

Vanguard's approach to target-date funds

- Target-date funds (TDFs) are designed to provide investors with a professionally diversified portfolio to achieve their retirement goals.
- Vanguard TDFs are constructed using fundamental investment principles to offer the best opportunity of delivering clients' desired retirement outcomes. We apply portfolio construction best practices that balance market, inflation, and longevity risks in an efficient and transparent manner over an investor's life cycle.
- This paper provides an overview of Vanguard's methodology for designing TDFs, including our approach to glide-path construction, asset-class diversification, demographic assumptions for our investor population, and how we measure glide-path effectiveness while staying focused on client outcomes.
- Vanguard TDFs serve a large and diverse population. They are regularly evaluated to ensure that they have a high likelihood of meeting the retirement income needs of these investors.

Authors



Ankul Daga,
CFA



Roger Aliaga-Díaz,
Ph.D.



Nathan Zahm,
FSA, CFA



Victor Zhu,
CFA, CAIA



Bryan Hassett,
CFA



Greg Banis,
CFA

Why target-date funds?

The use of target-date funds (TDFs) in employer-sponsored and individual retirement plans has expanded since the passing of the Pension Protection Act (PPA) in 2006—and for good reason. TDFs help investors construct well-diversified portfolios—critical to achieving retirement readiness—while simplifying the investment process. TDFs also provide a sensible default investment option that plan sponsors can use in conjunction with plan design strategies to improve participant portfolio diversification, enrollment, and savings rates.¹ TDFs are designed to help address a particular challenge facing many retirement investors: constructing a professionally built portfolio with a suitable amount of risky and defensive assets given their time horizon, retirement goals, and other considerations.

Vanguard research and other studies indicate that many investors lack either time for or interest in retirement planning.² TDFs address these challenges by simplifying the asset allocation decision. Once an investor decides to invest in a TDF (or is defaulted into one as part of their employer's retirement plan), subsequent decisions about portfolio construction and ongoing life-cycle rebalancing are handled by the fund's portfolio manager. Through design focused on retirement goals and removal of the burden of portfolio management, TDFs deliver a compelling single-fund option.

Principles guiding glide-path construction

Theory suggests that the mix between risky assets such as broadly diversified equities and more stable assets such as high-quality fixed income investments should evolve as one gets closer to retirement. This change in the portfolio's risky asset composition is called a glide path.

Downward-sloping glide paths are common in the industry and are suggested by many researchers as well (see Bodie, Merton, and Samuelson, 1992, and Gomes, Kotlikoff, and Viceira, 2008). However, debate about the shape of the glide path remains unsettled. Shiller (2005), Basu et al. (2013), Arnott (2012), and Arnott, Sherrerd, and Wu (2013) state that a rising glide path is better, while Pfau and Kitces (2014) argue for a U-shaped path, and Estrada (2016) recommends an inverted U-shape.

The investment case for Vanguard TDFs rests on two fundamental principles: that there are significant potential rewards for taking market risk, and that younger investors are better able to withstand that risk than older investors because a larger percentage of their total wealth is in human capital versus their financial holdings.

The expectation of an equity risk premium is justified by the historical premium equity investments have earned over bonds and the positive forward-looking outlook for corporate earnings in the long term.

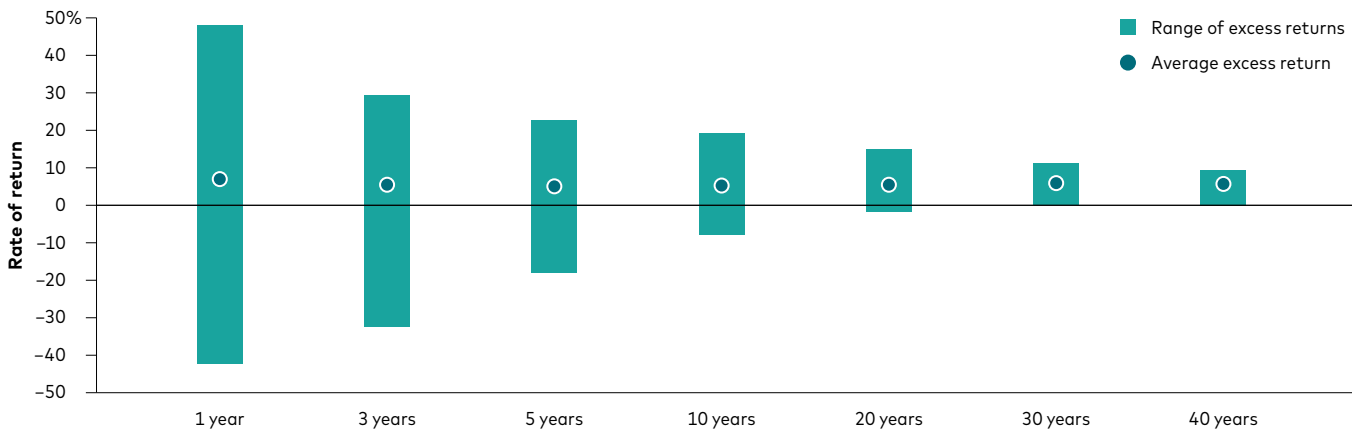
¹ See Vanguard Group (2018) for further information.

² For a more detailed discussion of these issues, see Young and Young (2018) and Choi et al. (2006).

In the past, stock market investors in many countries have been rewarded with such a premium. **Figure 1** shows historical returns for equities in excess of returns of nominal U.S. bonds over various time periods from 1926 through 2021. This indicates that stocks have provided higher average returns than bonds over all time horizons analyzed—albeit with a greater propensity to underperform by significant

amounts over shorter time frames. Historically, bond returns have lagged equity returns by about 4 to 5 percentage points, annualized—amounting to a sizable return differential in most circumstances over longer time periods. Consequently, retirement savers investing only in “safe” assets must dramatically increase their savings rates to compensate for lower expected returns.

FIGURE 1.
Historical equity risk premium over different time periods, 1926–2021



Notes: Past performance is no guarantee of future results. The performance of an index is not an exact representation of any particular investment, as you cannot invest directly in an index. U.S. stock market returns are represented by the Standard & Poor’s 90 from 1926 through March 3, 1957; the Standard & Poor’s 500 Index from March 4, 1957, through 1974; the Wilshire 5000 Index from 1975 through April 22, 2005; the MSCI US Broad Market Index from April 23, 2005, through June 2, 2013; and the CRSP US Total Market Index thereafter. U.S. bond market returns are represented by the Standard & Poor’s High Grade Corporate Index from 1926 through 1968, the Citigroup High Grade Index from 1969 through 1972, the Lehman Brothers U.S. Long Credit AA Index from 1973 through 1975, the Barclays U.S. Aggregate Bond Index from 1976 through 2009, and the Spliced Barclays U.S. Aggregate Float Adjusted Bond Index thereafter.

Sources: Vanguard calculations, based on data from Standard & Poor’s, Wilshire, MSCI, CRSP, Citigroup, and Barclays.

Additionally, stocks can be expected to outperform bonds in the future based on the positive long-term outlook for global corporate earnings. The fact that investors sometimes question this outlook because of the risk involved is precisely why stock investors should expect to earn higher average returns over the long run than those who choose less volatile investments.

The second strategic principle underlying Vanguard TDFs' construction is inspired by the human capital theory, which holds that younger investors are better able to withstand portfolio risk (see **Figure 2**). It recognizes that total net worth consists of both current financial holdings and future work earnings. Most of the younger individuals' wealth is in the form of what they will earn in the future. This human capital may be looked at as a more stable or bond-like asset, and therefore it may be appropriate for a younger person's portfolio to have a larger commitment to stocks to balance and diversify risk exposure to work-related earnings (Viceira, 2001; Cocco, Gomes, and Maenhout, 2005).

