Vanguard research

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A novel approach to financial planning using Vanguard Financial Advice Model (VFAM)

- In this paper, we introduce Vanguard Financial Advice Model (VFAM), a proprietary model that can evaluate multiple financial strategies simultaneously to make optimal financial planning decisions.
- For a financial planning model to truly support optimal decisions, it needs to be able to evaluate multiple strategies simultaneously, incorporate granular tax lot accounting, and account for uncertain future economic conditions and variable life expectancy. Developed to take into account all of these dimensions, VFAM uses life-cycle modeling and expected utility to evaluate financial planning strategies.
- Rather than just provide users with a recommended financial plan, VFAM quantifies multiple integrated strategies and ranks them by degree of potential added value relative to a user's current financial planning approach.

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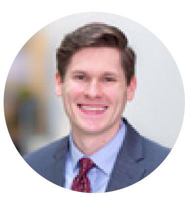
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Introduction

Investors have an almost unlimited number of financial planning strategies at their disposal to help them meet their goals. Winnowing down these strategies to an optimal one is a major challenge, especially since many factors, both internal and external, influence what an optimal plan might be for an investor. These factors include the investor's personal circumstances, taxes and tax laws, uncertain economic conditions, and the inherent uncertainty around household compositions and life spans.

VFAM aims to address many of these challenges. It uses distributional forecasts of capital market returns and life expectancy, life-cycle modeling, and expected utility to help investors—and their advisors—make optimal financial planning decisions and assess outcomes such as lifetime consumption and wealth accumulation.

There is an extensive body of research on how to help investors make optimal financial planning decisions. For example, Scott (2012) employs a net present value of additional wealth generated from optimizing Social Security to evaluate various claiming strategies. Other research—Blanchett and Kaplan (2013), for example—focuses on multiple financial planning strategies, using distributional asset returns.

Our model furthers such research by accounting for the crucial nuances of uncertain life expectancy distribution and the dynamic interaction of client goals and investment decisions—without making simplifying assumptions about investor life spans and expected asset returns.

The life-cycle framework is well suited for considering uncertainties related to health and market forecasts, as it strives to optimize around a stated living standard (Bodie, 2002). These living standards are static in real terms, but one can adjust them dynamically to reflect changes in inflation, taxes, and household composition. By evaluating financial strategies with a utility function, one can calibrate trade-offs between strategies to reflect personal behavioral preferences of the individual household such as loss aversion, time-based discounting, and—importantly—risk aversion. An optimal system for evaluating strategies for individual investors would be able to assess these trade-offs for any combination of financial planning strategies within the investment context of any policy or tax regime.

Notes on risk

All investing is subject to risk, including the possible loss of the money you invest. There is no guarantee that any particular asset allocation or mix of funds will meet your investment objectives or provide you with a given level of income. Investments in bonds are subject to interest rate, credit, and inflation risk. Investments in stocks or bonds issued by non-U.S. companies are subject to risks including country/regional risk and currency risk. Diversification does not ensure a profit or protect against a loss. Annuities are long-term vehicles designed for retirement purposes and contain underlying investment portfolios that are subject to investment risk, including possible loss of principal.

IMPORTANT NOTE: 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. VCMM results may vary with each use and over time. For more information, see Appendix 1 on page 17.

One such model is the Vanguard Life-Cycle Investing Model (VLCM) (Aliaga-Díaz et al., 2021). This proprietary model for glide-path construction can be used to create custom investment portfolios for retirement as well as nonretirement goals, such as saving for college. It embodies key principles of life-cycle investing theory, including a utility-based framework encompassing risk aversion, time preference, and behavioral finance considerations such as loss aversion and income shortfall aversion. (For more information on this model, see **Appendix 2**.)

VFAM is a life-cycle model similar to VLCM designed to evaluate financial planning decisions. The model produces lifetime, personalized cash flow projections for any combination of advice strategies over a distribution of potential life-cycle, market, and economic forecasts to assess how each strategy would perform.[1] It then scores these advice strategy combinations' value through what matters to an individual—evaluating trade-offs between consumption and wealth, and between current and future consumption. It uses a utility function framework that provides a reasonable and objective way to determine the best combination of strategies for a given investor. In the end, rather than a single recommended approach, the investor receives relative valuations of all of the considered approaches. These valuations can then be considered in light of the investor's personal preferences and beliefs.

VFAM has several notable features listed below. The model:

- Helps investors evaluate and trade off considerations between consumption and wealth accumulation and current and future consumption.
- Helps investors assess multiple financial planning strategies, and the relative value added by them, by quantifying the benefit in dollars or guaranteed return.
- Incorporates granular accounting of taxes—which means that it can provide a recommendation that considers the impact of both current and future expected taxes.
- Provides insights on the likely estimate of bequest (in both real and nominal terms) and on the probability of maintaining consumption targets throughout a life cycle.
- Can be used to evaluate the optimal relationship of multiple simultaneous advice interventions and investor characteristics.
- Can be used to simulate the effects of policy recommendations for an individual or for a sample population.

