The glidepath puzzle

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Abstract

There is a discrepancy between theoretically optimal investment glidepaths derived from academic research and those implemented in practice, with actual glidepaths often presenting lower risk than models suggest for typical risk aversion levels. We call this discrepancy the glidepath puzzle. In this paper we explore the impact of incorporating both economic and behavioral utilities in the optimization of investment glidepaths, an approach traditionally driven solely by economic considerations. We introduce the concept of path-sensitive behavioral utility, highlighting its significance in understanding the glidepath puzzle. Our findings demonstrate that existing glidepaths implicitly address behavioral factors but do so inefficiently. Through simulations, we show that explicit weighting of economic and behavioral utilities can substantially improve combined welfare. Based on our model assumptions, welfare gains of at least 10% are achievable if the average observed glidepath is adjusted to the efficient frontier.

Samenvatting

In dit paper onderzoeken we de zogenoemde lifecycle (glidepath) puzzle: het verschil tussen theoretisch optimale beleggingspaden voor pensioenen en de feitelijke, veel voorzichtigere paden die in de praktijk worden gebruikt. Volgens de economische theorie zouden jongere deelnemers, vanwege hun grote ‘menselijk kapitaal’ een veel hogere aandelenblootstelling moeten hebben dan ze in de prakijk hebben.

We verklaren dit verschil door naast een traditionele economische nutsfunctie ook een gedragsmatige nutsfunctie te gebruiken in de optimalisatie. Waar economische nut draait om het behaalde pensioeninkomen, richt gedragsmatig nut zich op de beleving van tussentijdse veranderingen in het verwachte pensioeninkomen: mensen ervaren verliezen sterker dan winsten en hechten zodoende waarde aan een stabiel pad van verwachte pensioenopbouw.

Met Monte-Carlo-simulaties van ruim een miljoen mogelijke lifecycles laten we zien dat de puur economisch optimale strategie veel risicovoller is dan we in de praktijk zien, terwijl de gedragsmatig optimale strategie juist zeer defensief is. Tussen beide extremen bestaat een duidelijke efficiënte grens: een uitruil tussen een hoger verwacht pensioen en meer stabiliteit van de verwachte pensioenopbouw.

Lifecycles die in de praktijk gehanteerd worden lijken impliciet rekening te houden met gedragsaspecten, maar doen dit inefficiënt. Door economisch en gedragsmatig nut expliciet te wegen in het ontwerpproces kan de totale welvaart van deelnemers op basis van onze modelaannames met wel 10% toenemen.

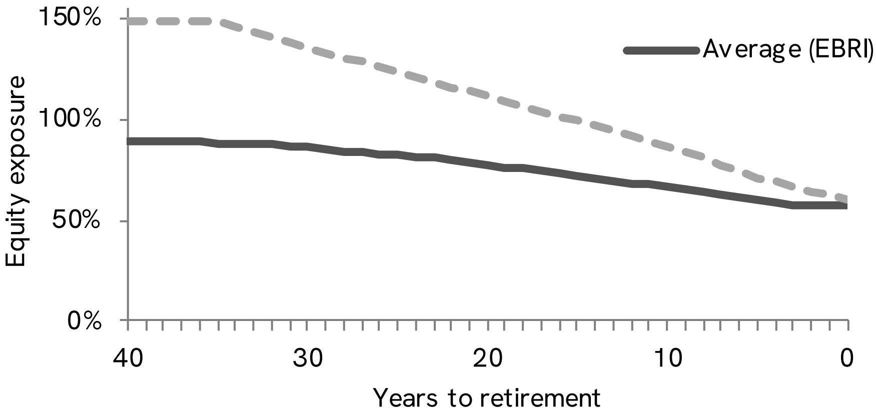
1. Introduction

Mainstream economic theory holds that the optimal allocation of pension capital depends on age. Younger participants possess substantial human capital but limited financial capital. Because human capital is typically weakly correlated with financial markets, it can be viewed as low risk and therefore cushions pensionincome volatility. Consequently, theory recommends that younger participants allocate a larger share of their financial capital to risky assets than older participants, who hold more financial but less human capital (Bodie, 1995). This agedependent decline in riskyasset exposure is known as a glidepath (or lifecycle).

