 84.2% of the investors born in the 1955 birth group ({1953,1954,1955,1956,1957}) picked the normatively correct 2020 TRF whereas only 45.5% of the investors born in the 1960 birth group ({1958,1959,1960,1961,1962}) choose their appropriate 2025 TRF.

Third, the zero bias is asymmetric: investors with birth year ending with 8 or 9 tend to choose an earlier TRF (retire at 60) whereas investors with birth year ending with 0, 1 or 2 tend to choose a later TRF (retire at 70). For instance, 45.5% (gray bars) of the investors in the 1960 birth group selected the appropriate 2025 TRF, leaving the rest 54.5% as deviators. Among the deviators born in 1958 or 1959, the majority or 68% (37.1% of the total, shown in orange) deviate to the earlier 2020 TRF. In contrast, majority or 72.3% (39.6% of the total, shown in yellow) of the deviators born in 1960, 1961 or 1962 deviate to the later 2030 TRF. We observe similar patterns in other birth-year groups as well, as shown in Figure 3 – 5.

The mismatched selection can be explained by the use of computational heuristics. Consider an investor born in 1968 who in 2016 is making a choice between TRFs. One approach the investor can begin with is her current age, 48, and then decide the age at which she will retire. We assume the typical age of 65. The next step is to determine the number of years left until retirement which is 65-48 = 17. She then calculates the year she will retire which is 2016+17 =2033. The closest alternatives comprise the 2030 and 2035 TRFs. Normatively, the 2035 TRF should be selected as it is the closest to retirement age. This series of steps requires calculations that involve subtraction, addition and rounding. As the precise calculation may be cognitively difficult, the computational estimation in the first two steps could lead to use of simplifying heuristics. For instance, rather than using her age of 48, the investor may begin by rounding off her age to 50 and approximating the numbers of years to retirement as 65-50 = 15. In the next step of calculating the calendar year of retiring, the relatively harder computational estimation of 2016+15 = 2031 can be approximated by rounding 2016 to 2015, leading to 2030. The empirics we observe are consistent with the use of this heuristic.

This proposed computational process also explains the asymmetric effect for investors with birth year ending with 1 or 2. Consider an investor born in 1972, 44 years old in 2016. If she also decides to retire at 65, the number of years left until retirement is 21 (65-44). As her retirement year is 2037 (2016+21), the normative pick is 2035. Computational heuristics suggests that she begins the simplification process by rounding down her age to 40, followed by calculating years left to retirement as 25 (65-40). Finally, as before, rounding 2016 to 2015, yields the retirement year to 2040 (2015+25), which is what we observe in the choices made by investors.

The most interesting effects the data show are the people born in 0 ending years. For instance, people born in 1970 should select the 2035 TRF as it is precisely appropriate for their retirement age. Any deviation implies a choice between rounding down to 2030 or rounding up to 2040. The data shows that these investors round up to 2040, suggesting an optimism bias. The use of the heuristics in the computational estimation we infer are consistent for all age groups including those born in the 1950s, 1960s and 1980s.

The zero bias significantly impacts investors' welfare in that it subsequently alters the amount investors contribute and therefore their accumulated wealth over their life-cycle. First, we find that individuals are more likely to contribute less (more) if they select a later (earlier) TRF as compared to selecting the appropriate TRF. Figure 6 shows the average contribution, measured as percentage of income, by the birth year of the individual. The three lines[1], with colors blue, gray and orange, represent the average contribution when investors choose an earlier TRF, the appropriate TRF that reflects the retirement age of 65, and a later TRF. For example, for investors born in 1970, the TRF that matches the retirement age of 65 is the 2035 fund. Within these investors, those who choose the 2035 fund on average contributed 4.08% of their income towards their retirement while those who choose the 2030, the earlier fund, on average contributed 4.29% and those who choose the 2040, the later fund, on average contributed 3.89%. The downward trend simply indicates that older people contribute a higher percentage. Summarizing over all age groups, we find that people who select a later TRF contribute 4.65% less than those who pick the appropriate TRF.

The zero bias also exposes investors to different risk-return tradeoffs: choice of an earlier (later) TRF generally implies lower (higher) returns and lower (higher) risk than the normative TRF that matches a retirement age of 65. To understand the impact of incorrect risk levels on consumers' welfare, we follow the approach in Poterba (2009). Please refer to the web Appendix for details.

The results in Table 1 illustrate the extent of accumulated wealth[2] at time of retirement resulting from the zero bias. For example, row 1 shows that the implications for a risk-neutral investor who was born in 1979 and started investing $200 in 2010 at the age of 30. Deviating

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[1] Some observations are missing from the figure. For example, the blue lines are not available for the following birth years: 1953, 1954, 1955, 1956, 1957 while the gray lines are not available for the birth years 1973 and 1974. This is because no investors choose the associated TRF. For example, the appropriate TRF for investors born between 1953 and 1957 is the 2020 fund, the earliest TRF in our sample. So no investors choose funds that are earlier than 2020. No investors born in 1973 or 1974 choose a later TRF, the 2045 fund.