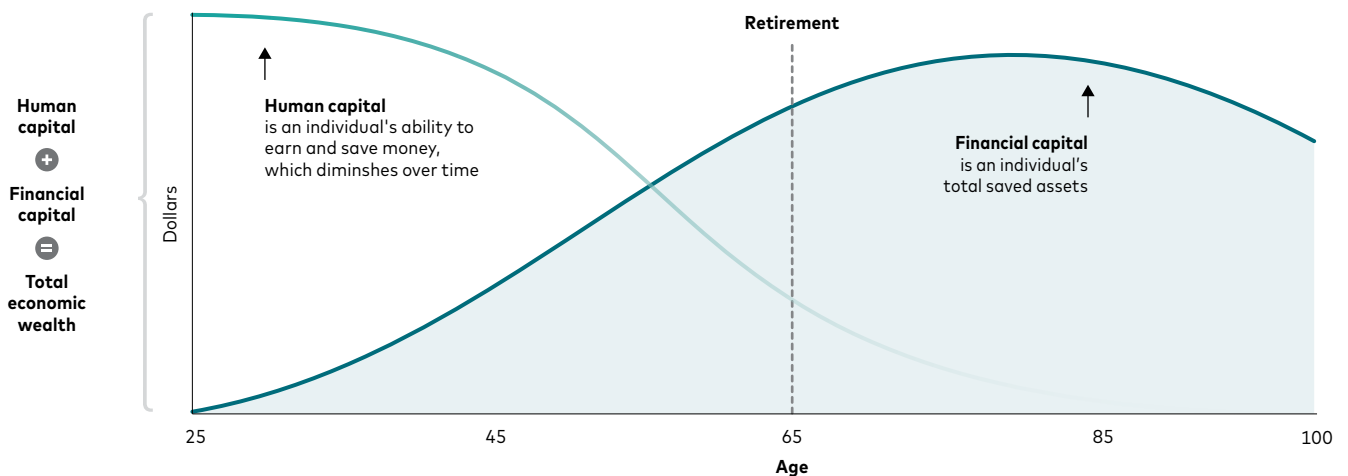
The human capital theory doesn't explicitly state how quickly or in what proportion equity exposure should diminish without the addition of a variety of assumptions and caveats. It does, however,

support the theoretical concept that equity allocations should decline with age to help manage risk through time. Widespread debate remains as to what level of equity exposure may be appropriate. There is no universally accepted optimal answer; ultimately, this is a fiduciary decision that sponsors offering TDFs must make for their participants and that individual investors must make for themselves.

While TDFs are not tailored at the individual level, Vanguard does consider investor behavior in its glide-path construction, as the ability to withstand market risk does not necessarily translate into the willingness to bear such risk. Put differently, the inevitable ups and downs in portfolio returns must be made tolerable to investors to ensure they don't flee the market in downturns—a step that would lower the chances of reaching their long-term financial objectives.

The remainder of the paper is divided into four sections. First, we describe our life-cycle investing framework. This is followed by a discussion of the Vanguard target-date glide path and its implementation. We then elaborate on a few practical case studies and conclude with insights drawn from the process.

FIGURE 2.
Human capital theory



Source: Vanguard.

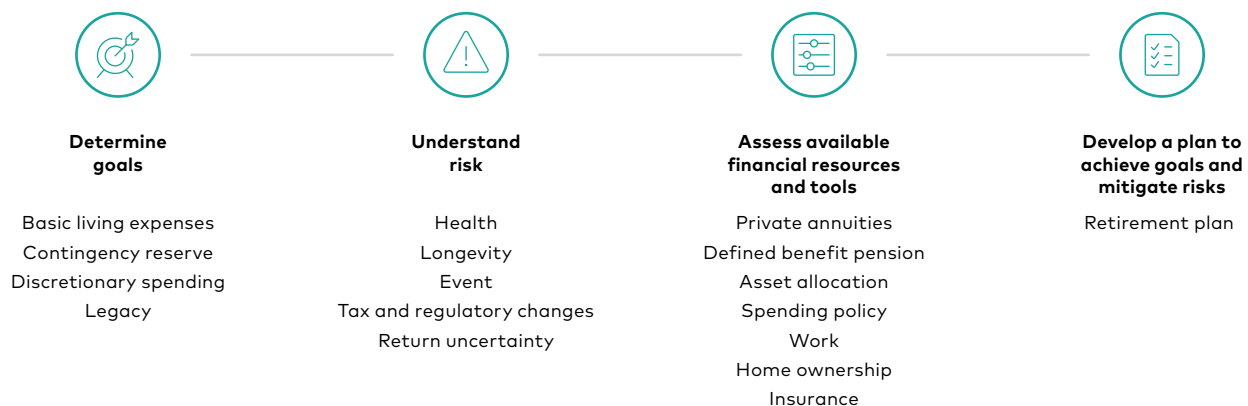
Vanguard's life-cycle investing framework

Most investors have multiple goals throughout their lifetime, each requiring them to make complex, interconnected decisions about saving, spending, and asset allocation. When it comes to retirement, it's not uncommon for some to depend on their TDF and Social Security to cover their basic living expenses. Others may be able to cover a portion of these expenses with guaranteed income they receive from a defined benefit (DB) plan, an annuity, or a similar product and use the TDF to support higher levels of discretionary spending or a bequest.

At Vanguard, we take stock of the range of these circumstances and the retirement ecosystem using the process shown in **Figure 3**. We developed this retirement planning process to assess how different goals, risks, and resources can lead to different asset allocation and spending strategies.³ It consists of four steps:

1. Determine goals
2. Understand risks
3. Assess available financial resources and tools
4. Develop a plan to achieve goals and mitigate risks

FIGURE 3.
Differences in goals, degrees of susceptibility to risk, and access to tools mean there's no single retirement income solution for all investors



Source: Vanguard.

3 See Vanguard Research (2021).

We then optimize the investment plan using a quantitative framework embodied by the Vanguard Life-Cycle Investing Model® (VLCM) shown in **Figure 4**.⁴ We generate an optimal glide path by assessing the trade-offs between the expected lifetime spending that can be funded from a glide path and the uncertainty of market risk to that spending. The model evaluates thousands of potential paths and selects the one that offers the best balance between amount and volatility of lifetime spending. It provides a rigorous framework for the construction of glide paths based on an investor's specific circumstances and goals.

Often, we find the spending and wealth objective will conflict with the stability objective because investments, such as equity, that are expected to provide higher wealth (supporting the spending objective) also come with more volatile periodic returns (subverting the stability objective). The VLCM strikes a balance by weighing and comparing each objective. It incorporates behavioral finance considerations in the form of income shortfall aversion (an investor's fear of income falling below a certain level) and loss aversion (an investor's distaste for return volatility, even if it doesn't affect their long-term outcome).

The Vanguard Life-Cycle Model captures three dimensions of utility

The Vanguard Life-Cycle Model incorporates investors' goals and fears through utility functions. These are a proven way to represent human behavior and decision making by capturing the asymmetric trade-offs between the positive feelings arising from a good outcome and the amplified negative feelings that accompany a bad one. The three types of goals and fears measured in our utility function include:

1. Risk aversion. This assesses how tolerant an investor is of uncertainty about their outcome. Investors highly tolerant of a wider range of retirement spending have low risk aversion,

whereas those who want less uncertainty even if it reduces their level of spending have high risk aversion.

2. Income shortfall aversion. This captures the pain felt by investors when their income falls below a certain threshold, such as basic living expenses—an important consideration in selecting a glide path.

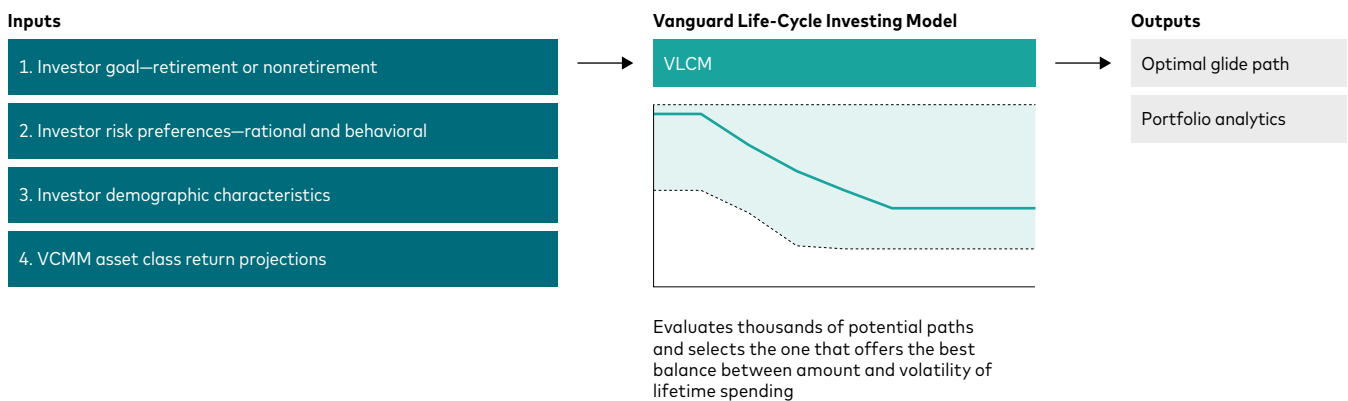
3. Myopic loss aversion. This indicates the higher sense of loss due to a negative return as compared to the sense of gain from a positive return. Because the VLCM applies a greater penalty for losses, the more loss-averse an investor is, the more the model will favor investment stability.

⁴ See Aliaga-Díaz et al. (2021) for more details.

Combined with long-term asset return expectations derived from the Vanguard Capital Markets Model (VCMM), the VLCM is a powerful simulation tool for developing retirement portfolios through evaluation of various market scenarios or changing economic conditions, calculating key metrics of investment success such as retirement income sufficiency, and the probability of meeting objectives.⁵ This makes it effective in understanding the trade-offs when making complex investment decisions, facilitating a deeper understanding of a TDF’s glide path and asset allocation.