There is, however, a large gap between theory and practice when it comes to glidepath investing. While theory prescribes that young pension scheme participants with average levels of risk aversion should allocate larger proportions of their accumulated capital to risky assets, often more than 100% (Campbell & Viceira, 2001), few actually do so. For instance, U.S. 401(k) participants in their twenties hold roughly 90% in equities (Holden, Bass, & Copeland, 2024), whereas the theoretical optimum is closer to 150% (Viceira, 2001). Figure 1 illustrates that actual equity allocations fall well below optimal levels, particularly for younger cohorts. Even where pension funds or insurers set or advise allocations (e.g., in the Netherlands), default glidepaths still allocate substantially less to risky assets for younger participants: the median Dutch allocation is below 80% twenty years before retirement (LCP, 2021). We refer to this discrepancy as the 'glidepath puzzle'.

In this paper we measure the impact of what we will refer to as behavioral utility on glidepath construction. We do so by optimizing one glidepath under expected utility theory

Figure 1: Allocation to equities



Average allocation to equities in 401(k) plans by age (including equity funds, company stocks and equity allocations of balanced funds) as of 2022. Source: Holden, Bass, & Copeland (2024). Optimal allocation based on a relative risk aversion () of 3 and no (0%) correlation between financial and human capital. Source: Viceira (2001).

with constant relative risk aversion (CRRA) preferences (the ‘economic glidepath’) and another under loss aversion (the ‘behavioral glidepath’). The difference between the two provides information about the glidepath puzzle. Additionally, our method allows for explicit weights to be given to the ‘economic’ and ‘behavioral’ utilities to find the optimal glidepath. This makes behavioral effects an explicit, rather than implicit, component of design. We demonstrate that such explicit integration produces more efficient allocations than today’s practice of merely trimming risky-asset exposure in the economic glidepath.

Several factors may account for the gap between theory and practice. One possibility is a positive correlation between human and financial capital (e.g., employment prospects tied to market cycles); Viceira (2001) estimates that this reduces the optimal allocation for someone 35 years from retirement from 148% to 130%. However, this still leaves a large gap between theory and practice. Differing capital-market expectations among participants or providers offer another explanation. A lower expected equity risk premium, for example, reduces the optimal allocation to equities. But even a two percentage-point drop does not bridge the gap between observed and optimal allocations (Alserda et al., 2019).

Some authors argue that a dynamic glidepath (i.e., adapting the glidepath to realized investment results) increases expected welfare (e.g., Basu, Byrne & Drew, 2011). However, this can only explain the glidepath puzzle for participants for whom realized investment returns have far exceeded expected returns and is thus not a general solution to the puzzle. Blake, Cairns & Dowd (2001) and Arnott, Sherrerd & Wu (2013) even argue against the general glidepath design and show that a balanced or even contrarian strategy would have resulted in better outcomes in the past. While these results depend on the specific definition of risk, it would only make the puzzle bigger for younger participants.

Two other factors that may explain the remaining gap are mental accounting and loss aversion. First, people tend to make interrelated choices in isolation, within specific mental accounts (Thaler, 1985), instead of optimizing the conjunct choice set. Many people will view their risk-carrying pension separately from other forms of pension income or capital, such as a state pension or a defined benefit pension. As these other forms of pension income tend to hold little market or other risk, the pension that does hold risk should hold more in order to get the total risk exposure in line with risk preferences. Due to mental accounting this is often neglected, causing the risk-carrying pension capital to have a below-optimal allocation to risky assets.

Second, loss aversion describes how people are generally more sensitive to losses compared to gains of the same size (Kahneman & Tversky, 1979), both for financial (Barberis & Huang 2001) and non-financial outcomes (Allen et al. 2017). This can also affect the pension accumulation phase: people being substantially more sensitive to reductions in their expected pension income than to increases. This is closely linked to myopic loss aversion as discussed by Benartzi & Thaler (1995). As a result, they may opt for a lower allocation to risky assets, even if this is suboptimal in the long run according to mainstream economic literature.