[2] We calculate the certainty equivalent of accumulated wealth. Please see the web appendix for details.

from the appropriate 2045 TRF to the earlier 2040 TRF lowers the accumulated terminal wealth from $327,710 to $314,120, a loss of 4.33%. Essentially, the earlier fund is too conservative. As the risk aversion increases, this loss decreases. Additionally, investors who choose an earlier fund tend to contribute more relative to those who choose the appropriate fund. Therefore, a risk-averse individual who contributes more to an earlier fund can be better off than a consumer who selects the appropriate fund.

Now consider an investor born in 1980, who is risk averse, and begins investing $200 a month at age 25. The change in accumulated wealth by selecting the inappropriate 2045 TRF to the later 2050 TRF is from $250,700 to $231,250, an 8.41% loss. The decrease in welfare is due to bearing excessive risk. Incorporating our empirical finding that shifting to a later TRF decreases contributions by 4.6% indicates that the wealth of the investor at the age of 65 decreases by 13.40%.

The effect we document demonstrates that investors, specifically those born in years ending 8, 9, 0, 1 and 2 are subject to the “zero” bias in their target retirement fund choice. This bias significantly impacts their contributions and retirement wealth. A question that we cannot completely address with the empirical data is the precise nature of the computational estimation used in the choice process. We only infer these from the outcomes. The heuristics we suggest that are being used are consistent with the choices made inter-generationally. However, we acknowledge that there may be alternative heuristics that lead to the same consequences. The zero bias effect has clear implications for policy makers and fund providers. 401(k) plan menu designers should take this bias into consideration, emphasize the implications of the choices made at the point of decision, and nudge investors into making selections that maximize financial well-being.

References and Notes:

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Fig. 1. Predicted vs. true frequency of target retirement funds