The flexibility of the model allows us to solve for multiple goal definitions, different investor characteristics, and a full range of risk preferences. This can provide unique investment options tailored to a wide range of needs and circumstances. Along with selecting the optimal glide paths, the VLCM generates a comprehensive set of relevant portfolio metrics such as drawdown, distribution of wealth and consumption, and probability of successfully meeting an investor’s goals (as shown in **Figure 4**). It quantifies the value of different glide paths to a wide array of investor types and allows for a comparison of the incremental costs and benefits of different approaches.

FIGURE 4.
The VLCM framework



Note: See **Appendix 4** for full listing of capabilities.
Source: Vanguard.

⁵ See Vanguard Group (2015).

The Vanguard target-date glide path

Having established the case for a target-date fund, we use our VLCM framework to focus on the needs of our investors. Our utility-based framework selects the most useful glide path for individual investors aiming to financially secure their retirement goals. We seek to meet consumption levels to fund their retirement lifestyle while leaving some balance as a bequest to heirs. **Figure 5** shows the resultant glide path.

Target-date fund specification

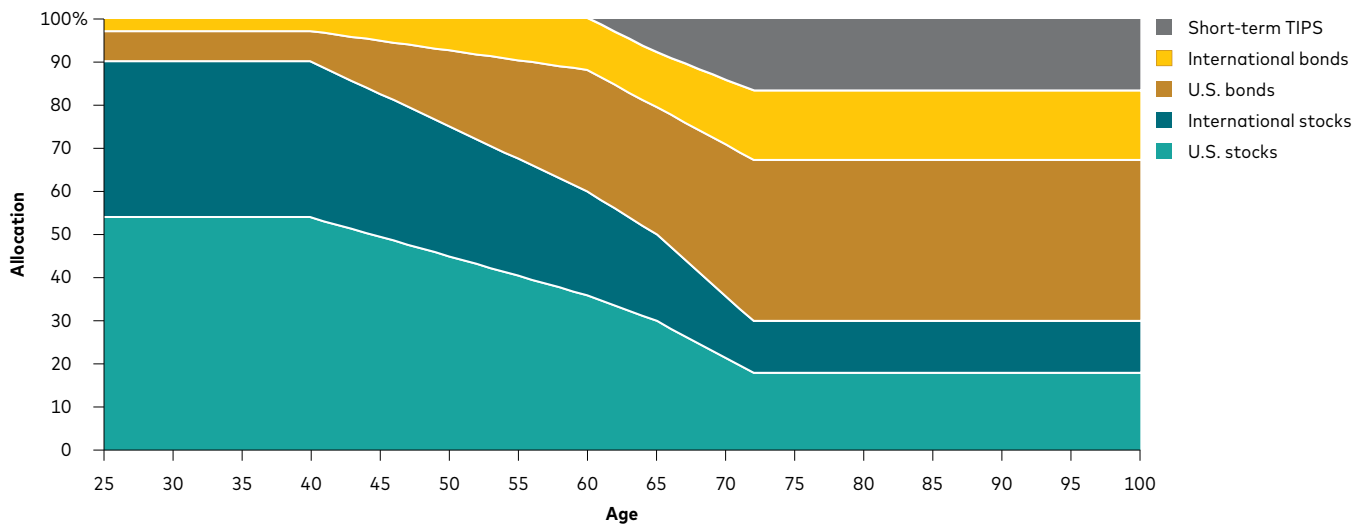
In selecting the glide path for Vanguard TDFs, the following assumptions are made for the baseline investor. They are meant to reflect the most generalized form of the TDF investor and specify a glide path that best fits our expected investor base.⁶

Assumptions for baseline investor

Starting age	25
Retirement age	65
Savings rate (as % of salary)	8.8%–12.0%
Starting real salary	\$52,000
Total replacement ratio	79%

This process results in a glide path that we consider to be most applicable for a wide percentage of the population that will look to invest in this option. Beyond the target age for retirement, we generally have limited actionable personal information for investors using a TDF, but we do know that our investor base largely consists of individuals with limited skill or interest in the asset allocation decision (“set it and forget it”). We can therefore think of them as less risk tolerant than the broader population and model the TDF glide path for more risk-averse investors seeking to maintain their lifestyle in retirement.

FIGURE 5.
Glide path for Vanguard target-date funds



Source: Vanguard.

⁶ See **Appendix 5** for a detailed investor profile.

Evaluating the benefit of TDFs

In evaluating the benefit that Vanguard TDFs provide, measures should be considered in the context of the funds' objectives. They are designed to support portfolio growth in accumulation, provide modest risk exposure to pre-retirees, and support a stable portfolio for sustainable withdrawals in retirement. Thus, metrics identifying the effectiveness of the TDFs should focus on long-term outcomes balancing risk and return over the lifetime of an investor instead of short-term performance in selective market conditions.

We can further extrapolate this principle to "real-world outcomes" that reflect the performance of a TDF. By modeling returns under different market scenarios, we calculate a distribution of outcomes related to the projected wealth and spending of our investor. On top of this, we layer expectations about an investor's earnings and replacement ratio, which determine retirement spending expectations. This then informs our calculation of the probability of success for said investor, for which we evaluate the likelihood that the spending supported by the TDF will match or exceed the investor's expected spending requirements in retirement.

Additionally, we quantify the benefits of an optimized glide path through the concept of a certainty fee equivalent (CFE) or "equivalence payment" calculated by the VLCM. This is the payment (an annual fee in basis points of the assets) that an investor would be willing to pay in order to be placed in one glide path over another. The higher the equivalence fee, the higher the benefit of the given glide path over another (the benefit of striking the right risk-return balance in context with the investor's goal). We use this metric to provide an additional frame of comparison for our TDFs with other potential glide-path options.

Implementation of TDFs

We adhere to a rigorous framework to quantitatively balance the risk and return trade-offs of multiple investment options for retirement goals. While this defines the glide path, additional points must be considered. We can broadly divide these into specifying the sub-asset allocation, framing our use of indexed investments, and contextualizing our focus on long-term outcomes.

Sub-asset allocation of the glide path

For broadly diversified, balanced portfolios such as the Vanguard TDFs, exposure to all key sub-asset classes allows the investor to participate in some of the stronger-performing sectors while mitigating the negative impact of weaker-performing ones.

The level and rate of change of equity exposure as the investor ages are the most recognizable components of risk in TDFs and their most significant drivers of long-term performance. However, over shorter periods, performance differentials can also stem from the portfolio's relative allocation to sub-asset classes within stocks and bonds. Plan sponsors and investors should be aware of the trade-offs associated with various sub-allocations in both the more risky (equity) and less risky (fixed income) asset classes.

Equity allocation (U.S. and international)

The equity allocation in the Vanguard TDF portfolios includes a market-cap-weighted exposure to the broad U.S. and non-U.S. stock markets. Because current prices (and, hence, company values) are set based on current and expected events, market-cap-weighted indexes represent the expected, theoretically mean-variance-efficient, portfolio of securities in an asset class (Rowley et al., 2018).

After the decision is made to invest globally, the next step is to determine an appropriate allocation between home country and global equity markets. The standard financial theory approach is to invest proportionally—whether globally or within a specific country or market—according to market capitalization. Our research has shown that allocations of 30% to 40% have provided more than 95% of the benefit of full market-cap diversification. Vanguard TDFs currently invest in a diversified equity portfolio with 60% of total equity exposure attributable to U.S. stocks and 40% to international stocks.

Fixed income allocation (U.S. and international)

We also follow a market-proportional approach in the U.S. bond market. We combine broad exposure to nominal U.S. investment-grade bonds with the safety and liquidity of government and short-duration bonds to provide diversification to the equity exposure. High-yield bonds are not included because they represent a small portion of the taxable U.S. bond market, and Vanguard research has shown that overweighting them compared to the market has increased average volatility and downside risk (if replacing investment-grade bond positions) or reduced average returns (if replacing equity positions) (Philips, 2013). U.S. investment-grade bonds represent 70% of Vanguard's TDF fixed income exposure.

The fixed income allocation also includes hedged exposure to broadly diversified international fixed income. Although risk factors such as interest rate fluctuations, inflation, economic cycles, and issues associated with changing or unstable

political regimes may seem worrisome to U.S. investors, a portfolio that includes the bonds of many countries and issuers benefits from imperfect correlations across those issuers. Vanguard's decision to hedge currency exposure significantly reduces the volatility of international fixed income returns by alleviating currency risk. Vanguard research suggests that a strategic allocation to hedged international bonds can further moderate risk in a diversified portfolio (Schlanger et al., 2018). Accordingly, this asset class represents 30% of Vanguard TDFs' fixed income exposure.