1 VFAM can currently explore several types of financial planning strategies and is being continuously enhanced to consider more.

Details and key components of the model

VFAM has four key components—cash flow simulation, market return expectations, life expectancy variability, and assessment of individual preferences (**Figure 1**):

1. **Cash flow simulation.** VFAM simulates a household's life cycle, incorporating personalized inputs, tax situations, and impacts from different financial planning strategies projected across a wide distribution of uncertain economic paths over the investor's lifetime.
2. **Market return expectations.** It uses a distributional capital market forecasting framework to calculate wealth outcomes over a life cycle from any given financial planning strategy or combination of strategies.
3. **Life expectancy variability.** It explores how strategies will perform given the probability distribution of life expectancy associated with members of the household, producing insights related to both longevity risk and the risk of earlier-than-expected death.
4. **Assessment of individual preferences.** It evaluates the performance of a given strategy, using a utility function that incorporates investors' empirically demonstrated desire to balance risk, return, and multiple financial goals.

FIGURE 1.

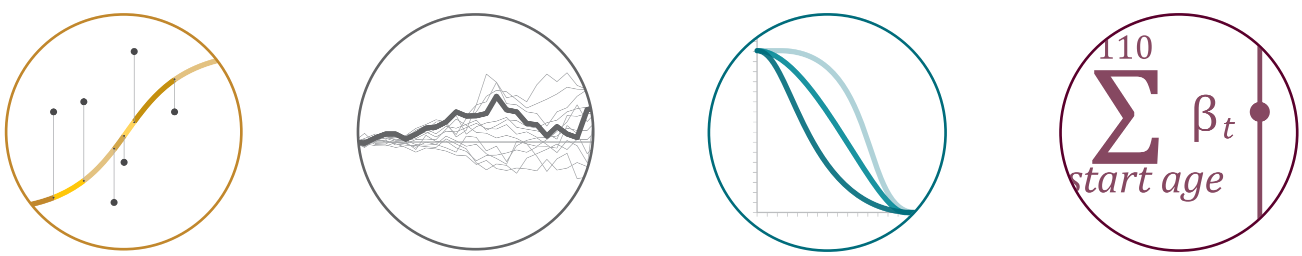
The four key components of VFAM

1 Cash flow simulation
Highly personalized, tax-aware foundation

2 Market return expectations
10,000 market return and inflation scenarios

3 Life expectancy variability
"True success rates" including survivor scenarios

4 Assessment of individual preferences
Focus on entire range of outcomes, with emphasis on mitigating tail risks



Source: Vanguard.

Cash flow simulation

At the core of VFAM is a cash flow projection model that considers inputs based on a household's point-in-time characteristics, assets, preferences, and predicted future financial flows. VFAM also incorporates the impact on cash flows of any number of financial planning strategies—or combination thereof—that are being considered, in order to provide an optimal recommendation.

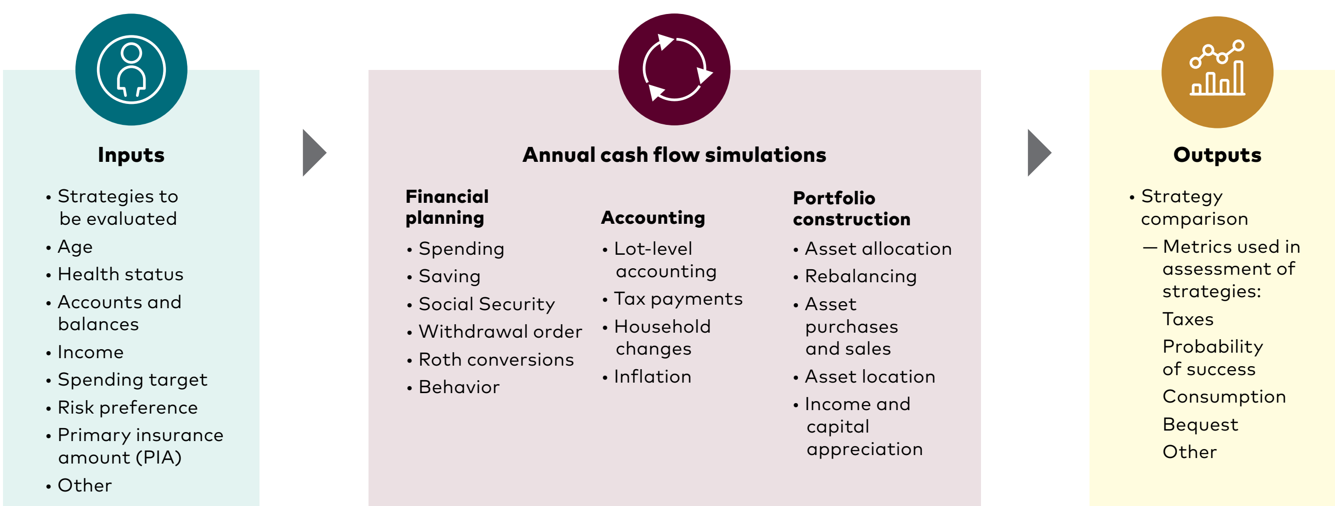
Using VFAM, we can evaluate a host of potential advice strategies, such as:

- Increasing or decreasing annual savings amounts.
- Directing savings to different account types.
- Asset location strategies.[2]
- Purchasing varying amounts of term life insurance.
- Social Security claiming strategies.
- Roth conversion strategies.
- Withdrawal strategies.
- Increasing or decreasing retirement spending targets.
- Applying disciplined investor behavior rather than chasing performance or trying to time markets.