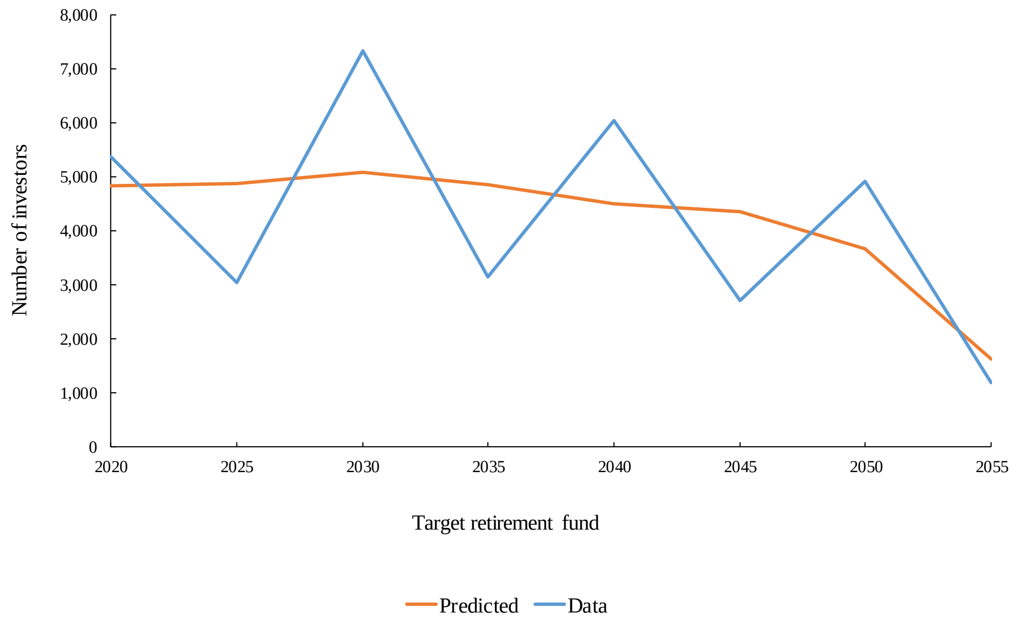


Fig. 2. Fund choice distribution for investors born between 1953 and 1962

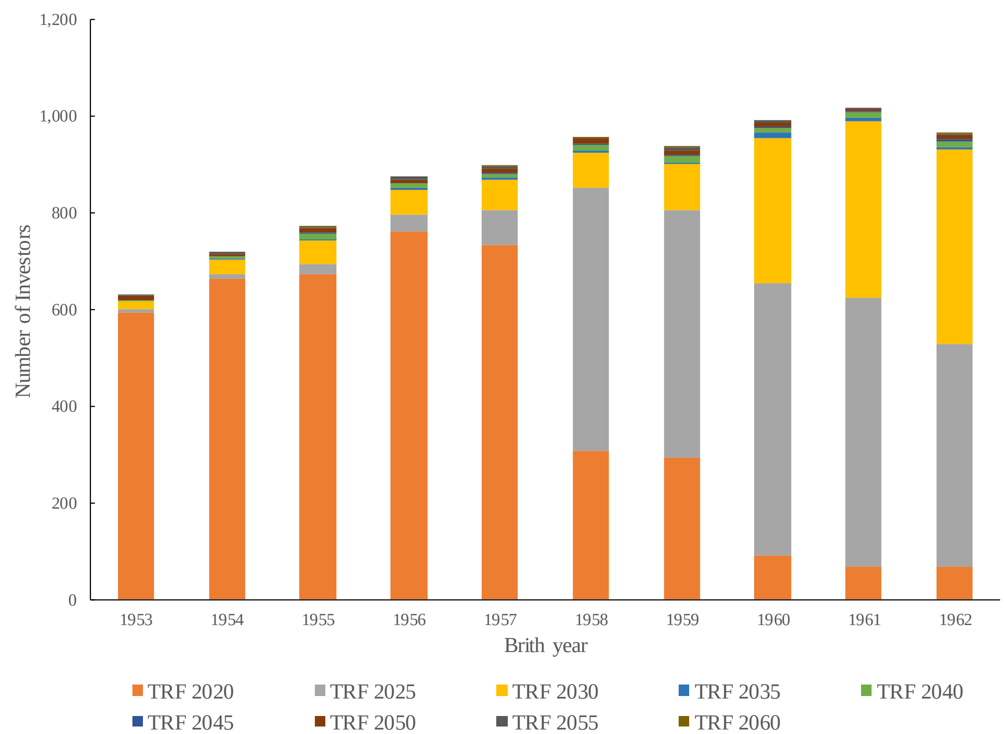


Fig. 3. Fund choice distribution for investors born between 1963 and 1972

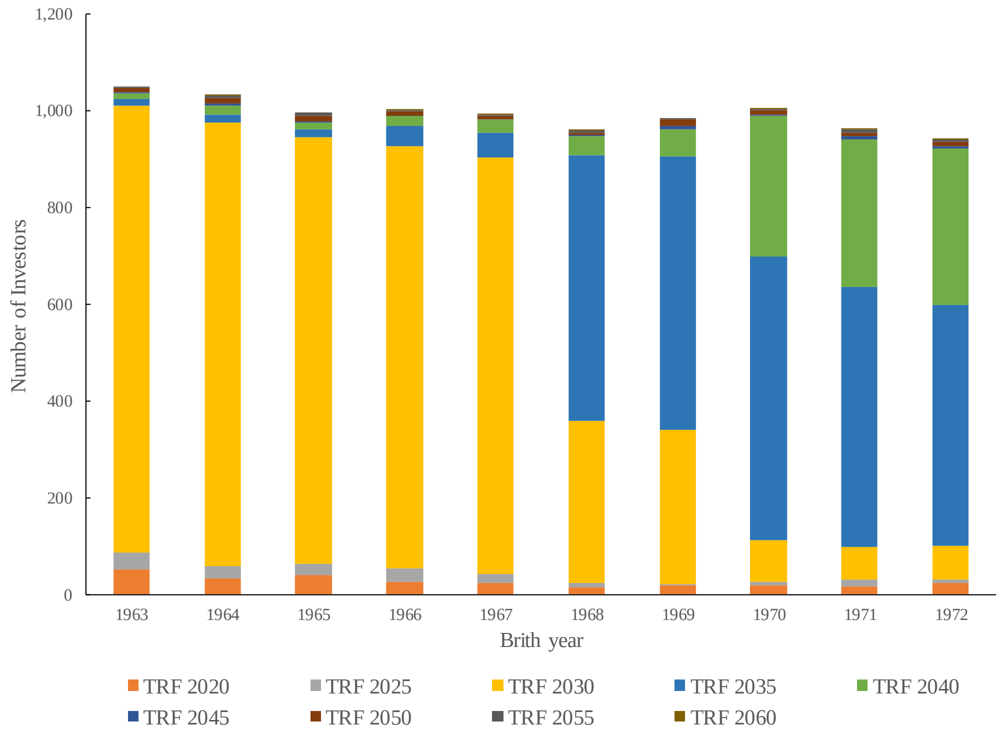


Fig. 4. Fund choice distribution for investors born between 1973 and 1982

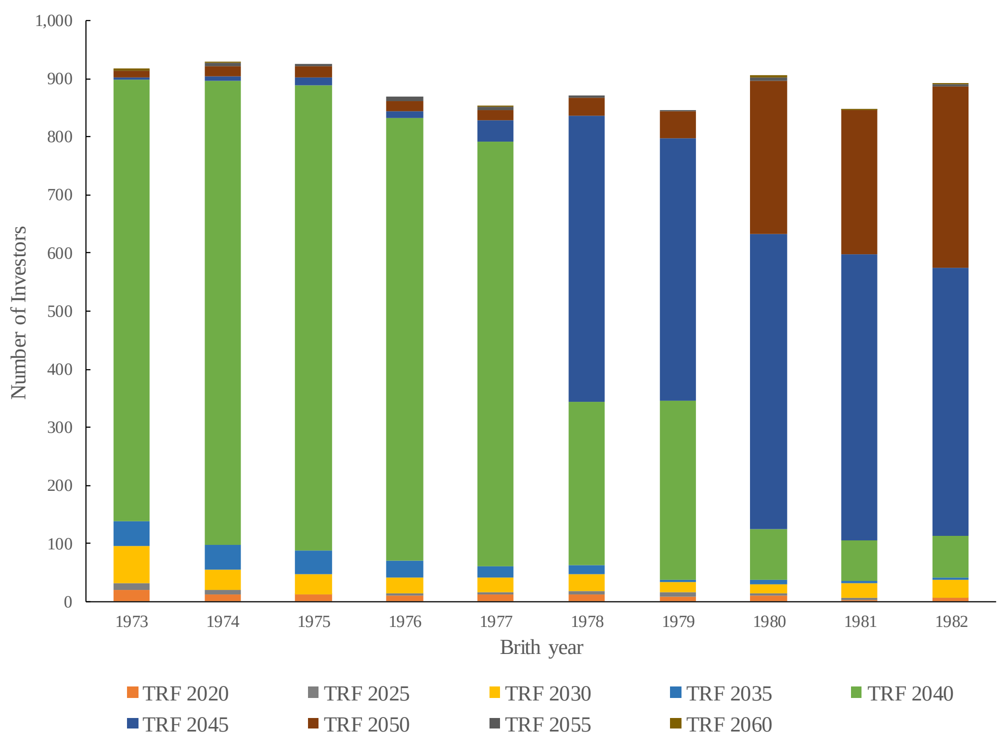


Fig. 5. Fund choice distribution for investors born between 1983 and 1989

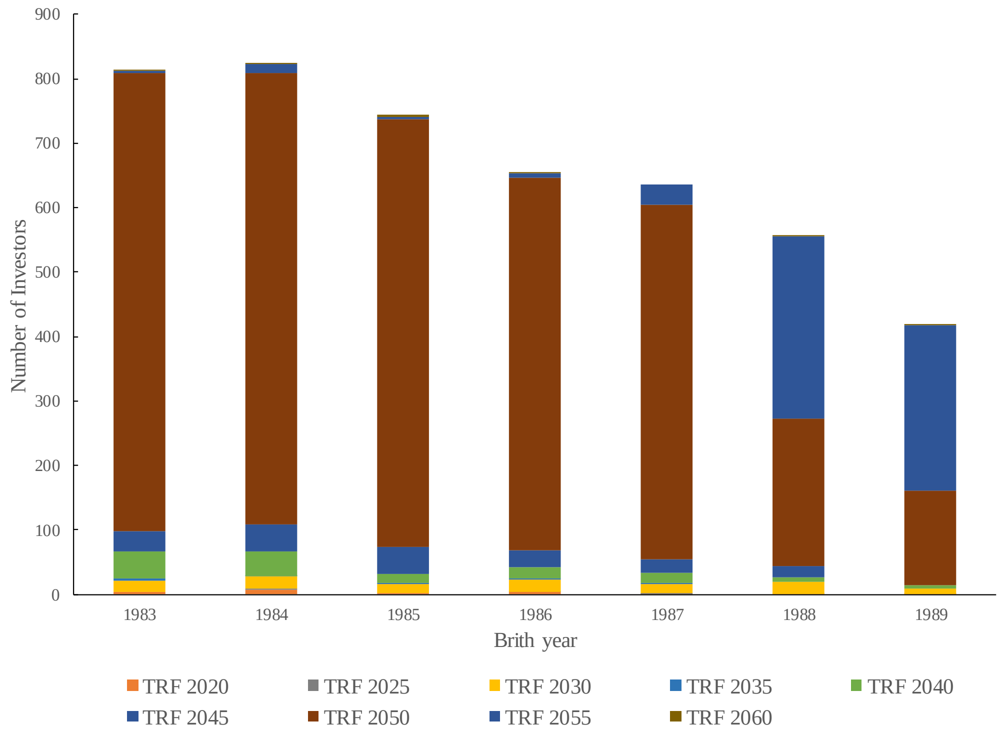


Fig. 6. Average contribution as a percentage of income by birth year

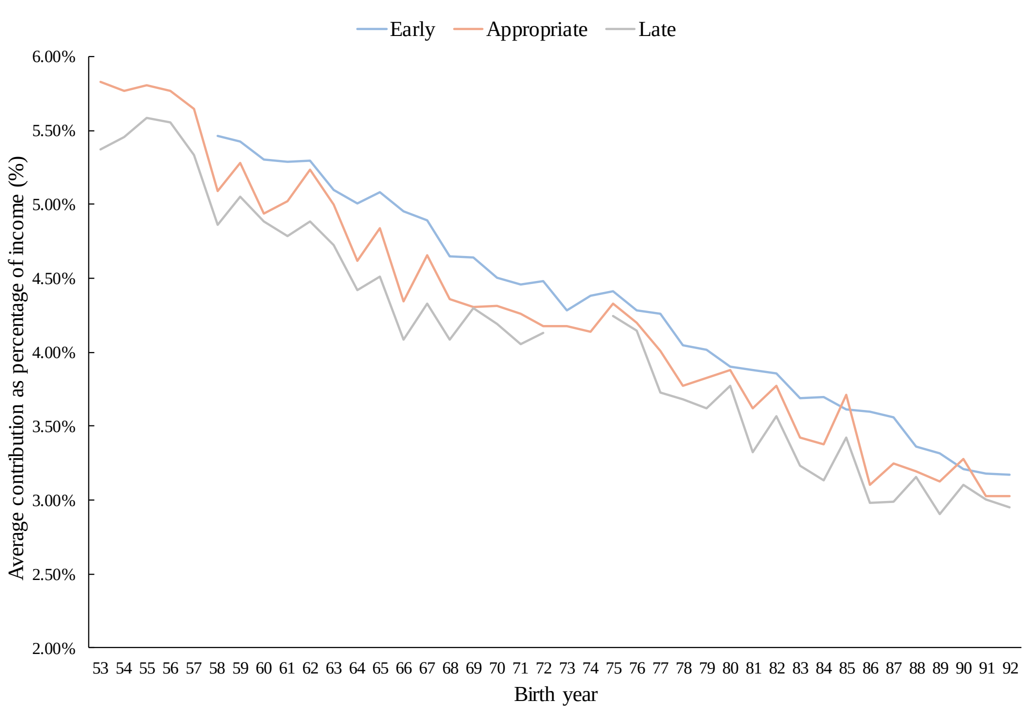


Table 1. Illustration of investors' accumulated wealth at retirement when choosing the inappropriate TRF

Case	Birth year	Appropriate TRF	TRF Selected	Monthly contribution	Start age	Risk aversion	Adjusted for contribution*	Wealth from Appropriate	Wealth from Selected	Percentage Difference
1	1979	2045	2040	$200.00	30	Neutral	No	$327,710	$314,120	-4.33%
2	1979	2045	2040	$200.00	30	High	No	$196,800	$209,730	6.17%
3	1979	2045	2040	$210.60	30	Neutral	Yes	$327,710	$330,768	0.92%
4	1980	2045	2050	$200.00	25	High	No	$250,700	$231,250	-8.67%
5	1980	2045	2050	$190.80	25	High	Yes	$250,400	$219,860	-13.91%
6	1982	2045	2050	$200.00	30	High	No	$204,260	$188,800	-8.19%
7	1982	2045	2050	$190.80	30	High	Yes	$204,260	$180,115	-13.41%