While many different retirement investment strategies have been discussed and tested in the literature, little attention is paid to perceived risk during the pension accumulation phase. Understanding the origins of the glidepath puzzle can help us promote better decision-making and/ or design glidepaths that more efficiently balance the ‘economic’ utility of the actual pension payments that participants will receive with the ‘behavioral’ utility of a smooth accumulation of those pension payments.

The rest of this paper is organized as follows: Section 2 outlines the methodology employed in this study, Section 3 highlights the findings, and Section 4 offers the concluding remarks.

2. Method

Several methods exist to determine optimal pension asset allocations. For simplified problems a closed-form solution might exist, but when real-life complexities (such as interest rate dynamics) are included, this is generally not the case. The sheer number of possible glidepaths[1] and finite computing power makes brute-force optimization infeasible. Finally, dynamic solutions to optimize glidepaths run the risk of finding only locally (rather than globally) optimal solutions. We therefore restrict the search space to four key glidepath parameters and evaluate 1,006,566 combinations via Monte-Carlo simulation. The four key variables (and limits) that we use are:

A. Initial exposure to equity (0-150%[2])
B. Final exposure to equity (0-100%)
C. Age start of change in equity exposure (0-40 years before retirement)
D. Age end of change in equity exposure (0-40 years before retirement)

A similar glidepath can be constructed for the interest rate hedge. However, information on the average interest rate hedge per age cohort is not available. We therefore restrict the analysis to the glidepath for equity exposure and assume that a full interest rate hedge is built up linearly in the twenty years before retirement.

Collectively, these variables capture the essential shape of glidepaths observed in practice (Drew & West, 2021; LCP, 2021). By evaluating a sufficiently large number of combinations, we can closely approximate the optimal glidepath design, given a set of projected economic scenarios and a suitable utility function. In retirement, allocations are fixed: without human capital, neither economic nor behavioral considerations imply age-varying allocations past retirement age.

For every candidate glidepath we simulate a distribution of retirement incomes via a Monte-Carlo method. Our economic model is based on Koijen, Nijman & Werker (2010), featuring a two-factor model of the term structure. Parameter inputs are taken from Dijsselbloem et al. (2019) – a committee of Dutch experts – who have calibrated the inputs on the European market. The average (standard deviation) 10-year interest rate using these parameters is 3.7% (1.8%), average inflation is 1.9% (0.8%), and the average (geometric) equity premium is equal to 3.2% (15.1%). Mean reversion is assumed for both interest rates and inflation, while equity (excess) returns follow an i.i.d. lognormal distribution.

We simulate a participant who starts working at the age of 25 with an initial income of $25,000 and retires at age 68. Income develops (deterministically) in line with an age-related

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[1] Even with two asset classes and 1% increments in allocations, over a Googol (10100) discrete glidepaths exist.

[2] We allow for leverage in the exposure to equity. However, we limit the exposure to 150%, which is often either a practical or legal (e.g., in the Netherlands) limit.

promotional scale[3] and (stochastically) with price inflation. Contributions to pension capital are equal to 20% of income. Each year the participant adds contributions and receives investment returns that comprise equity returns, the return on the interest rate hedge, and a cash return (the latter is used to set total exposure equal to 1). The interest rate hedge is calculated assuming a perfect hedge of expected cash flows.

At retirement, the pension capital is converted to an annual pension income by dividing the available pension capital by the relevant annuity factor. During retirement, mortality credits (biometric return) deliver a lifelong pension. In essence, this is a life annuity with investment risk. In the special case that equity exposure is 0% and the interest rate is 100%, the result is a constant (nominal) annuity. Total retirement income adjusted for inflation is translated to economic utility with a standard power utility curve (equation 1) and a relative risk aversion coefficient of 3.0 (Knoef et al., 2022). Expected utility is taken as the average utility over each scenario and is then translated to a certainty equivalent by taking the inverse of the utility function (2).

