Risk management for pensions: Does the risk you're taking align with your stated risk tolerance?

Vanguard Research

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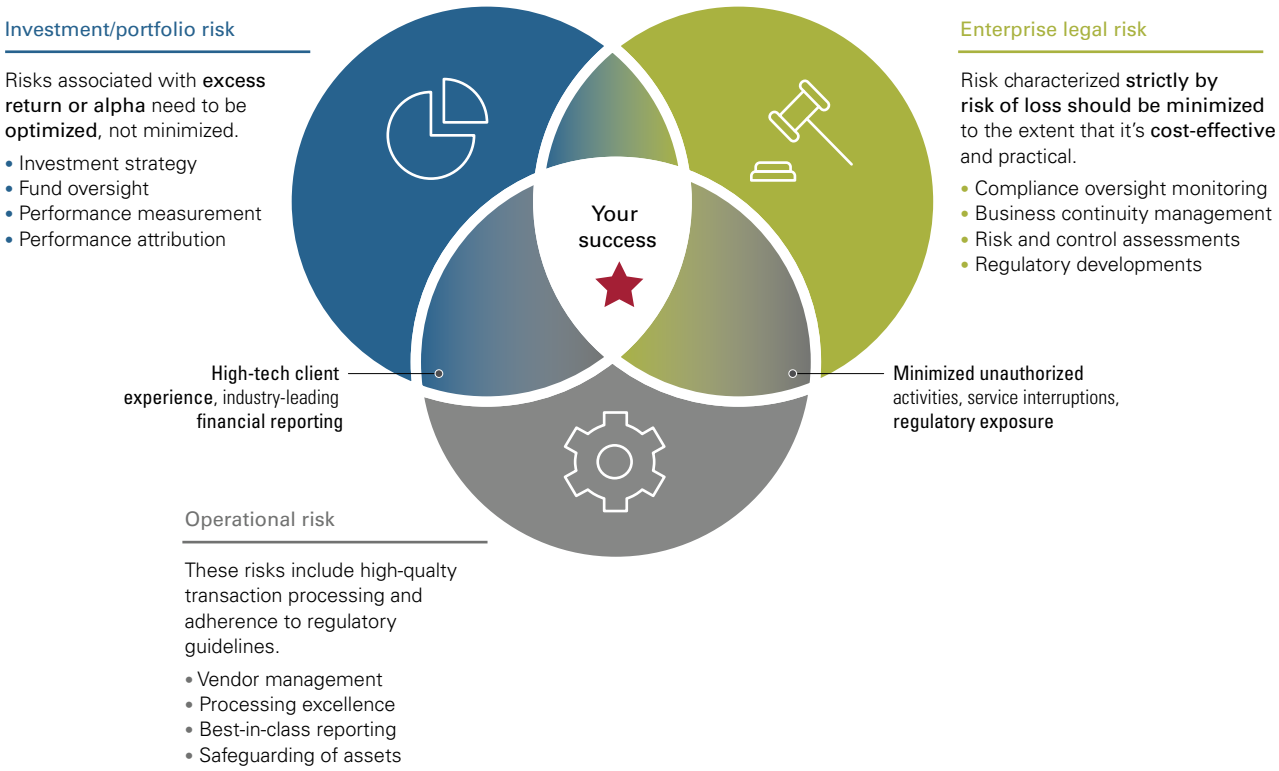
- In our 2019 survey of pension plan sponsors, we learned that many are taking on significantly more funding status risk than they indicated was tolerable.
- In this paper, we will describe the primary risk factors for pension plans and the available tools to manage those risks.
- We will explore how Vanguard helps clients set their investment strategies to mitigate risk and measure the risk inherent in their pension plans so it is consistent with their stated risk tolerance.
- Risk management for defined benefit pension plans is a multifaceted endeavor comprising investment/portfolio risk, enterprise legal risk, and operational risk. This paper will concentrate on investment/portfolio risk.

The three facets of defined benefit pension plan risk—management investment/portfolio risk, enterprise legal risk, and operational risk—are shown in **Figure 1**. Investment/portfolio risk, the concentration of this paper, can be managed using the following five-step management cycle. We will focus on steps three and four.[1]

1. Establish a formal governance process and a set of procedures for decision-making.
2. Identify the risks faced by the stakeholders of the pension plan.
3. Measure, evaluate, and understand the risks and their impact on stakeholders.
4. Set an investment strategy to address those risks.
5. Monitor and review the results on an ongoing basis.