* We adjust monthly contribution of the investors who deviate from appropriate TRF according to empirical findings from Figure 6.

Supplementary Materials:

Web Appendix A1: Simulations of Consumers' Retirement Wealth

We discuss the model to simulate consumers' accumulated wealth at time of retirement. Please find more details directly from Poterba et al. (2009).

The notion behind the simulation is to construct the path of contributions over an investor's life before retirement and combine these contributions with information on asset returns. In the data, we observe investors' monthly contributions. Using these contribution trajectories, we extrapolate the data to obtain the yearly contributions until the age of 65 for each investor, regardless of which target retirement fund they have chosen.

For each investor i, let $C_i(a)$ be her contribution at age a, $R_i(a)$ be the return of TRF chosen by investor i at age a and S_i be the age when investor i starts to invest for retirement. The retirement wealth at age 65 is therefore given by:

$$W_i(65) = \sum_{t=0}^{65-S_i} \{\prod_{j=0}^{t} [1 + R_i(65 - j)]\} C_i(65 - t) \tag{1}$$

Because $R_i(a)$ is the return of TRF whose mix of stocks and bonds varies with time, we collect data on the glidepaths and underlying holdings of each TRF in our sample. Examples of the glidepaths are provided in Appendix A2. The glidepaths inform us of the weights of stock and bond holdings. Each fund's historical holdings and their returns are obtained from Morningstar[3]. Because Morningstar does not have the holdings information for fund of funds such as Vanguard Target Retirement Trust Funds, we exclude investors who hold these funds in

[3] https://corporate.morningstar.com/us/asp/subject.aspx?page=3&xmlfile=283.xml

the simulation analysis[4]. By varying weights overtime according to the glidepaths, we obtain the returns of the TRFs. Note that target retirement fund continues to accept monthly contributions and invest in various asset classes even after maturity.

Since asset returns are stochastic in nature, we simulate consumers' retirement wealth using the following algorithm: for each individual *i* at age A_i, in each iteration *h*, a sequence of 65-A_i stock and bond returns are drawn from the empirical return distribution of the holdings in the TRF chosen by the investor. Then the sequence of returns of the entire TRF span is calculated by applying the weights obtained from the glide path of the TRF. Next we use equation (1) to calculate the terminal wealth at age of 65. For each investor, we simulate the retirement wealth 20,000 times.