$$\mathrm{U_E}\left(\mathrm{X_{i,t}}\right) = \frac{\mathrm{X_{i,t}}^{1-\gamma_\mathrm{E}}}{1-\gamma_\mathrm{E}} \tag{1}$$

where $\mathrm{U_E}$ gives **E**conomic Utility, $\mathrm{X_{i,t}}$ gives the relevant total pension income in scenario i at time t, and γ_E the level of relative risk aversion for total pension income (γ_E = 3.0)

$$\mathrm{CE_E(X)} \ = \mathrm{U_E^{-1}}\left(\frac{\sum_{\mathrm{i=1}}^{\mathrm{I}} \mathrm{U_E}\left(\mathrm{X_{i,T}}\right)}{\mathrm{I}}\right) \tag{2}$$

where $\mathrm{CE_E}$ gives the (Economic) Certainty Equivalent pension by taking the inverse utility of the average utility in all $\mathrm{I} = 2{,}000$ scenarios at retirement date T.

In addition, for each year in every simulation we determine the expected pension income in nominal terms. We do this by determining the expected levels of future pension contributions and investment returns. To get to the expected levels, we assume that interest rates and inflation levels converge to their long-term mean. Next, the expected equity return is given by the expected instantaneous interest rate, plus an equity premium of 3.2% (as in the main simulation). The expected levels of future income – which determine future pension contributions – are based on expected wage inflation but do not take any promotional scale into account. Therefore, expected pension income generally underestimates actual average pension income. This calculation is similar to the one used to generate the expected pensions that Dutch participants observe in their yearly pension statement from their provider (Uniform Pension Overview) and on a national website (My Pension Overview).

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[3] The age-related promotional scale is equal to 3% above general wage inflation up to age 34 and then decreases towards 0% for ages 55 and above.

Behavioral utility is calculated over the difference between last year's (expected) pension income and current (expected) pension income. We thus use last year's outcome (the status quo) as reference point, consistent with empirical evidence (see, e.g., Baucells et al., 2011 & Baillon et al., 2020). The first expected pension income is set equal to the risk-free expectation for all glidepaths. For behavioral utility we only look at nominal amounts, as most individuals think in nominal rather than real monetary values, the so-called money illusion (Shafir, Diamond & Tversky, 1997). Negative changes (losses) are weighted λ times stronger than positive ones (gains). The behavioral utility function is given in equation (4).

$$\mathrm{Change}_{i,t} = Z_{i,t} - Z_{i,t-1} \tag{3}$$

$$U_B(\mathrm{Change}_{i,t}) = \begin{cases} \dfrac{\mathrm{Change}_{i,t}{}^{1-\gamma_B}}{1-\gamma_B} & \text{if} \quad \mathrm{Change}_{i,t} \geq 0 \\ -\lambda \dfrac{\left|\mathrm{Change}_{i,t}\right|^{1-\gamma_B}}{1-\gamma_B} & \text{if} \quad \mathrm{Change}_{i,t} < 0 \end{cases} \tag{4}$$

with $\mathrm{Change}_{i,t}$ representing the yearly change in scenario i from time $t-1$ to time t and U_B the Behavioral Utility function. Z gives the relevant expected nominal pension income, $\gamma_B = 0.12$ is the level of utility curvature for changes in (expected) pension income and $\lambda = 2.25$ the level of loss aversion. Parameters were chosen in line with Tversky & Kahneman (1992).

The certainty equivalent (change) is taken by using the inverse of this function on the expected utility over all scenarios. This gives us a certain change in expected pension that is felt equally (i.e. gives the same behavioral utility) as the actual set of possible changes over the scenarios. We average utility across years and scenarios without time discounting to avoid introducing an additional parameter/dimension and to keep results comparable to the economic certainty-equivalent pension, which is valued at the retirement date.

$$CC(X) = U_B{}^{-1}\left(\frac{\sum_{t=1}^{T}\sum_{i=1}^{I} U_B(\mathrm{Change}_{i,t})}{I \cdot T}\right) \tag{5}$$

with the CC 'certain change'.