Supplied with a set of inputs and financial planning strategies, VFAM loops through each year of the projected life cycle over any number of parallel market paths (**Figure 2** supplies a rough schematic). In each path, the model executes the given set of strategies and tracks year-over-year accounting of all assets and tax liabilities based on the tax code. Each path can include exogenous shocks to test each strategy over both sudden (e.g., investor deaths) and sustained (e.g., spending, income, and tax-bracket changes) impacts to investor situations. At the end of each simulation, the model aggregates the year-over-year and path-by-path accounting of performance metrics (such as after-tax real wealth/consumption) and calculates utility scores associated with each tested strategy combination. All combinations of strategies can then be ranked and their relative valuations can be quantified.

FIGURE 2.

VFAM's cash flow simulation considers highly personalized inputs and models plan activities at a granular level



Source: Vanguard.

2 Tax-minimizing strategies that require putting different investments into account types with different tax treatments: taxable, tax-deferred, and tax-free.

VFAM models the inflows and outflows of a household by avoiding assumptions and oversimplifications that may have unclear effects on financial performance. Thus, several tax, legal, and financial planning activities are incorporated into the model:

- Calculating and withdrawing annual required minimum distributions (RMDs) from qualified retirement accounts.
- Collecting income from various sources.
- Paying life insurance premiums or receiving a life insurance payout (when simulating a death of a member of the household).
- Selling assets as needed from the portfolio to meet household liabilities such as taxes and desired spending.
- Buying assets with excess investable cash.
- Rebalancing the portfolio as needed.
- Realizing appreciation of asset values and collecting income based on distributional asset projections.
- Converting assets into Roth as directed by input strategies.
- Calculating and netting taxes at year-end.
- Calculating any other taxes and fees associated with all of the above activity.

Tax awareness

To provide relevant advice given a specific tax setting, VFAM uses very detailed tax rules. These rules include granular tax lot accounting, marginal tax brackets, and income-based surcharges and fees (for example, the income-related monthly adjustment amount—"IRMAA"—of Medicare premium surcharges).[3] In this way, the model helps us understand the impact that changing tax rules may have on an investor's financial outcomes. The tax specificity allows us to avoid noise in our simulation from broad-stroke tax assumptions and simplifications.

For each potential forward-looking path provided by a capital markets model, VFAM simulates year-over-year tax liabilities resulting from the behavior of the investor and the portfolio that year. For taxable accounts, the model tracks lot-level accounting and growth, updated for each cash flow into or out of the portfolio. VFAM is aware of any given lot's tax-relative position to cost basis, and it can sell these lots using specific identification accounting, following tax minimization strategies in every situation. The model understands how to maximize tax losses and will use and carry forward those losses to offset capital gains and income throughout the life cycle. For tax-advantaged account contributions or withdrawals, VFAM keeps track of deductibility and income according to the rules of a given type of account. All of this tax specificity means that VFAM can help researchers and products explore niche tax optimizations that are personalized for the investor.

3 Currently, VFAM does not model potentially stochastic variables, including federal tax rates and health status. It assumes current tax rates (in real terms), and health status inputs are static throughout the simulation horizon.

Asset allocation

VFAM's cash flow engine also incorporates flexible modeling of a wide variety of asset allocation strategies, including static or glide-path allocations. The asset allocation assumptions are an input; the cash flow model maintains or adjusts the prescribed asset allocation throughout the life cycle and rebalances when the asset allocation drifts. Additionally, VFAM incorporates simulations of a wide variety of asset location strategies, active strategies, and fees. **Figure 3** lays out the key inputs and outputs of the model in more detail.

FIGURE 3.

The model's inputs and outputs in more detail

Inputs

Investor characteristics

Income and expenses

Assets

Investor preferences
- Risk aversion
- Preferences about timing of consumption

Asset class return projections

Strategies
- Social Security claiming age
- Withdrawal order
- Roth conversion strategy
- Investment order by tax type
- Asset location strategy
- Spending variability
- Rebalancing
- Life insurance
- Alpha and volatility adjustments
- Saving strategy
- Spending strategy
- Other

VFAM

Tax code considerations
- Income tax
- Investment taxes
- Social Security and Medicare taxes
- Other taxes and surcharges
- Required minimum distributions (RMDs)

Outputs

Outcome distributions over time
- Probability of success
- Taxes by type
- Consumption
- Hypothetical bequest
- Account balances
- Withdrawals by account type
- Investments by account type
- Roth conversions
- Social Security benefits

Utility concepts
- Certainty fee equivalent (CFE) return gaps
- CFE wealth gaps

Source: Vanguard.