To understand the impact of asset returns on consumers' well-being, we calculate consumers' expected utility associated with the distribution of these simulated terminal wealth values. Following Poterba et al. (2009), we use the utility function with a constant relative risk aversion parameter α:

$$U(W) = \frac{W^{1-\alpha}}{1-\alpha} \tag{2}$$

As a result, the utility of investor *i* for the return history *h* (one iteration in the simulation) is given by:

$$U_{ih}(W_{ih}) = \frac{W_{ih}^{1-\alpha}}{1-\alpha} \tag{3}$$

We then obtain the expected utility as the probability-weighted average of these utility outcomes. Given that the expected utility is a function of consumers' risk tolerance, we construct a certainty

[4] This reduces our sample size from 33876 to 12265.

equivalent measure, i.e., the total certain wealth that can provide utility as the same level as the expected utility. Specifically, the certainty equivalent of the accumulated wealth is

$$Z_i = E[U_{ih}(W_{ih}) * (1-\alpha)]^{\frac{1}{1-\alpha}} \tag{4}$$

This suggests that an investor with a higher level of risk aversion has lower expected utility for a later TRF because the later TRF puts investors in excess risk. However, an investor with a low level of risk aversion will have higher expected utility for the same later TRF due to better expected returns.

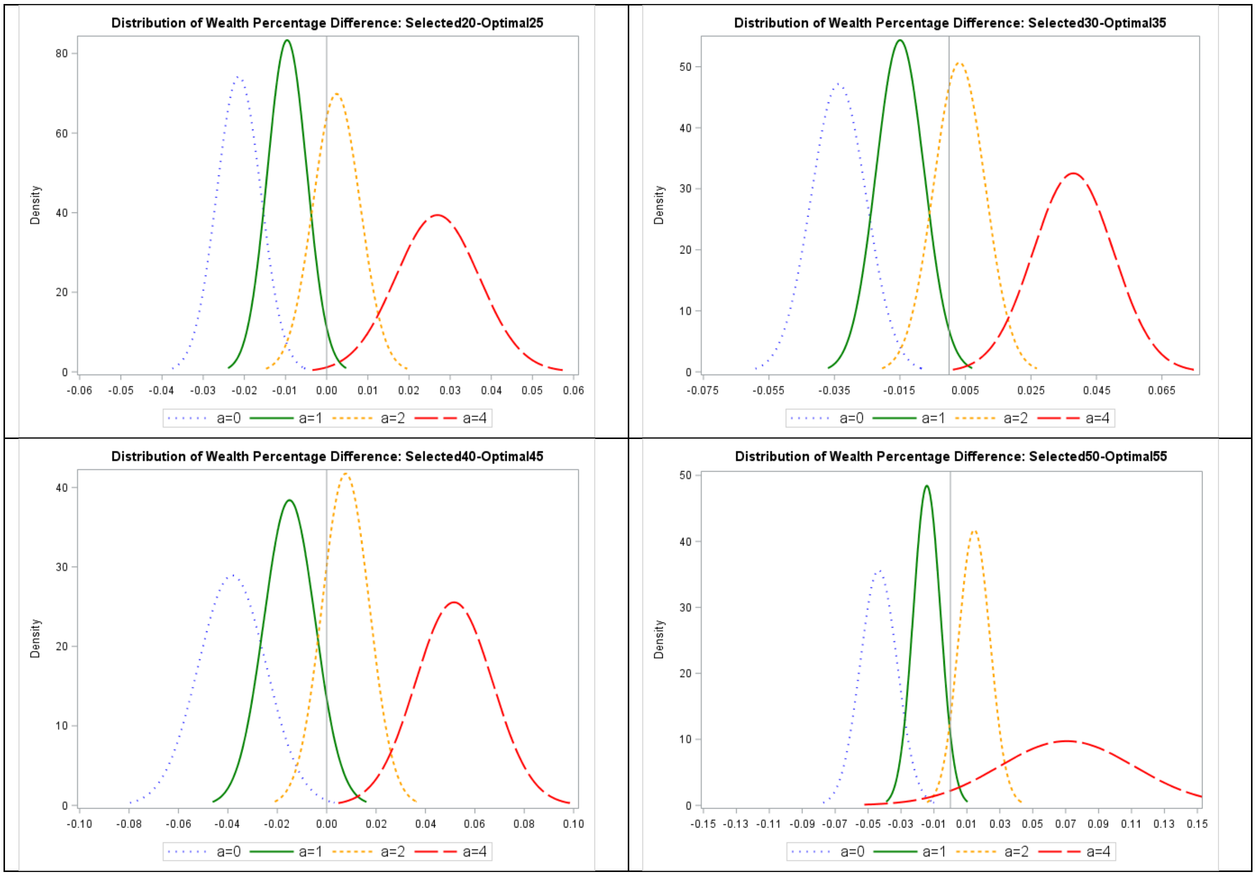
By comparing the certainty equivalent of accumulated wealth, our simulations show that people are usually worse off when deviating from the appropriate TRF. The actual extent of loss or gain depends on each individual's level of risk aversion.