Short-term Treasury Inflation-Protected Securities (TIPS)

A downward-sloping glide path ensures that throughout their lifetime, investors will balance stability and growth. In most cases, their wages can be seen as a recurring bond coupon, providing stability. Hence, balance is achieved by changing the risk taken in their financial capital. Entering the retirement phase, the typical investor's human capital is much smaller than their financial capital. This would make it prudent to reduce their overall equity exposure. To mitigate exposure to short-term inflation shocks at the same time, we allocate an increasing proportion of bonds toward short-term TIPS, which have a much higher inflation beta than U.S. bonds, as shown in **Figure 6**. Inflation beta represents how reactive or variable the asset is to unexpected inflation. A well-correlated asset with high inflation beta can be a good choice to help secure spending from the portfolio.

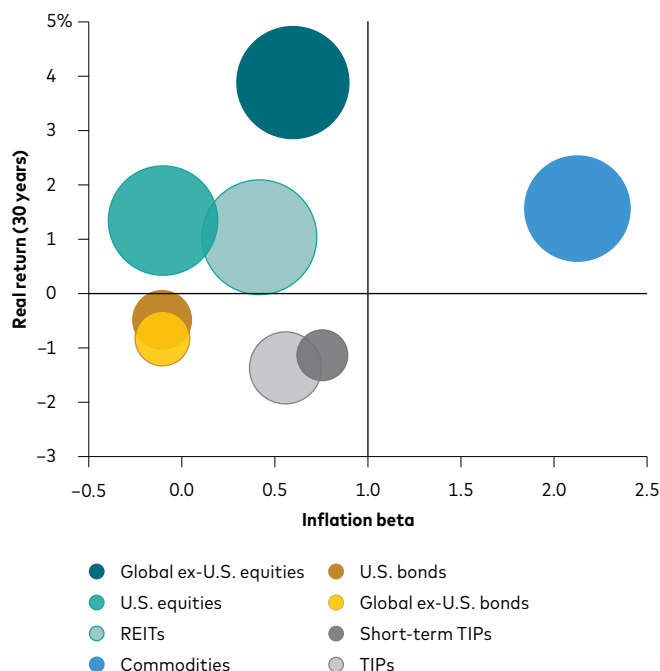
Commodities

While short-term TIPS and commodities have shown high correlation to inflation, commodities also offer a high beta related to inflation and thus will show the strongest reaction to changes in the inflationary environment. For investors seeking to meet the sole goal of inflation hedging in their portfolio, commodities may be a sound choice. During the accumulation phase, this inflation protection is provided by the equity allocation in the TDF. As the investor enters retirement, their human capital erodes, and they start making drawdowns from their retirement savings. This limits their ability to recover from market shocks. As TDFs reduce the equity allocation in favor of fixed income over time to mitigate this risk, they become exposed to inflation shocks. The most appropriate way to hedge the fixed income portion against inflation would be to reallocate assets to an investment that provides similar volatility while hedging against inflation.

We meet this need by using an asset class aligned to the investor's phase of life. While commodities can be effective in inflation hedging, they tend to be very volatile, as represented by the relatively large size of the bubble in Figure 6. and are unable to provide portfolio stability in the retirement phase. Short-term TIPS provide the most appropriate and effective inflation hedge for a TDF portfolio, as they provide a significant correlation to inflation without the volatility of a commodities investment.

FIGURE 6.

Vanguard projection: Inflation beta, real return, and volatility of asset class



Notes: The table compares real (inflation-adjusted) returns projections over the next 30 years to the inflation beta for various asset classes. Inflation beta is the linear regression coefficient between the 30-year inflation forecast and the 30-year portfolio return forecast. The size of the bubble represents the median annualized volatility. The indexes used are as follows: U.S. equities: MSCI US Broad Market Index, Global ex-U.S. equities: MSCI All Country World ex USA Index, U.S. bonds: Bloomberg U.S. Aggregate Bond Index, Global ex-U.S. bonds: Bloomberg Global Aggregate ex-USD Index, Commodities: Bloomberg Commodities Total Return Index, U.S. TIPS: Bloomberg U.S. Treasury Inflation Protected Securities Index, U.S. short-term TIPS: Bloomberg U.S. 1-5 Year Treasury Inflation Protected Securities Index, and U.S. REITs: FTSE/NAREIT US Real Estate Index.

Sources: Vanguard calculations as of March 31, 2022.

IMPORTANT: The projections and other information generated by the Vanguard Capital Markets Model®(VCMM) regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Distribution of return outcomes from VCMM are derived from 10,000 simulations for each modeled asset class. Simulations as of March 31, 2022. Results from the model may vary with each use and over time. For more information, please see Appendix 1.

Alternatives

Vanguard believes that there is a high hurdle for asset classes and investment strategies to be included in a TDF because of the portfolios' large, heterogeneous investor population and the vehicle's typical designation as a qualified default investment alternative. As TDF investors cannot express a personal preference for alternatives, inclusion would be purely at the fund manager's discretion. While use of these strategies may offer advantages, broadly speaking they can easily increase costs, introduce complexity, lower transparency, and reduce liquidity. As highlighted above, commodities have historically provided an effective hedge against inflation along with diversification benefits to global stock and bond portfolios despite high standalone volatility. However, funding a commodities allocation (at least in part from equities) would historically have generally resulted in lower wealth accumulation, higher fees, and greater complexity.

Debating indexed versus active investments

Discussions regarding the active/passive decision have recently become more commonplace among investors and investment professionals. Placing the decision within a quantitative framework (Aliaga-Díaz et al., 2020) personalizes it for an individual based on their particular aversion to active risk. If we consider the active/passive decision as being directly related to active risk aversion, active investment then becomes appropriate only if the investor demonstrates a requisite level of risk tolerance.

In constructing the Vanguard TDFs, we strongly believe in balancing the risks borne by investors with returns expectations that appropriately compensate for those risks, all within a solution encompassing the wide range of TDF investors. While active management does offer the opportunity to outperform the market, we consider the TDF investor base to have a high risk aversion and therefore an implied lack of active risk tolerance. Taking on active manager risk is a decision that investors should make on their own. Because indexed investing makes sense as a starting point for many investors, we build our default strategy for the broad TDF population with index funds.

Static optimization

At Vanguard, we appreciate that asset returns vary over the business cycle, and these changes in turn can have implications for portfolio construction.⁷ Forecasting future asset returns can be extremely difficult. We focus our TDFs on grounded, long-term expectations for asset returns, using a time horizon that reflects the entire lifetime of our investor—more than 80 years. Investors with an appetite for forecasting risk could use time-varying asset allocation to incorporate more short-term asset return expectations. In light of our risk-averse TDF population, we focus on strategic allocation changes as investors approach retirement age rather than reacting to the economic environment.

⁷ See Wallick et al. (2020).

Practical application of Vanguard's TDF approach

When constructing TDFs for a heterogeneous population, we focus on investors' ability to maintain their lifestyle post-retirement and assume they are moderately conservative.⁸ While this leads to a glide path with modest growth potential, the reduced exposure to risky assets is also more likely to have a stable return pattern and therefore be more appropriate for a wider swath of investors.

In this section, we look at TDFs in the context of different lifestyle needs, analyze the impact of guaranteed income, and then stress-test our archetype. We review the optimal glide paths for a range of personas with different risk preferences, lifestyle needs, sources of income, and timing of retirement. This allows us to examine the sufficiency of our investor

assumptions and further informs our TDF glide path. We also quantify the impact of these variables in terms of CFEs.

Evaluating TDFs' sufficiency for supporting different lifestyles in retirement

While a TDF is typically a "one-size-fits-all" type of investment, we would not consider the retirement investor population to be "one size." Many investors will be expected to fall, in some way, outside the categorization we specify for our main TDF archetype.⁹ We acknowledge this but still find the Vanguard TDFs highly suitable in aggregate. However, investors may strive to achieve other retirement lifestyles that could potentially push the bounds of suitability. Using our VLCM framework, we can compare the Vanguard TDFs to the glide-path results of three main investor personas: Maintaining lifestyle, Enhancing lifestyle, and Prioritizing legacy.

FIGURE 7.
Different lifestyle personas in retirement

Investor persona	Spending rule	Spending level	Income shortfall aversion
Maintaining lifestyle	Fixed real dollar	79% of final salary	None
Enhancing lifestyle	Percentage of portfolio	6% increasing with age	Yes
Prioritizing legacy	Required minimum distribution (RMD)	Maximum (6% of portfolio or RMD)	Yes

Source: Vanguard.

⁸ See Vanguard Group (2021b).

⁹ See **Appendix 5** for baseline TDF assumptions.

Maintaining lifestyle

This persona's goal is consistent with that of most TDFs: to replace a reasonable portion of pre-retirement income. In our modeling, we assume that a TDF, combined with Social Security, can help clients replace 79% of their pre-retirement income to cover basic living expenses (assumed to be around 60% to 70% of pre-retirement income) and some discretionary spending. Clients in this category have a high probability of meeting their basic living expenses, limited capacity to fund discretionary spending, and no plans to leave a legacy.