Utility scoring

A common financial planning methodology uses "portfolio success rate" to measure financial planning results—to "score" a portfolio's preparedness, as well as the quality of a financial planning strategy or decision. (See Cooley, Hubbard, and Walz, 2011). While this metric is useful to convey a given portfolio and plan's longevity at a specific age, it has clear shortcomings. For example, let us consider an investor with a 95% success rate at age 100. It may seem as if this investor has a great chance of financial success, but the metric does not capture the possibility of potential bad outcomes if the investor lives beyond that age, nor does it measure the magnitude of the shortfall in cases of failure. It also doesn't capture the impacts of death before age 100, the risks that come with underspending, or the effects of other financial decisions such as life insurance.

To address all these considerations, VFAM employs utility scoring, rather than portfolio success rate, to quantitatively compare different strategies and evaluate which one is the best. A utility function allows VFAM to make quantitative trade-offs between strategies while considering additional aspects of both an investor's financial plan (e.g., longevity risk, portfolio risk, spending needs, bequest outcomes) and aspects of investor behavior and preferences.

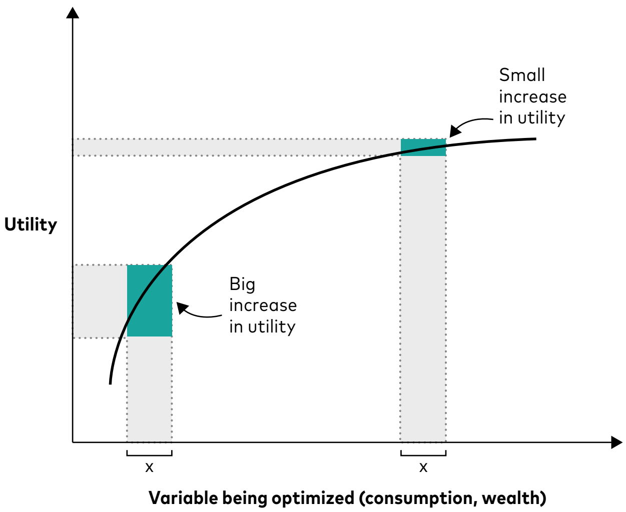
Utility scoring is a way to rank the different strategies from best to worst. It captures the trade-offs between current and future consumption, and between consumption and bequests. It rewards higher consumption or bequests—but penalizes heavily any strategy that leads to a terrible outcome. The best utility strategy is one that fares better than other strategies across all different risk categories, including across different market scenarios, and accounts for uncertain mortality risk. In VFAM, utility scoring evaluates investor satisfaction using two metrics: (1) the investor's ability to meet their desired spending target each year and (2) the after-tax amount they can bequest.

The utility score does not simply recommend the best average outcome—it also penalizes strategies that have large-tail risk of extremely negative outcomes. For example, consider the following two options.

Option 1 gives investors a 50% chance of going bankrupt and a 50% chance of ending with $3 million. With Option 2, investors would have $1 million with certainty. Option 1 has the higher average outcome (50% chance of $0 and 50% chance of $3 million, for an average of $1.5 million). However, using utility scoring, Option 2 is preferable, as it guarantees $1 million. (Unless an individual has little aversion to risk—in which case, they would choose Option 1.) In short, utility scoring provides better protection against a variety of risks that investors may face, such as market return risk and longevity risk.

VFAM uses a constant relative risk aversion (CRRA) utility function to score strategy combinations for a given individual while considering distributional economic and life expectancy outcomes. As **Figure 4** shows, this function is concave, meaning that with each additional unit of consumption (or wealth), the increase of additional utility becomes smaller. For example, going from $2 million to $1 million has the same proportional reduction in utility as going from $2,000 to $1,000 or from $200 to $100. This design is intended to reflect investors' inherent risk aversion by penalizing catastrophic scenarios. The concave shape also reflects diminishing marginal utility: Investors care more about losing $1 than they care about gaining $1.

FIGURE 4.
Constant relative risk aversion (CRRA) utility function



Source: Vanguard.

Because VFAM uses a utility function to evaluate outcomes, it is not intended to make wealth-maximizing, consumption-maximizing, or tax-minimizing recommendations at the expected median or average forecast. Instead, the model considers downside risk and chooses options that result in utility maximization across a wide array of potential outcomes. It makes decisions based on a snapshot of an investor's wealth status in between years, and simulates strategies over a full life cycle of potential futures.