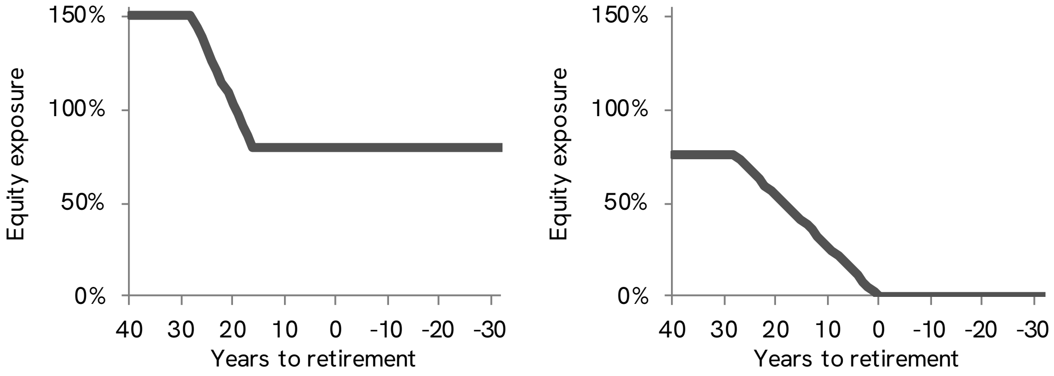
For the sake of comparison, we translate the certain change to a behavioral certainty equivalent pension. We do this by multiplying the first pension expectation with the certain change over the entire accumulation phase (i.e., 43 years). This gives a value that can be directly compared to the economic certainty equivalent pension.

The results, which we show in the next section, obviously depend heavily on the preference parameters (λ, γ_E, γ_B). We do not claim that the chosen parameters are representative, although we have tried to select the most reasonable parameters. The methodology we describe can be used with parameters that are representative of the population for which the glidepath is designed. Ideally, the glidepath is even tailored to an individual's preferences. Economic preferences (γ_E) and behavioral preferences (λ, γ_B) can be measured separately from other factors (such as probability weighting) by using methods such as described by Wakker & Deneffe (1996) and Abdellaoui et al. (2007), respectively.

3. Results

We start by analyzing what we call the economic utility of pension outcomes. We do this for our set of glidepaths, selecting the one that yields the highest certainty equivalent. This glidepath is presented in Figure 2 (left panel). The glidepath starts with a maximum (150%) allocation to equity and decreases the exposure during the period 28 to 16 years before retirement, ending at 80% allocation to equity. This glidepath quite closely resembles the optimal glidepath as presented by Viceira (2001) and is thus substantially more risky than those that we see in practice. Selecting a suboptimal glidepath can reduce economic welfare by 48% within our set of glidepaths.

Figure 2: The economic (left) & behavioral glidepaths (right)

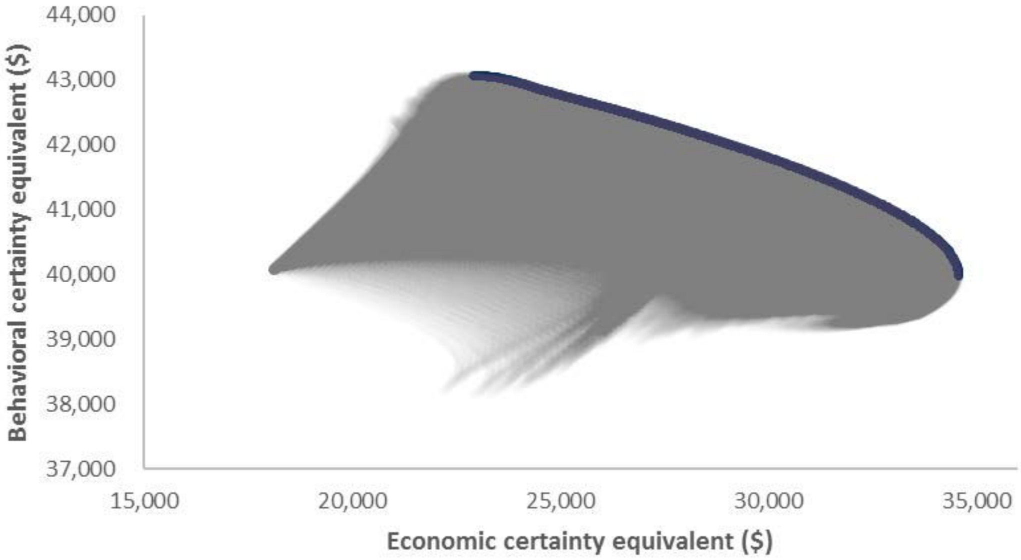


Glidepaths that optimize economic utility (left) and behavioral utility (right) based on our set of potential glidepaths.