Figure 1. Vanguard's culture of risk management leads to better outcomes

Holistic risk management and fiduciary confidence



Source: Vanguard.

1 These two steps occur after Vanguard has helped clients articulate their overall risk tolerance for the pension in the context of the broader organization, which is outside the scope of this paper.

Risk implications of our 2019 survey

In our 2019 Vanguard survey,[2] 87% of pension plan sponsors[3] stated that their acceptable downside variation in funding status in a given year was 10% or less (see **Figure 2**).[4] However, based on asset allocation data and Vanguard's capital market forecasts, we calculated that downside variation for most pension plans is much higher than 10%. This difference reveals a significant disconnect.

As Figure 2 shows, a plan sponsor would need an asset allocation of 70% or more in liability-hedging fixed income assets to be comfortable that the downside variation in funding status was 10% or less. But the same study showed that the average allocation to those assets was closer to 40%, indicating a downside variation of nearly 17%—nearly double what the sponsors considered acceptable.

Figure 2. Acceptable downside variation in funding status

Variation range	Percentage of respondents	
	2015 survey	2019 survey
0%	5%	4%
1% to 5%	47%	47%
6% to 10%	42%	36%
11% to 20%	6%	9%
>20%	1%	3%

In 2019, 87% of survey respondents stated that an acceptable downside variation in funding status was less than 10%; the response was similar in our previous study.

Funding status at risk for varying asset allocations

Asset allocation (percentage equity/percentage liability-hedging fixed income)	Downside variation in funding status at a 1-in-20 level
10%/90%	3.5%
20%/80%	5.8%
30%/70%	8.7%
40%/60%	11.6%
50%/50%	14.5%
60%/40%	17.4%
70%/30%	20.4%

Source: Vanguard, 2019.

Only asset allocations with 70% or more in liability-hedging fixed income are designed to have a downside variation in funding status of less than 10%.

The average asset allocation in the survey had a projected downside funding status variation of 17.4%, much higher than what many sponsors considered acceptable.

2 See Dion and Gannon (2019) for further discussion.

3 Respondents to this survey were a random sample of corporate pension plan sponsors, not necessarily clients of Vanguard's OCIO business.

4 Acceptable downside variation in funding status was defined as the annual decline in funding status expected to occur one time in 20 years.

Many pension plan sponsors may be defining their risk tolerance without testing whether their investment strategy is designed to achieve it. Alternatively, they may be using unrealistically optimistic capital market forecasts to measure their risk. All of these factors—stated risk tolerance, investment strategy used to mitigate risk, and assumptions and methods used to measure that risk—should work together in an effective risk-management system.

At Vanguard, we help our outsourced chief investment officer (OCIO) pension plan sponsors articulate what downside risk is acceptable. This lets us formulate an investment strategy consistent with their risk tolerance and limits the plan's impact on their organization. We measure the risk using a robust set of capital market forecasts and a variety of assessment methodologies.

Identifying risks

We begin with a discussion of common pension risks.

Risks manageable through asset allocation[5]

Asset risk: the variability of investment returns in the portfolio and the impact of that variability on other pension measurements. Asset risks can be measured in absolute terms or relative to a benchmark and can be attributed to anything from high-level asset class selection to individual security selection, with many levels in between. Another form of asset risk is liquidity risk—the risk of having difficulty selling an asset for its full price during times of market stress. The typical strategy for managing asset risk is diversification of asset allocation.

Liability risk: the variability in the value of pension liability due to movements in financial markets. Because pension liabilities are valued by discounting expected future benefits using current market interest rates, declines in interest rates are plan sponsors' primary liability risk. Other typical causes of liability risk are changes in credit spreads and the shape of the yield curve.[6]

Sponsors of ongoing public and multiemployer plans may not be directly affected because they don't use mark-to-market accounting. However, lower interest rates can still lead to lower return forecasts, which can create long-term funding challenges.

Asset liability risk: the risk that asset returns will not keep pace with or move in tandem with liability returns. The higher the correlation between the asset portfolio and liability measurement, the lower the asset liability risk. The typical strategy for managing this risk is liability-driven investing, in which the asset portfolio is designed to mimic the movements of the plan's liabilities, usually by investing in long-duration, high-quality corporate or government bonds.

Vanguard believes that pension plans should state their primary risks in terms of asset liability risk rather than asset-only. Asset-only risk is typically a secondary measurement for the plan sponsor or a primary goal of an individual manager within the plan.