Figure 5 shows the VFAM utility function. The first summation is over the distribution of asset returns; the second is the distribution over time. The utility function is designed to be flexible, so that as many investor preferences can be incorporated as possible. For example, the β considers the investors' time preference (how much they prefer immediate consumption over future consumption), while the θ takes into account how strong their bequest motives are. The γ_t captures the probability that at least one person in the household is still alive in year t, and the δ_t denotes the chance that the last person in the household dies in any particular year t (and thus triggers a bequest). Moreover, as previously mentioned, VFAM can incorporate any distribution of asset returns.

FIGURE 5.
VFAM's consumption and bequest utility model

$$\sum_{i = path}^{N} \sum_{t = start\ age}^{T} \beta^t \left(\gamma_t U\left(C_{i,t}\right) + \theta\ \delta_t U\left(W_{i,t}\right)\right)$$

where:

N = Distribution of asset returns
i = Investment path
T = Simulation horizon
t = Time (begins at investor age at start; ends at simulation horizon T)
β = Time preference
γ_t = Probability that at least one member of household is alive in year t of simulation
δ_t = Probability that last member of household dies in year t of simulation
θ = Relative weight of bequest
$U(C)$ = Utility of consumption
$U(W)$ = Utility of bequest

Source: Vanguard.

As an example, VFAM can use the VCMM to evaluate each strategy through 10,000 potential market scenarios. Within each of the 10,000 scenarios, VFAM simulates every year through the investor's potential lifetime. For each market scenario and each year, VFAM applies a life expectancy distribution to calculate the likelihood that an investor is alive at that point, and if so, how much utility value they get from the consumption amount. Similarly, VFAM also calculates how likely it is that the investor would pass away in that year and leave a bequest. The model then computes the utility value of the bequest amount. By aggregating the utility values for consumption and bequest across potential lifetime and across the 10,000 potential market scenarios, VFAM can find the strategy that provides the highest expected utility value for the investor.

Value calculations using certainty fee equivalents

Certainty fee equivalents (CFEs) allow VFAM to convert the utility metrics and describe how much additional return or wealth one would need to achieve the same well-being (utility) with an inferior strategy combination as one would have with a superior strategy combination. The model does this by solving for the additional return or starting wealth required by the simulation to bring the utility score of the inferior strategy to parity with the utility score of superior strategy. For example, Strategy A may need a cash infusion of $10,000 at the beginning of the simulation to have the same utility score over the distribution of potential future outcomes as Strategy B.

We can also decompose a CFE into its components for an individual household. For example, given a strategy simulation to make Roth conversions every year to the 24% tax bracket and claim Social Security at age 70, we could attribute an estimated total of 50 basis points (bps) of annualized value (relative to making no Roth conversions and claiming at age 62), such that 40 bps of added value is from delayed claiming, 20 bps of added value is from Roth conversions, and –10 bps is from the interaction of those two strategies. (A basis point is one-hundredth of a percentage point.)

We accomplish this decomposition through a multivariate analysis of variance. To set up the regression, we create a dummy variable for each component strategy. Each variable can have two states, 0 or 1, where 0 represents the component strategy associated with the benchmark and 1 represents the component strategy associated with the comparison strategy. We first calculate the CFE associated with each permutation of the independent dummy variables. We then regress these CFEs (the dependent variable) against each dummy variable and each dummy variable pairwise combination, giving us the personalized effect of each strategy on an investor's benefit.

It is often intuitive that these interactions will have an impact. Given the diminishing marginal return context of our utility formulation, each additional utility of benefit is harder to achieve. This means that the improvements in outcome from one strategy will make it harder for complementary strategies to add value. For example, two strategies that would each add 10 bps of value when used on their own may add only 15 bps of value when combined. Combinations of strategies can also amplify the effects of other strategies.

Life expectancy

A standard cash flow model used by financial planners typically plans to a particular horizon age or uses a fixed or static age for life expectancy assumption, for both single investors and couples. A better approach is to use statistical life expectancies to account for mortality risk. In VFAM, we can incorporate any mortality table or life expectancy assumptions to provide a more personalized and distributional perspective about life expectancy.

One example is to apply the Society of Actuaries (SOA) mortality tables as the basis for different distributions of life expectancy outcomes based on age, gender, and health status. In the case of a couple, VFAM can also simulate random ages at death for the first death in a household, so that we can consider changes in spending need, tax filing status, and applicable Social Security benefits.

The use of life expectancy distribution in VFAM provides several benefits.[4] Of these, three are worth looking at in a bit of detail.

4 While VFAM accounts for market uncertainty and life expectancy uncertainty in its optimization, it does not account formally for model parameter uncertainty. Model parameters, in turn, may be subject to statistical uncertainty.

Benefit 1: Using a distribution of life expectancy allows VFAM to account for longevity risk

Like market returns, length of life is not an outcome that people get to choose; rather, it is something that is both largely out of one's control and subject to great variation. Just as we do not plan that a stock will generate a specific percentage of return with certainty (and therefore we typically simulate different potential market outcomes), it is better to consider the probabilities that an individual will live to various ages rather than to assume that they will live to a specified age. Applying the entire life expectancy distribution helps the model properly take into consideration the uncertainty of lifetime and account for longevity risk.