From a behavioral perspective we want to choose the glidepath that optimizes the certain change. All glidepaths in our set have a negative certain change, because, even with no exposure to equity and a 100% interest rate hedge, the expected pension income is not constant owing to interest-rate effects on future contributions and inflation effects on salary growth. Due to loss aversion the impact of negative changes is larger than that of positive changes, resulting in a negative certain change. The glidepath with the highest certain change is again shown in Figure 2 (right panel). This glidepath starts with a 76% allocation to equity and ends with no exposure to equity. The initial exposure to equity is explained by both the impact on promotional increases in early life (which gives some room for negative returns without causing the expected pension to decrease) and by the interest rate risk that is already present in early life (the marginal effect of extra equity risk being somewhat limited as there is already substantial background risk).

Figure 3 plots every simulated glidepath in a twodimensional space: the horizontal axis reports the economic **certainty equivalent pension**, while the vertical axis shows the behavioral **certainty equivalent pension**. The cloud of outcomes makes two unmistakable points:

Figure 3: Economic and behavioral certainty equivalents



Results of the glidepaths in terms of economic and behavioral certainty equivalent pensions for a participant who joins the pension fund at age 25 and retires at age 68. Efficient frontier in blue.

- **Many glidepaths are inefficient.**
  Most designs lie strictly southwest of the upper boundary and are dominated by others that deliver both a higher economic certainty equivalent and a higher behavioral certainty equivalent. These can be ruled out immediately.
- **A genuine tradeoff exists.**
  On the 'efficient frontier', moving towards the right (improving the economic certainty equivalent) requires accepting a lower behavioral certainty equivalent. In other words, smoother yeartoyear expectations come at the cost of a smaller pension, and vice versa.

With the economic and behavioral certainty equivalent pensions now defined, we can use them to show the trade-off between economic and behavioral welfare loss. Welfare loss is defined for a given glidepath as the difference between the respective certainty equivalent pension and that of the optimal glidepaths (as shown in Figure 2). This trade-off is presented in Figure 4.

Minimizing **behavioral** welfare loss (i.e., choosing the behavioral glidepath) reduces the **economic** certainty-equivalent pension by almost $12,000, whereas minimizing **economic** welfare loss reduces the **behavioral** certainty equivalent by about $3,000.

Selecting an efficient glidepath requires specifying a weighting function over economic and behavioral utility. As an illustration, we treat $1 of economic welfare loss as equivalent to $3 of behavioral welfare loss. This results in an optimal glidepath that has approximately equal economic and behavioral welfare loss. This glidepath – along with some other example glidepaths - is shown in Figure 5. Of course there are many different options for