Enhancing lifestyle

The second persona calls for a level of retirement spending greater than 79% of pre-retirement income. We assume that this client has additional

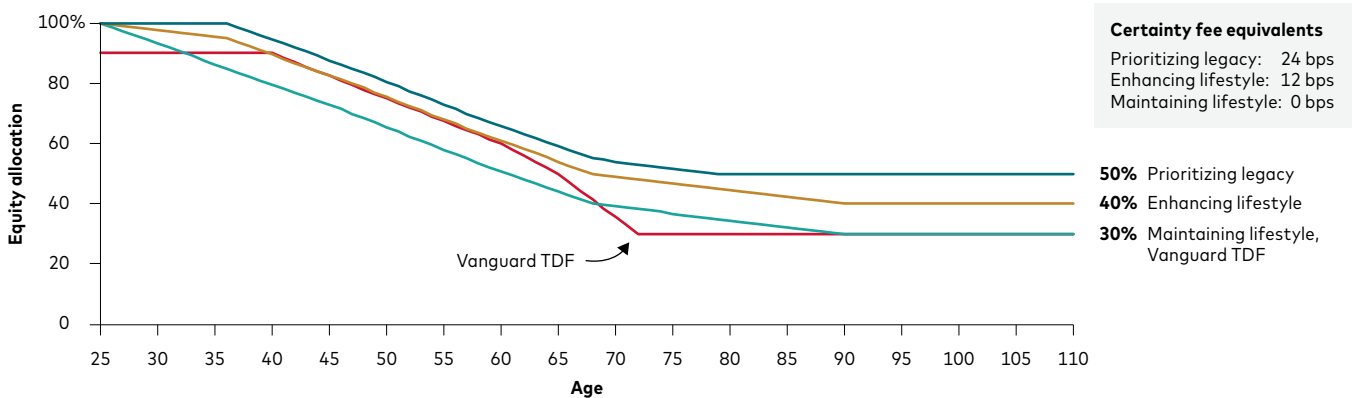
sources of assets or income that enable them to accept more risk with their retirement savings in pursuit of a higher total level of spending.

Prioritizing legacy

The third persona's goal is leaving a legacy. Spending levels are the same as those supported by the Enhancing lifestyle glide path. Again, clients must be willing to accept more risk in meeting their basic living expenses from the TDF. In this simulation, we use an additional coefficient in the VLCM utility function, allowing us to assign a higher importance to the satisfaction delivered by a bequest.

We then generate a glide path for each goal (see **Figure 8**). We also show the certainty fee equivalents relative to the Maintain lifestyle glide path, our base case TDF investor.

FIGURE 8.
Different glide paths for different personas



Source: Vanguard.

We find the TDF glide path is highly appropriate for the Maintaining lifestyle investor and moderately so for the Enhancing lifestyle investor (with potential customization value). We find some excess value in customization for investors who seek to prioritize legacy, a sensible outcome of additional focus on the bequest motive. Because TDFs focus more on the consumption motive, investors (likely with higher net worth) with a bequest motive could find some value in a customized or advised solution in place of a Vanguard TDF. However, we would expect this segment to be outside of our target investor group.

Presence of a guarantee: Factoring in defined benefit income (or pension)

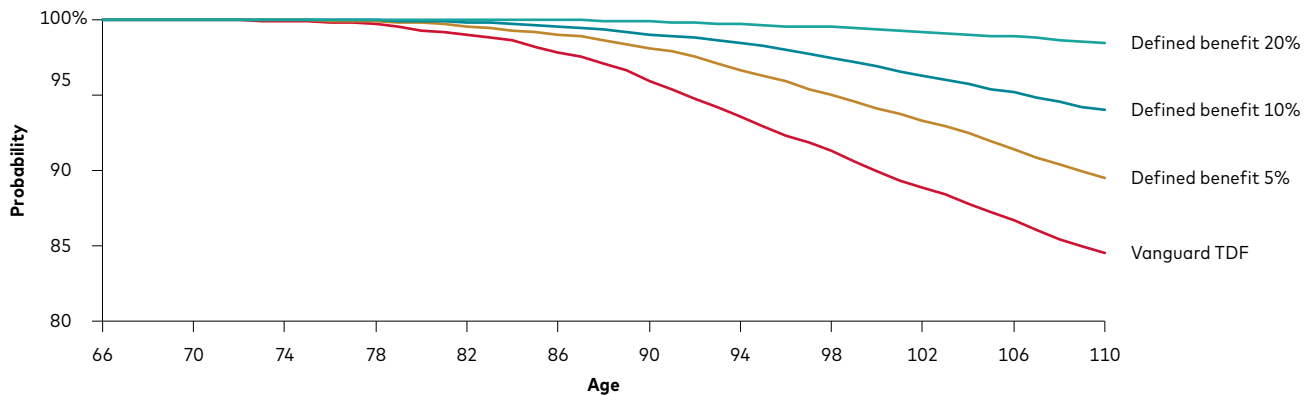
When formulating a holistic financial plan, an investor’s retirement spending goal should be considered in its entirety, including all sources of expected funding and lifestyle needs. While the retirement portfolio is a significant funding source for this objective, alternative sources are not just typical but expected.

In determining a glide-path recommendation, the VLCM incorporates the expectation that Vanguard TDF investors will draw upon Social Security income (SSI) as an additional source of funding. Though this conforms to our expectation for the target TDF population, certain alternative funding sources such as defined benefit income (DBI or pension) may also be used to supplement retirement savings. While planning for the receipt of DBI is an incredibly important part of a financial plan, when we use the VLCM framework to quantify its value in selecting a glide path, we find that a Vanguard TDF is still a robust and applicable option for most investors.

Maintaining lifestyle

An investor looking to maintain their lifestyle is more concerned about running out of money in retirement than increasing their level of spending. Access to a pension on top of existing SSI results in a predictable boost to the chances that an investor will achieve their spending needs, as shown in **Figure 9**.

FIGURE 9.
Probability of meeting spending needs at specific ages in retirement



Source: Vanguard.

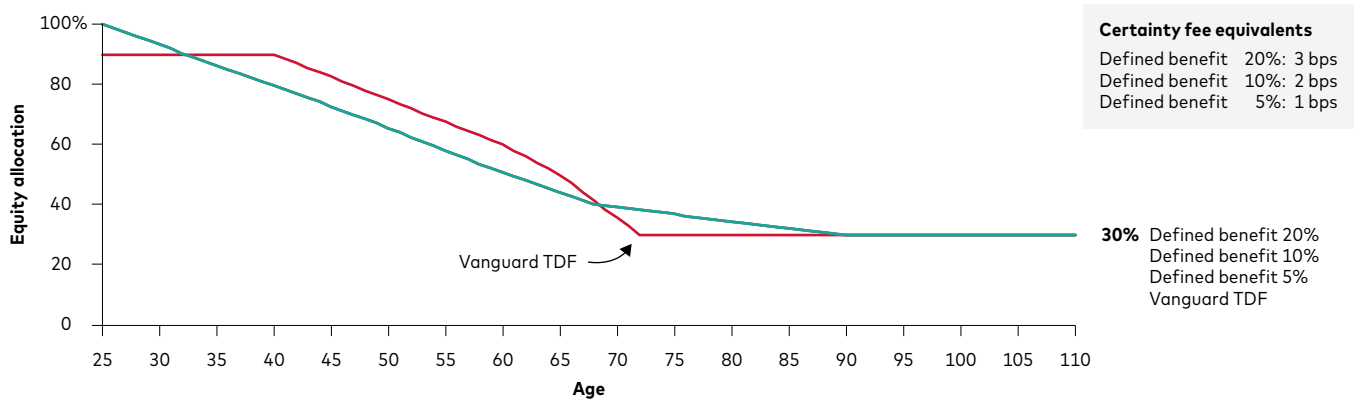
While there is a marginal impact on the investor's optimal asset allocation strategy (as shown in **Figure 10**), the quantified value of that impact is relatively low, ranging from 1 basis point to 3 basis points. We find the optimal asset allocation to be the same for all investors with pension income regardless of the level of that income.

We do, though, see increases in CFE as the level increases. Because pension income increases success rates, the optimal asset allocation as compared to our TDF more effectively mutes the downside impact in the remaining failure scenarios.