Figure 6 presents one example of a life expectancy distribution. In the case of a single point estimate, we assume that the investor would require consumption every year with 100% certainty up to the horizon age, then with 0% need of consumption after that. The "consumption adjustment" shown in Panel B, on the other hand, reflects the uncertainty of mortality risk. While today the investor has a 100% certainty of needing the consumption amount, the probability steadily decreases over time as the investor's likelihood of death increases. The "success adjustment" shown in Panel A is another good example of the value of a life expectancy distribution. If an investor is 65 years old now and sets a horizon age of 100, then a portfolio that is expected to last for 30 years is considered a complete failure. Yet, based on this life expectancy distribution, more than 80% of the time the investor may not even live to age 95. Therefore, such a portfolio can provide this investor with over 80% success in not outliving his resources.

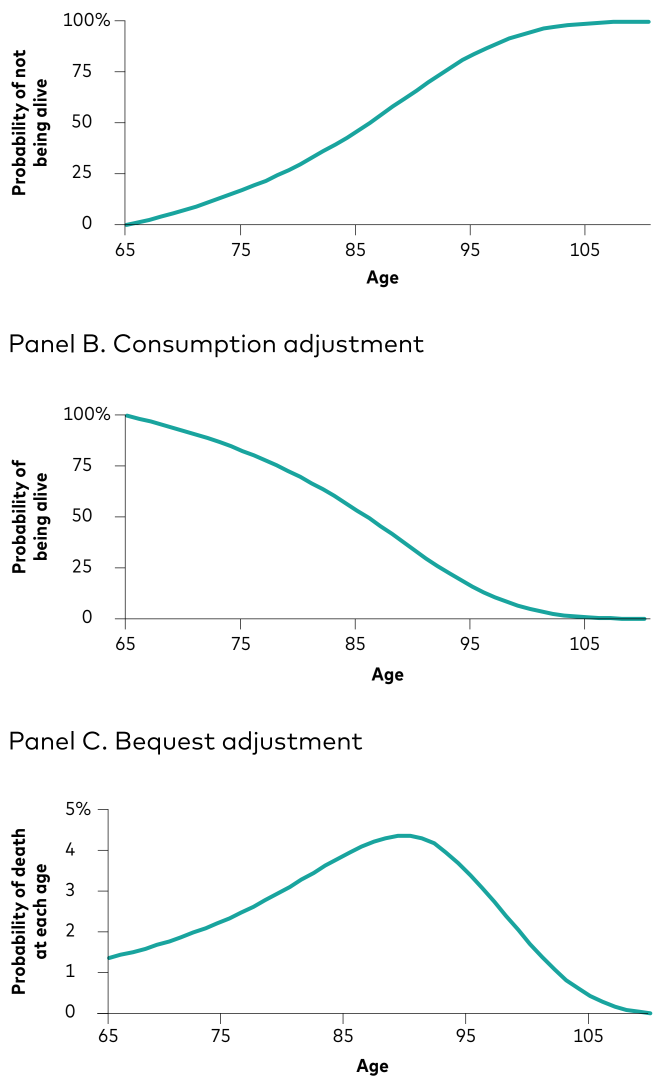
FIGURE 6.

Adjustments based on one example of a life expectancy distribution

Panel A. Success adjustment

Panel B. Consumption adjustment

Panel C. Bequest adjustment



Note: Adjustments are based on a household made up of a 65-year-old man.

Sources: Vanguard calculations, using data from the Society of Actuaries.

Benefit 2: Using a distribution of life expectancy results in a more meaningful measure of success

Conventional methodology that uses a fixed or static horizon age often layers one conservative assumption on top of another. Such an approach leads to the pursuit of a high success rate to account for market risk, and it uses a long horizon age to protect against longevity risk. The compounding effect of both conservative assumptions makes the probability-of-success metric especially conservative: The only way to fail, assuming a high success rate, is to live an unusually long time and have unusually bad investment returns while you do so. Consider that a household of two average healthy 65-year-old investors has only a 1% chance that both members will live to the age of 100—but it has a 16% chance that one member will live past age 100.[5] Put another way, there is a 50% chance that the household will not last more than 28 years.

Taking a life expectancy distribution into account provides more personalization. It allows investors with lower life expectancy the freedom to spend more; it allows investors with higher life expectancy to consider strategies that mitigate longevity risk (e.g., deferring Social Security claiming). Many simple pieces of information, such as age, health status, gender at birth, have significant impact on life expectancy. (Even household composition plays a role: A married household needs to plan for a longer distribution period than a single household because joint life expectancy is higher.) Using a fixed or static horizon age for everyone would ignore the benefit of personalization to them. The problem is not so much that fixed or static horizons are conservative in nature, but that they are esoteric and one-size-fits-all.

While the conventional methodology defines probability of success as the probability of not running out of money before a specified horizon age, VFAM can calculate a more useful and meaningful success measure: the probability of not outliving resources during one's lifetime.