Risks less manageable through asset allocation

Model risk: the risk that a decision-maker relied on a set of forecasts that did not adequately represent the range of possible future outcomes or used methods to measure risk that were narrow and lacked sophistication. This can happen because the assumptions were not well-chosen or did not contain key pieces of information that influenced the future.[7] In general, we shouldn't pretend we know how the market will behave with precision. We shouldn't use just one process or set of assumptions to measure risk or be too confident in our measurements.

Other risks: actuarial assumption risk—the risk that actuarial assumptions are different than actual plan experience because of demographics (retirement rates, lump-sum election rates, or longevity) or economics (inflation or salary increases), and plan design risk—the risk that certain properties of the pension plan, such as lump-sum features or early retirement provisions, will cause adverse outcomes, especially during times of market stress.

5 Note that these are primary risks that often lead to other risks. For instance, asset liability risk could lead to funding status erosion (falling) if the asset return consistently trails the liability return, or funding status risk if these don't move together in all markets. Funding status erosion or risk will then lead to the risk of either high or volatile contributions. Neither asset allocation nor diversification can guarantee a profit or prevent loss in a declining market.

6 See Gannon and Dutton (2019) for further discussion.

7 This can happen when key pieces of information are unavailable (such as who will win the next presidential election and what policies will be pursued) or if certain scenarios are ignored or discarded from the analysis because they were thought to be unlikely (such as, "no country can have negative interest rates for a long period of time").

Measuring, evaluating, and understanding the risks and their impact[8]

The first step to measuring risk is to derive a probability distribution for the risk's expected behavior. Key assumptions include the future distribution of all major asset classes (return, volatility, and correlations) and the movement of interest rates (level and volatility). These capital market forecasts are based on a combination of current market conditions, expected future conditions, and historical measurements and relationships between asset classes.[9]

It is important to understand if risks are independent or correlated—that is, whether movements in one variable would affect other variables and possibly uncover other risks or magnify existing ones. A simple relationship might be: if interest rates fall, then the value of the liability will rise.

But we also must consider more complex impacts. For instance, falling interest rates will increase the value of lump sums payable upon retirement. That may raise the number of people who retire and the percentage of those who take a lump-sum benefit rather than an annuity. This could in turn lead to higher-than-expected benefit payments and increase sensitivity to investing in illiquid assets, which would be more difficult to sell to raise cash for those payments.

In addition, risks may be asymmetric, or non-normally distributed. Some involve discontinuities, or "cliffs." For instance, an underfunded pension plan may have increasingly large contribution requirements during adverse market events, but the benefits of favorable markets will be limited because contributions cannot be less than $0 and any surplus is often difficult for the sponsor to recapture.

Also, the impact of funding status risk on a corporation is not continuous. Other penalties include "at-risk" designation or the adoption of benefit distribution and accrual restrictions on falling below certain funding status thresholds. Similarly, multiemployer pension plans that fall below certain levels could be labeled as being in a red or yellow zone, requiring additional funding or filing requirements. Plan sponsors often become more sensitive to risk as they approach these breakpoints.

Once the various risks are measured and understood, decisions can be made about which to take and which to mitigate. Possible investment strategies should be assessed for their ability to maintain risk within the desired risk tolerance while still producing a suitable level of return.

Setting an investment strategy

Next, the plan sponsor should begin to address the risks by selecting an investment strategy and testing to see if it meets the risk tolerance goals.

Plan sponsors typically take risk relative to their liability: They seek return (by holding assets that may grow faster than liabilities) in order to improve funding status or reduce required contributions. Alternatively, they might limit risk (by holding assets that move in tandem with liabilities) to maintain funding status and lower the chance of requiring excessively high contributions.

Many of the ways to measure plan outcomes are tied either directly or indirectly to the way assets relate to liabilities. The most obvious example is a plan's funding status. This not only tells us how well-funded the plan is but also feeds into other important measurements. Funding status may find its way into a rating agency's debt analysis. A plan's unfunded amount could be seen as corporate debt (owed to plan participants). A public plan could make the headlines of the local news. The risk of assets relative to liabilities is the primary way Vanguard measures and manages pension plan risk.

Assessed in this way, the lowest-risk asset for a pension plan is one that behaves like a liability by growing at the same pace or increasing/decreasing in the same market environments. If it does, funding status will not change much from year to year and funding status risk will be minimal.

In a corporate pension plan, this low-risk asset is typically long-duration, high-quality bonds (usually a combination of corporate and Treasury) because benefit payments are by nature periodic, are paid over a long horizon, and are generally regarded as guaranteed.