To illustrate, in Figure A1 – A2 we plot the distribution of the difference between the certainty equivalents of the chosen TRF, denoted as Data, and the appropriate TRF that matches the retirement age of 65, denoted as Optimal. We first simulate the retirement wealth of an investor who has chosen the earlier (or later) TRF as compared to the same investor who has chosen the appropriate TRF. Next, we calculate certainty equivalent of the retirement wealth. Then we calculate the differences of the two corresponding certainty equivalents, (Data - Optimal)/Optimal, and plot the distribution of these differences across investors. We plot four levels of risk preferences, where the relative risk averse coefficient is 0,1,2 and 4 respectively.

Figure A1 plots the distribution of differences between an earlier fund and the appropriate fund. Please note that negative values (left of the zero cutoff vertical line) indicate investors are worse off. As can be seen, when the relative risk averse coefficient is low (taking on values of either zero or one), the difference between the chosen fund and the optimal fund is on average negative. This suggests that deviating from the optimal fund by choosing an earlier fund lowers the certainty equivalent of the retirement wealth because the earlier fund is too conservative. However, when the relative risk averse coefficient is high (values of either 2 or 4), the difference between the chosen fund and the optimal fund is on average positive. This implies that deviating from the optimal fund and choosing an earlier fund can generate a higher certainty equivalent of the retirement wealth because investors prefer the conservative nature of the earlier fund.

Figure A2 plots the distribution of difference between a later fund and the appropriate fund. Now when investors have a low risk averse level, the difference between the certainty equivalent of retirement wealth for the chosen fund and optimal fund is generally positive, indicating choosing a later fund in general in people being better off due to higher expected returns. Nevertheless, when investors have a higher risk averse level, deviating to a later fund will make them worse off (the difference of certainty equivalents are on average negative) because of the excess risk.

Fig. A1. Distribution of the wealth difference between the early fund and optimal fund.



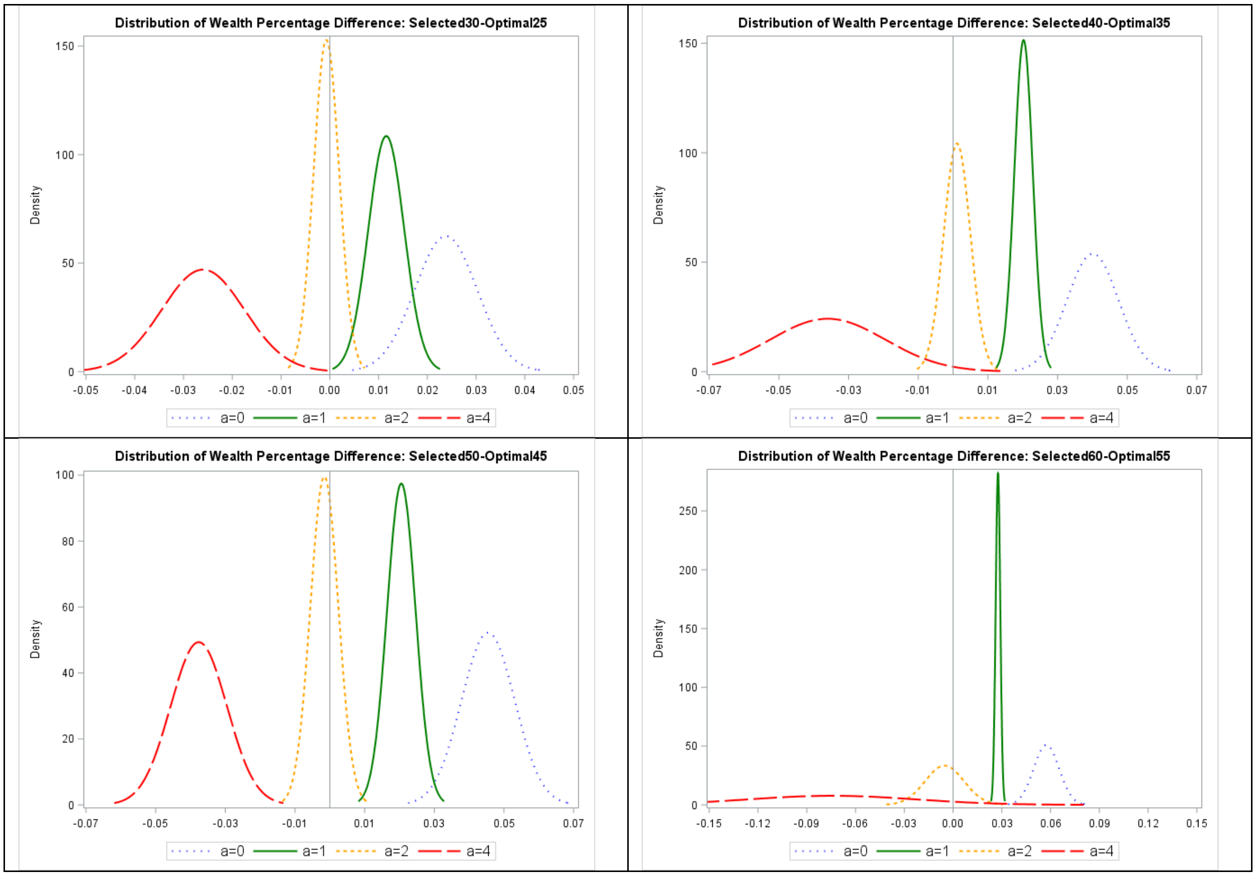
Blue line: risk neutral (risk coefficient = 0)