Benefit 3: Using a distribution of life expectancy allows for a variety of cash flow scenarios

By modeling a distribution of life expectancies, VFAM can incorporate many intricate cash flow scenarios that would occur as the result of a death in the household, such as reduced Social Security benefits, change of tax filing status, and changes in income and spending. These cash flow scenarios can have important implications to the financial plans of the investors. For example, a household with an income of $200,000 that may be in a federal tax bracket of 24% when filing jointly could face a 32% tax bracket when their filing status changes to single.

The following case study illustrates these benefits by examining the decisions surrounding Social Security claiming and Roth conversions.

5 Calculation is based on the SOA mortality tables.

Case study
Noel, age 59, and Jenny, age 61: Social Security claiming, Roth conversions

Advice questions

- When should they claim Social Security?
- How much of their assets, if any, should they convert to Roth?

Relevant details

- Noel and Jenny are retiring soon.
- If they claim at the Social Security full retirement age, Noel will have $3,000 of Social Security benefits per month. Jenny, who has worked less in her career, will have $800 of Social Security benefits per month based on her earnings record.
- They have $370,000 in their tax-deferred accounts. If they don't spend all of it during their lifetimes, they would like to pass the remainder to their son, who is in the 24% tax bracket.

Recommendation if a fixed life expectancy of 100 is assumed

- A financial planning model with a fixed horizon age of 100 would recommend that both Noel and Jenny delay claiming Social Security benefits until age 70. Delayed claiming can increase the monthly Social Security benefit amounts, and thus this strategy works best if both Noel and Jenny live very long lives.
- This model would not recommend any Roth conversions for Noel and Jenny unless their taxable income is lower than the standard deduction. The long horizon means that annual spending and RMDs would whittle away at the tax-deferred account over their lifetimes, making Roth conversions both unnecessary and not the best strategy.

VFAM recommendation using SOA mortality tables

- VFAM would prefer that Noel delay claiming Social Security benefits until age 70 and that Jenny start claiming at age 62. Using more realistic life expectancy assumptions, it is likely that at least one of them may pass away earlier in life. This strategy provides better benefits to Noel and Jenny: Noel waiting until age 70 will maximize the spousal and survivor Social Security benefits, while Jenny claiming at age 62 allows them to enjoy eight more years of Social Security benefits.
- VFAM would recommend a Roth conversion up to the point that taxable income is at $83,350. This allows Noel and Jenny to stay in the 0% long-term capital gains tax bracket, convert the tax-deferred asset at the 12% tax rate, and save their son from paying taxes on the inherited asset at the 24% tax rate.

This case study illustrates the flexibility of VFAM in using different life expectancy assumptions, as well as the differences in advice recommendations when doing so. The more realistic life expectancy distributions used in VFAM led to better and more personalized recommendations for Noel and Jenny: namely, to better optimize their Social Security claiming decisions and use Roth conversions to maximize their after-tax wealth across generations.

Another example that demonstrates the advantage of VFAM over traditional models is measuring the value of buying life insurance. In models that assume a fixed life span, life insurance is a value-diminishing strategy. Since VFAM models uncertainty in life expectancy, it can evaluate the benefit of obtaining life insurance more appropriately. The stochastic nature of the life expectancy simulation means there are certain paths in VFAM where a life insurance benefit is paid out in the event of the policyholder's death. Below we present a simple example from VFAM where—all else being the same—the CFE from obtaining a life insurance policy with a payout of $1,000,000 and an annual premium of $1,000 is 8 basis points annually over the client's expected lifetime.

Case study
Pete, age 25, and Pat, age 26: life insurance

Advice questions

- What is the benefit of buying life insurance?

Relevant details

- Pete (25 years old) and Pat (26 years old) are a couple. They earn $44,000 and $30,000, respectively.
- They save an annual amount of $10,000 and consume the rest in taxes and expenses. They desire an annual consumption of $65,000 in today's dollars.
- They want to evaluate the pros and cons of buying an insurance policy with a death benefit of $1,000,000 and an annual premium of $1,000.

Recommendation using VFAM

Of the 10,000 simulation paths, 200 are paths in which one of the policyholders dies during the policy period and the other receives a benefit. The lifetime consumption distribution with and without life insurance is shown in **Figure 7**. Panel A shows the distribution for all paths—including those where no insurance payout is made and those where a payout is made. Panel B and Panel C zoom in to show, respectively, the distribution for all paths without payout and the distribution for all paths with payout.

While the distribution is shifted to the left with life insurance because of premium payments, the life insurance distribution eliminates the tails in consumption without life insurance and adds value. VFAM can demonstrate this value by using a utility function that captures the entire distribution compared to median or average measurement models.