Figure 4: Trade-off economic & behavioral welfare loss

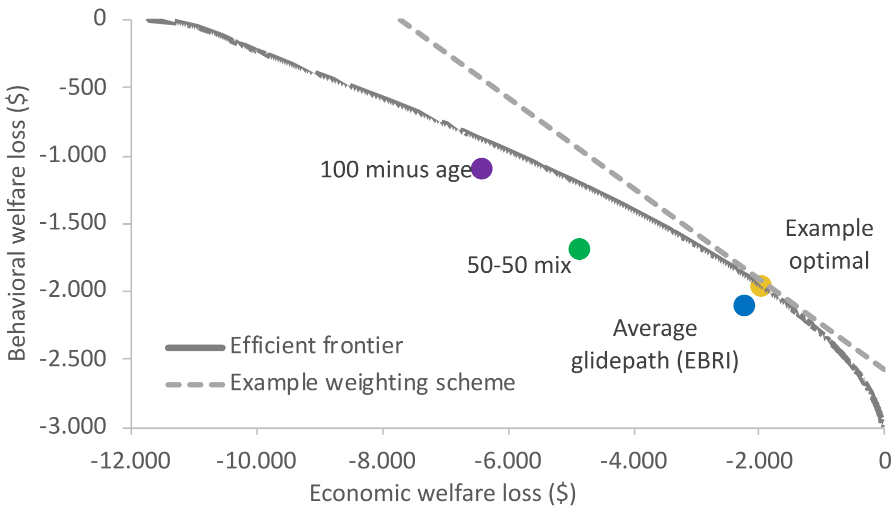
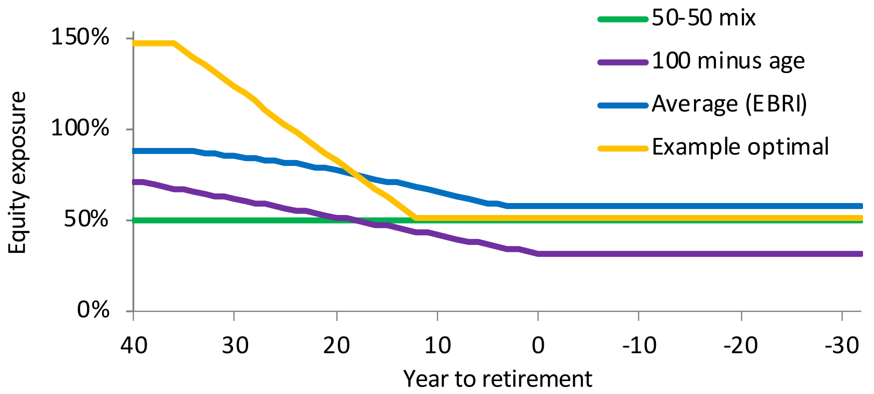


Figure 5: Example glidepaths



this weighting scheme; finding the weighting function that best represents participants' preferences would be an interesting avenue for future research.

Two observations stand out for the average glidepath based on EBRI data4, which is also plotted in Figure 4. First, the glidepath does seem to take both economic and behavioral utility into account, as it is not situated towards the rational economic optimum, nor towards the behavioral optimum. Second, the glidepath does not lie on the efficient frontier. Choosing a glidepath on the efficient frontier would reduce welfare loss by at least 10% under our model specification. A possible explanation for this inefficiency is that behavioral utility is considered, although not explicitly, resulting in an inefficient trade-off between both types of utility. Our approach, in which we explicitly calculate and weigh both types of utilities, could then substantially improve pension participants' welfare (be it economically or behaviorally).

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[4] The EBRI database – or any other database we are aware of – does not contain information about the average interest rate hedge for different age cohorts (or duration of the bond portfolio). Therefore, we use the same interest rate hedge glidepath as for all other glidepaths in our analysis.

4. Conclusion

While it may be rational for ‘homo economicus’ to consider only actual pension payments when optimizing an investment glidepath, most ‘homines sapientes’ will also pay close attention to yearly changes in their actual or expected pensions. We refer to this as path-sensitive behavioral utility, as opposed to economic utility, which is traditionally considered when looking at glidepath optimization. Our results indicate that behavioral utility helps explain the ‘glidepath puzzle’: real-world glidepaths contain far less risk than theory recommends for average risk aversion, especially in the accumulation phase. Although current glidepaths seem to accommodate behavioral concerns implicitly, they appear to do so in an inefficient manner. Explicitly weighing economic and behavioral preferences can lead to substantial welfare improvement. Based on our model assumptions, welfare gains of at least 10% are attainable if the average observed glidepath moves to the efficient frontier.

The optimal glidepath depends strongly on economic expectations (model specifications), the institutional setting and risk preferences, as well as a host of other assumptions. We have shown one example in this paper, but the framework of explicitly measuring and weighting behavioral utility alongside economic utility can be applied in any specific setting to design an optimal glidepath, leading to substantial welfare improvements – economic, behavioral, or even both.

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