Enhancing lifestyle

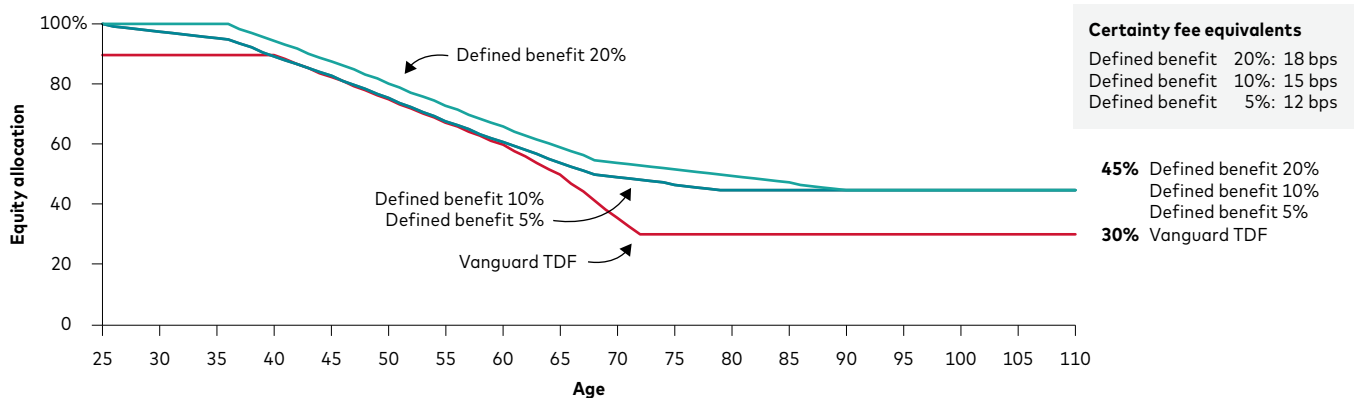
For investors looking to enhance their lifestyle, the pension alongside SSI can provide security from adverse market outcomes (see **Figure 11**). Compared to the TDFs, a customized glide path allows them to improve their level of spending further through additional risk taking. Since they are spending a percentage of their portfolio each year, the pension boosts their minimum level above SSI and improves their chances of drawing an income much higher than the 79% replacement ratio. Investors in this circumstance are not considered part of our main distribution and could likely benefit from an advised relationship including a holistic financial plan.

FIGURE 10.
Maintaining lifestyle with different levels of DBI (or pension)



Source: Vanguard.

FIGURE 11.
Enhancing lifestyle with different levels of DBI (or pension)



Source: Vanguard.

Investor permutations: Stress-testing the TDF archetype

After defining the archetype that underlies the TDF portfolio, we stress-test the assumptions underlying the archetype in isolation. We then show their impact on the glide path and on investor welfare by measuring CFE against the Vanguard TDFs. In most cases, we find that a TDF is largely sufficient to meet investor needs, except in the case of significant divergence. To accommodate for unique personal circumstances, investors may benefit from financial advice.

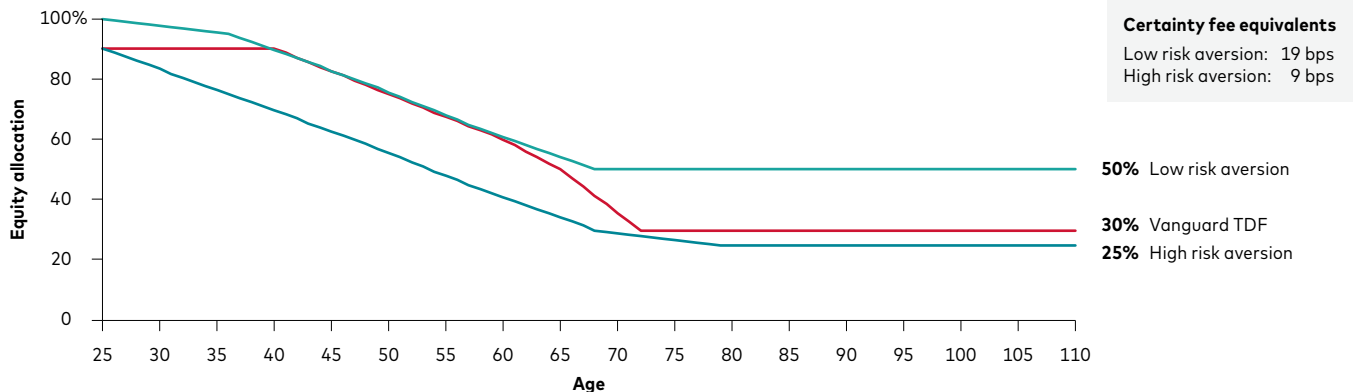
Risk aversion

Risk aversion can be defined as aversion to the uncertainty of outcomes. A risk-averse investor dislikes uncertain outcomes and prefers a degree of certainty. An investor with low risk aversion would tolerate uncertainty for a potentially better outcome, whereas someone with high risk aversion would seek to reduce uncertainty and be satisfied with modest outcomes. Consequently, if an investor's risk aversion increases, the risk (or equity level) in their glide path should decrease.

One of the main advantages of a life-cycle framework based on utility theory is that it explicitly accounts for an investor's risk preference or risk aversion. Risk aversion helps us balance the growth from risky assets with diversification from more stable ones for the investor focused on a retirement spending goal. Using CFE, we can quantify the value of a customized glide path to investors exhibiting various levels of risk aversion.

Figure 12 shows two hypothetical investor profiles, high and low risk aversion, that differ from the level used by the TDFs. As the CFE metrics demonstrate, the TDFs are most closely aligned with an investor who exhibits a normal risk aversion with a conservative skew. This can be seen in the slightly higher CFE for the low-risk-aversion investor as compared to the high-risk-aversion investor. While an investor with low risk aversion sees some additional CFE benefit, this can largely be attributed to the deviation in glide-path allocations in retirement (50% equity versus 30% equity). An investor in either circumstance may find value in financial advice at the pre-retiree or retirement phase of their investment horizon in order to optimize both their asset allocation and financial plan.

FIGURE 12.
Impact of risk aversion



Source: Vanguard.

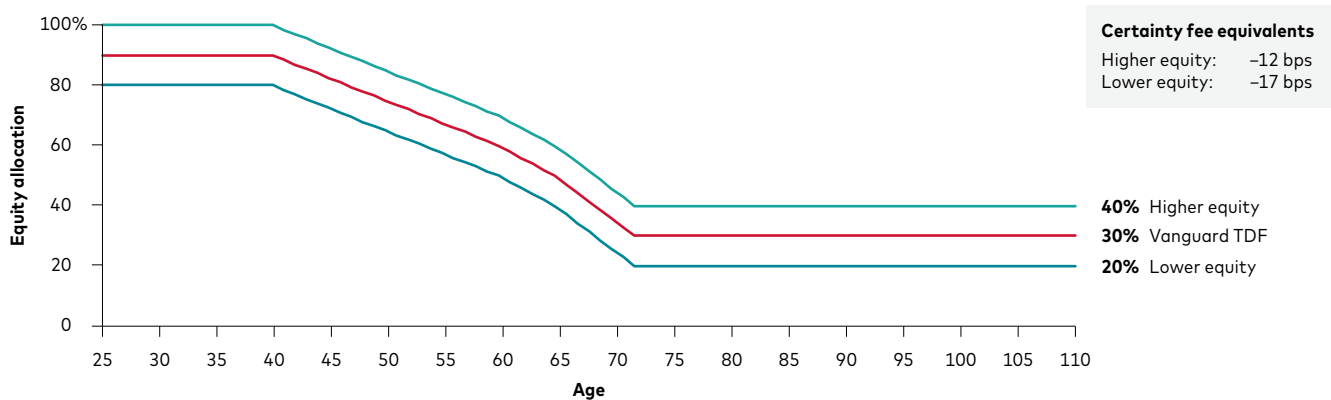
Impact of higher or lower equity allocation over the investor's lifetime

Recommendations regarding an appropriate level of equity for the TDF investor will differ among providers. To test the level recommended by the Vanguard TDFs, we compare alternative options with uniformly higher or lower levels and determine their standing in relation to ours. Specifically, we review options with a uniform 10% increase and a 10% decrease in equity versus the glide path.

As shown in **Figure 13**, the higher-equity glide path provides higher returns over time, and the lower-equity path provides increased stability over an 85-year period as compared to the optimal glide path. However, the Vanguard TDFs

exhibit 12- and 17-basis-point CFE values when compared to the higher-equity and lower-equity glide paths, respectively. The wealth and consumption profile generated by the Vanguard TDFs is better suited to the risk profile of the investor than either the riskier or more conservative glide paths shown. The higher-equity path offers higher returns over time but exposes the investor to larger fluctuations, which risk the investor abandoning the plan altogether. Conversely, the lower-equity path better maintains stability but comes with lower return expectations. These paths reduce the ability of the investor to meet their income target in later life. Our TDF glide path is most aligned with the investor's selected risk preferences.

FIGURE 13.
Glide path for higher and lower equity allocation



Source: Vanguard.

Early or late retirement

A key consideration in designing a glide path to support a retirement spending goal is to align it with the investor's retirement date and age. Those who retire early will depend on their portfolio to fund their spending needs for a longer time, while those who defer retirement will have a longer time to accumulate wealth. The VLCM considers retirement age an essential input into its modeling of investor behavior, and optimal glide paths can pivot on this.