Green line: low risk aversion (risk coefficient = 1)

Yellow line: medium risk aversion (risk coefficient = 2)

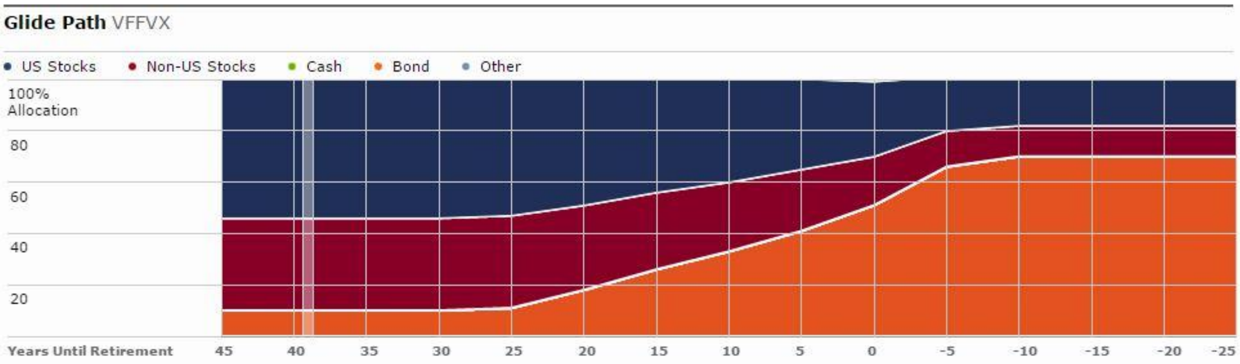
Red line: high risk aversion (risk coefficient = 4)

Fig. A2. Distribution of the wealth difference between the later fund and optimal fund

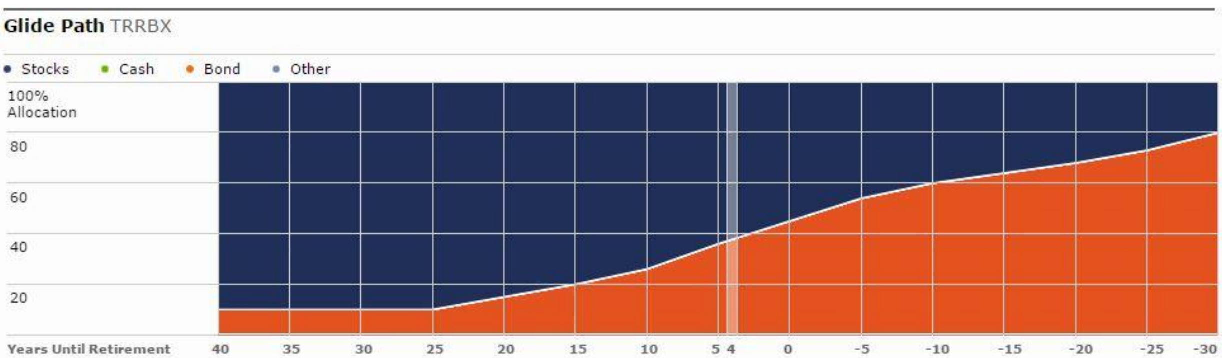


Web Appendix A2: Examples of Glidepaths

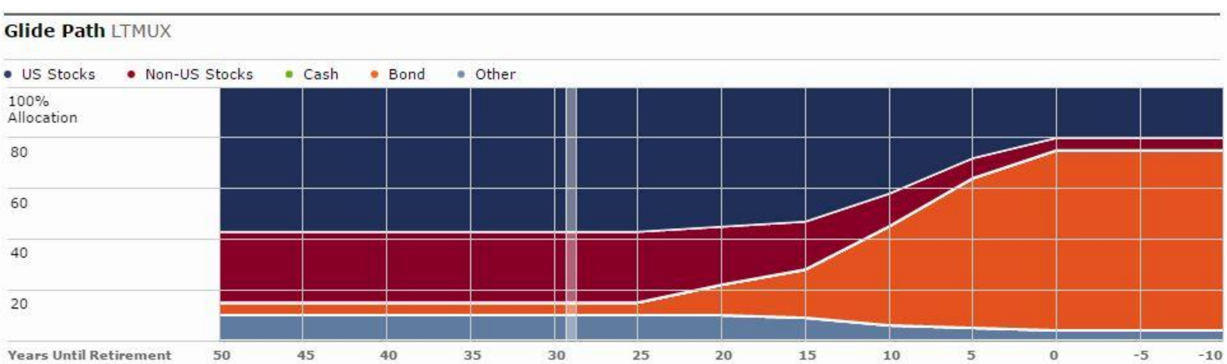
1. Vanguard Target Retirement Fund



2. T. Rowe Price Retirement Fund



3. MFS Lifetime Fund



4. Manning & Napier Target Fund