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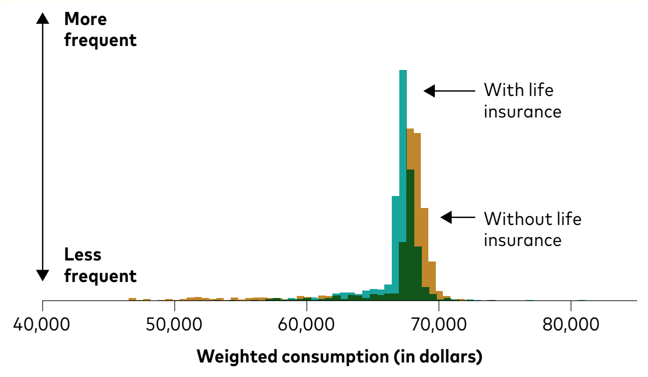
(Case study continued)

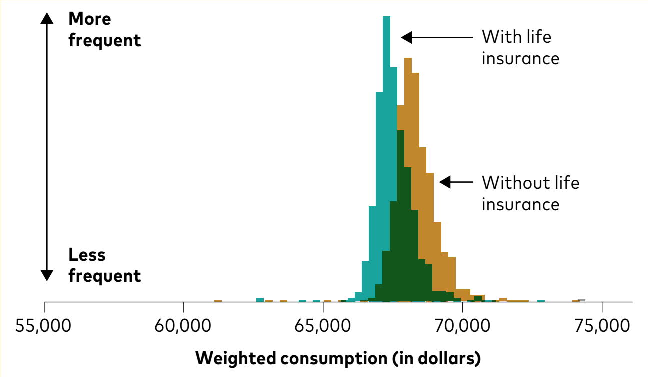
FIGURE 7.

Lifetime consumption distributions for Pete and Pat, with and without life insurance

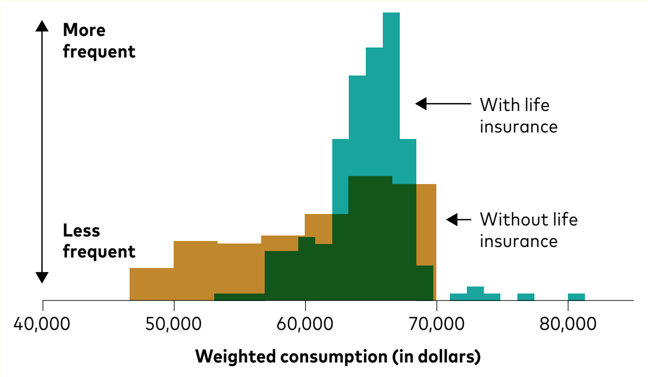
Panel A. Lifetime consumption distribution across all paths



Panel B. Lifetime consumption distribution where no payout occurs



Panel C. Lifetime consumption distribution where payout occurs



Sources: Vanguard, using data from the Society of Actuaries and the VCMM. See Appendix 1 on page 17 for more information on this model.

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 are as of December 31, 2020. Results from the model may vary with each use and over time. For more information on VCMM, see Appendix 1 on page 17.

Conclusion

Making financial planning decisions is complicated by interactions between multiple financial planning strategies, personal situations, taxes, life expectancy, and economic uncertainty. VFAM is a proprietary financial planning model that aims to address many of the challenges associated with these interactions. The model uses a cash flow engine to study the effects of implementing multiple financial planning strategies. It evaluates these strategies using a utility-based framework, and accounts for tax implication of planning decisions—all while taking into account the uncertainty inherent in asset returns, household compositions, and life spans. In this way, it improves on many of the existing models.

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Appendix 1.

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. VCMM results presented are as of December 31, 2020.

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 VCMM 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 simulation 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.

Appendix 2.

The Vanguard Life-Cycle Investing Model is designed to identify the product design that represents the best investment solution for a theoretical, representative investor who uses the target-date funds to accumulate wealth for retirement. The VLCM generates an optimal custom glide path for a participant population by assessing the trade-offs between the expected (median) wealth accumulation and the uncertainty about that wealth outcome, for thousands of potential glide paths. The VLCM does this by combining two sets of inputs: the asset class return projections from the VCMM and the average characteristics of the participant population. Along with the optimal custom glide path, the VLCM generates a wide range of portfolio metrics such as a distribution of potential wealth accumulation outcomes, risk and return distributions for the asset allocation, and probability of ruin, such as the odds of participants depleting their wealth by age 95.

The VLCM inherits the distributional forecasting framework of the VCMM and applies to it the calculation of wealth outcomes from any given portfolio.

The most impactful drivers of glide-path changes within the VLCM tend to be risk aversion, the presence of a defined benefit plan, retirement age, savings rate, and starting compensation. The VLCM chooses among glide paths by scoring them according to the utility function described and choosing the one with the highest score. The VLCM does not optimize the levels of spending and contribution rates. Rather, the VLCM optimizes the glide path for a given customizable level of spending, growth rate of contributions, and other plan sponsor characteristics.

A full dynamic stochastic life-cycle model, including optimization of a savings strategy and dynamic spending in retirement, is beyond the scope of this framework.

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