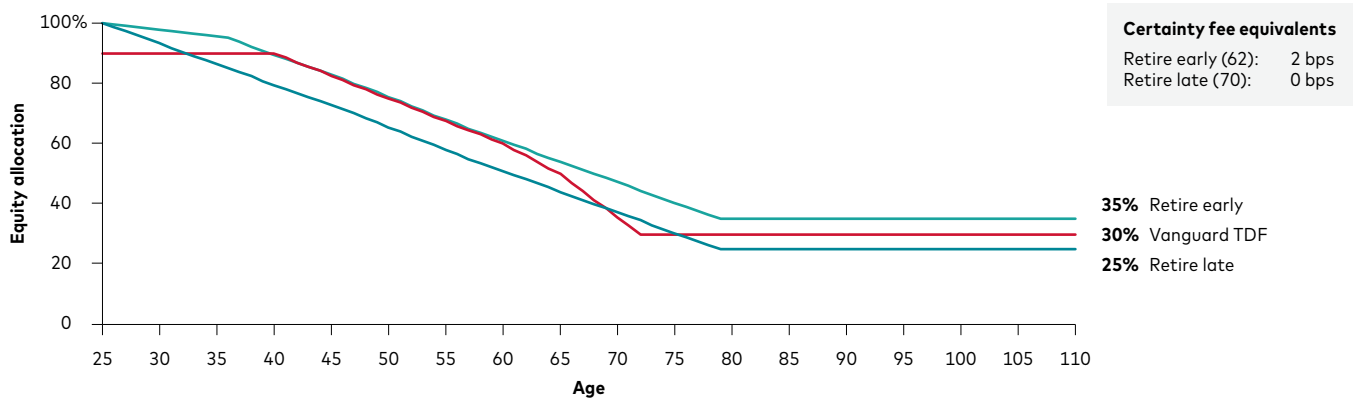
The baseline retirement age of the hypothetical investor in our TDF is 65, broadly representative of the TDF investor population. However, predicting a precise retirement age in early to mid-working life can be tricky. Thankfully, our findings provide some comfort. Our analysis in **Figure 14** shows a range of optimal glide paths corresponding to the age of retirement.

In preparing this analysis, we consider that the amount of Social Security income will likely be lower for those who retire earlier and higher for those who retire later. For those retiring early (at age 62), we observe a steeper change in glide path than that of our TDFs, but the CFE remains low. On the other hand, for those retiring later (at age 70), the change is marginal.

For those seeking to retire before age 62, the benefits of a customized glide path increase as retirement age decreases. They are likely to not receive full Social Security as they enter retirement, which would be a significant burden on their financial resources. We would consider such early retirees to be outside of the primary audience of the TDFs, and they may see benefits from financial advice.

Given the likely lack of prevalence of early retirement planning among TDF investors, our current recommendation aligns with the typical allocations of our expected investor base.

FIGURE 14.
Glide path for those retiring earlier or later than age 65



Source: Vanguard.

Spending target in focus: Varying the replacement ratio

Determining the level of spending for an investor is a key step in planning for a successful retirement. The primary objective of a retirement spending portfolio is to support the investor's objective. Within the VLCM, we can specify the level of this objective through the use of an appropriate replacement ratio (RR, or retirement spending as a percent of final salary) assumption (see **Figure 15**).

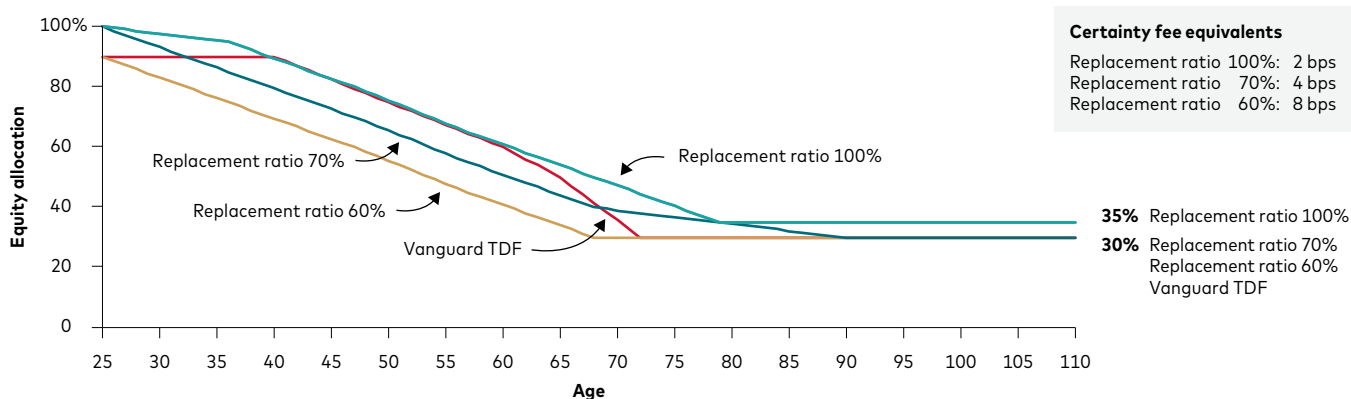
The Vanguard TDFs assume that investors will seek to replace approximately 79% of pre-retirement income with spending when in retirement. While we have confidence that this reflects a broad segment of our TDF investor population, the assumption is certainly not a panacea, and some variation is expected. An investor may have a higher spending level from items such as funding a college goal for a child or covering an expanded travel budget to explore the globe. Conversely, an investor may have lower

required spending, potentially having fully paid their mortgage or perhaps having moved to an area with a lower cost of living.

Investors with replacement ratios less than or above our baseline 79% will require lower or higher amounts of spending from their retirement portfolio. While this impact is intuitive, whether a Vanguard TDF remains an appropriate asset allocation for that investor is less certain. We choose to determine the impact of diverging from our Vanguard TDFs by evaluating the CFE, glide-path allocations, and success rates of alternative variations of spending ratio.

Using our CFE analysis as an initial review, we find the Vanguard TDFs highly suitable for investors with non-standard replacement ratios. We find only marginal CFE value with an increase in replacement ratio from 79% to 100% (increasing the spending goal by one-quarter). On the other side of the ledger, some limited to moderate customization benefit would arise from specifying a glide path for investors who expect a significant spending reduction in retirement.

FIGURE 15.
Glide paths for retiring with different levels of spending



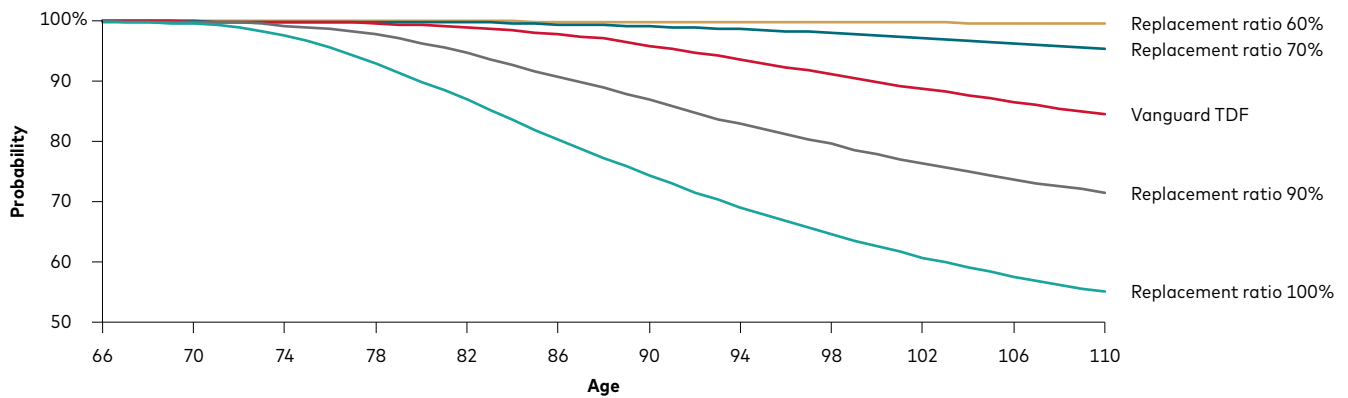
Source: Vanguard.

When this analysis is reframed to compare the allocations of the Vanguard TDFs to the VLCM selected glide path in each scenario (see **Figure 16**), we find that the glide path for the 60% replacement ratio takes a consistently more conservative tack than the TDFs. Conversely, the glide path for the 100% replacement ratio takes a more aggressive tack through most of the investor's lifetime to account for the higher spending need. Glide paths for other levels of replacement ratio display substantial similarity to the TDFs in terms of aggregate equity level.

While there are differences at specific points, on average each is within 5% of the equity allocation of the TDFs.

In further reviewing the expected success rate for each of the specified replacement ratios, we find that the differences follow an expected pattern: Individuals with higher replacement ratios experience lower success rates, and vice-versa. As evidenced by the glide-path summary, the differences result in some recommendations for glide-path changes. However, the Vanguard TDFs remain suitable for these replacement ratios.

FIGURE 16.
Probability of meeting spending needs at specific ages in retirement



Source: Vanguard.

Conclusion: Holistic considerations

Research indicates that many investors lack time for or interest in retirement planning.¹⁰ This highlights simplicity, transparency, and low cost as key principles when designing default investment options. Our TDFs assume a moderately conservative risk tolerance and seek to help investors maintain their lifestyle in retirement even when no information other than a target retirement date is available. An investor who selects a TDF receives a broadly diversified, professionally managed portfolio that reflects best practices in life-cycle investing theory.

The fund manager assumes all investment management responsibility, including fund selection, portfolio rebalancing, and the portfolio's transition from a growth orientation toward an increasingly conservative asset allocation as the retirement date nears. All current and future allocations are known in advance in the form of a glide path that spans a lifetime. Rebalancing rules are simple and constant throughout.

The lower your costs, the greater your share of an investment's return. By allocating assets to Vanguard target date funds, investors are well-positioned to benefit from quality funds at a low cost.

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¹⁰ For a more detailed discussion of these issues, see Young and Young (2018) and Choi et al. (2006).

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Appendix 1.

Asset returns: Vanguard Capital Markets Model

IMPORTANT: The projections and other information generated by the Vanguard Capital Markets Model regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. VCMM results will vary with each use and over time.

The VCMM projections are based on a statistical analysis of historical data. Future returns may behave differently from the historical patterns captured in the VCMM. More important, the VCMM may be underestimating extreme negative scenarios unobserved in the historical period on which the model estimation is based.

The VCMM is a proprietary financial simulation tool developed and maintained by Vanguard's Investment Strategy Group. The model forecasts distributions of future returns for a wide array of broad asset classes. Those asset classes include U.S. and international equity markets, several maturities of the U.S. Treasury and corporate fixed income markets, international fixed income markets, U.S. money markets, commodities, and certain alternative investment strategies. The theoretical and empirical foundation for the Vanguard Capital Markets Model is that the returns of various asset classes reflect the compensation investors require for bearing different types of systematic risk (beta).

At the core of the model are estimates of the dynamic statistical relationship between risk factors and asset returns, obtained from statistical analysis based on available monthly

financial and economic data. Using a system of estimated equations, the model then applies a Monte Carlo simulation method to project the estimated interrelationships among risk factors and asset classes as well as uncertainty and randomness over time. The model generates a large set of simulated outcomes for each asset class over several time horizons. Forecasts are obtained by computing measures of central tendency in these simulations. Results produced by the tool will vary with each use and over time. The asset-return distributions shown in this paper are drawn from 10,000 VCMM simulations based on market data and other information available as of March 31, 2022. The model uses index returns, without any fees or expenses, to represent asset classes. Taxes are not factored into the analysis. See the research paper Vanguard Global Capital Markets Model (Davis et al., 2014) for further details.

Appendix 2.

FIGURE A-2.
Annualized forward-looking long-run return expectations

	Median return	Standard deviation
Domestic equity	8.3%	18.6%
U.S. nominal bonds	4.5%	5.4%
Inflation	2.0%	3.0%
International equity	9.1%	19.4%
International bonds	4.3%	4.6%
Short-term TIPS	2.9%	4.2%

Note: TIPS = Treasury Inflation-Protected Securities.

Source: Vanguard.

Appendix 3.

FIGURE A-3.
Projected 70-year asset-class correlations

	Domestic equity	U.S. nominal bonds	Inflation	International equity	International bonds	Short-term TIPS
Domestic equity	1.0					
U.S. nominal bonds	-0.2	1.0				
Inflation	0.1	0.1	1.0			
International equity	0.7	-0.3	0.0	1.0		
International bonds	-0.1	0.6	0.1	-0.2	1.0	
Short-term TIPS	-0.1	0.7	0.7	-0.2	0.5	1.0

Note: TIPS = Treasury Inflation-Protected Securities.

Source: Vanguard.

Appendix 4.

FIGURE A-4.
The VLCM process

Inputs	Vanguard Life-Cycle Model	Outputs
<p>Investor circumstances for retirement</p> <ul style="list-style-type: none"> • Savings rate • Compensation • Defined benefits • Social Security • Starting age • Spending strategy • Retirement age • Employee contributions • Wage growth • Industry-based wage growth • Replacement ratio • Mortality rate • Annuity • Social Security withdrawal age • External cash flows <hr/> <p>Investor circumstances for nonretirement</p> <ul style="list-style-type: none"> • Initial capital • Accumulation time horizon • Decumulation time horizon • Contribution rate <hr/> <p>Behavioral preferences</p> <ul style="list-style-type: none"> • Myopic loss aversion sensitivity • Income shortfall aversion sensitivity <hr/> <p>Rational preferences</p> <ul style="list-style-type: none"> • Risk aversion • Preferences toward timing of consumption <hr/> <p>VCMM asset class return projections</p> <ul style="list-style-type: none"> • Domestic market equity • International equity • Domestic market fixed income • International fixed income • Inflation-linked bonds (short, intermediate, broad) • Government bonds (short, intermediate, long, broad) • Commodities • Inflation • Cash 	<p>Evaluates thousands of potential paths and selects the one that offers the best balance between amount and volatility of lifetime spending</p>	<p>Custom glide path</p> <hr/> <p>Portfolio analytics</p> <ul style="list-style-type: none"> • Simulated wealth distributions through time • Simulated consumption distributions through time • Risk metrics such as portfolio return volatility, consumption volatility, and wealth volatility • Probability of success, given a goal • Potential benefit of customization (certainty fee equivalent)—quantifies the benefit of a custom glide path versus an alternative glide path in units of expense ratio or fee

Source: Vanguard.

Appendix 5.

Below are a set of assumptions used in the VLCM to select optimal glide paths. We used them to validate our TDFs according to a set of calibrated parameters.

FIGURE A-5.

Inputs to Vanguard life-cycle model

Input	Assumption	Notes
Starting age	25	
Horizon age	111	
Retirement age	65	
Social Security withdrawal age	65	
Savings rate (as % of salary)	8.8%–12.0%	Saving rate increases over time because of the expectation of savings escalation for retirement plan enrollees as the investor approaches their retirement date
Starting real salary	\$52,000	For investor in the workforce at age 25
Ending real salary	\$75,000	For investor starting at age 25 and retiring at age 65. We add productivity growth and inflation to this over time
Wage scale	Social Security Administration Average Wage Index	
Total replacement ratio	79%	For ending salary of \$75,000 and savings rate of 15%. Single earner – RR = 79%*
Social Security replacement ratio	37%	Based on real monthly Social Security benefit estimates for ending salary of about \$75,000 and savings rate of 15%. Single earner – SS RR = 37%
DB replacement ratio	None (0%)	
TDF replacement ratio	42%	Total replacement ratio - Social Security replacement ratio - DB replacement ratio
Spending rule	Fixed real dollar with sustainability adjustment	Withdrawal amounts bounded on higher end by replacement ratio and on lower end by determining sustainable withdrawal amount given years of spending the portfolio is expected to support

* Source: Lobel, Jaconetti, and Cuff (2019).

Wage scale

Investor salary growth is modeled after the U.S. Social Security Administration's Average Wage Index. The index is based on reported wages across workers' age spectrum 25–65 for low-, medium-, and high-income earners. This allows us to trace the earnings progression of an average earner over a 40-year working career, accounting for factors such as career development. As modeled, the average participant reaches a peak salary at age 55 (in real terms) and experiences a decline in real salary through the age of 65. In our life-cycle simulations, we also allow for 1.1% annual salary growth, on a real basis, in addition to the cross-sectional increase in the wage scale, which reflects the historical average productivity growth of the U.S. economy.

Contribution rates

Age-specific contribution rates are derived from How America Saves 2018 (The Vanguard Group, 2018), a report surveying the 4.9 million participants served by Vanguard's recordkeeping business. Contribution patterns account for the likelihood that investors will start with a lower savings rate in their early working years and increase their contributions as retirement approaches. Contributions start at approximately

5% at age 25 and increase to approximately 10% at age 65. In addition, the simulations include a company match of \$0.50 per dollar up to 3% of salary, which is consistent with industry averages.

Replacement ratios and drawdown scenarios

We follow industry convention in assuming that retirees will spend a percentage of their age-65 salary every year in retirement from a combination of Social Security benefits and investment income from private sources. In our baseline analysis, the replacement ratio assumption (as a percentage of age-65 salary) is consistent with retirees' maintaining the same standard of living enjoyed during their final working years. Replacement ratios vary by income level, as Social Security makes up a smaller percentage at larger salaries. Vanguard draws on the work of Aon Consulting (with data taken from the U.S. Bureau of Labor Statistics 2021 Consumer Expenditure Survey) to assign appropriate replacement ratios based on retirees' age-65 income. Additional analyses are included in this study as a stress case that assumes 25% higher spending needs than the baseline assumptions from Aon Consulting.

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