8 This section will discuss the processes and tools available for measuring risk. We will not directly measure the magnitude of risks because that varies by organization.

9 See Davis et al. (2014) for further discussion.

By contrast, public and multiemployer pension plans discount future benefit payments at the long-term expected return on assets. An equivalent low-risk asset for these plans would generate the desired return target with little volatility. In the absence of such an investment, these plans cannot mitigate risk as well as corporate plans through their asset allocation unless they are willing to lower the desired return target.

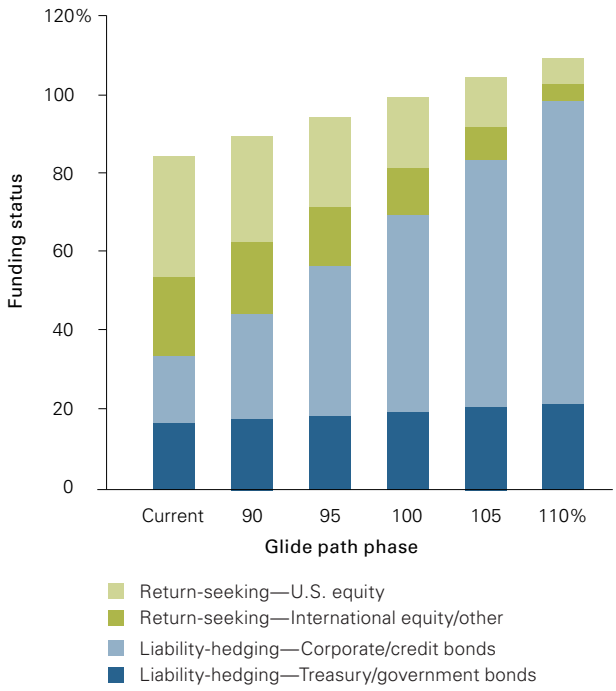
When taking and managing risks, Vanguard thinks about working "big to small." In other words, the asset allocation decisions that will have the biggest impact on the risk/reward trade-off should be considered first.

Allocation between return-seeking (such as equities, real estate, and alternatives) and liability-hedging (fixed income) assets. The biggest decision specifies the desired levels of return and risk relative to plan liabilities. Sponsors take risk relative to their liabilities (invest in equities rather than fixed income) to capture the equity risk premium that would allow them to either increase their funding status or earn an amount necessary to partially or fully cover their annual benefit accruals.

Plans with high benefit accruals or large underfunded positions would most likely, all else being equal,[10] allocate a larger percentage to equities than would those with the opposite characteristics. A plan whose funding status increases or benefit accruals decrease would seek to change its asset allocation to have more liability-hedging fixed income and fewer return-seeking assets because less risk will be required to increase funding status back to 100% or cover annual benefit accruals.

As shown in **Figure 3**, this process is often referred to as a glide path strategy. It forms a dynamic asset allocation based on a plan's current situation. A glide path focuses more on returns (relative to liabilities) to increase funding status or pay for future benefit accruals when a plan is not well-funded. It focuses more on risk mitigation when a plan is well-funded and looking to protect this status.[11]

Figure 3. Pension plan glide path asset allocation



Note: Glide path analysis is as of December 31, 2019.
Source: Vanguard, 2019.

Notes on risk

Neither diversification nor asset allocation can guarantee a profit or prevent a loss. All investing is subject to risk. Mid- and small-capitalization stocks historically have been more volatile than large-cap stocks. For U.S. investors, foreign markets present additional risks, including currency fluctuations and unfavorable developments in a particular country or region. Stocks of companies in emerging markets are generally more risky than stocks of companies in developed countries. Funds that concentrate on a relatively narrow sector face the risk of higher share-price volatility. It is possible that tax-managed funds will not meet their objective of being tax-efficient. Because it concentrates on a single stock, a company stock fund is considered riskier than a stock mutual fund, which is diversified. Investments in bond funds are subject to credit, interest rate, and inflation risk. High-yield bonds present higher credit risk than other types of bonds.

Derivatives are subject to a number of risks, such as liquidity risk interest rate risk, market risk, credit risk, and management risk. A portfolio invested in a derivative instruments could lose more than the principal amount invested.

10 Two sponsors with the exact same pension plan may take different levels of risk based on their organization's individual characteristics.

11 See Wolfram and Dutton (2018) for further discussion.

Glide path asset allocations typically shift assets from return-seeking to liability-hedging as funding status improves. These rules are often defined in advance and set out in the investment policy statement.

After the allocations to return-seeking assets and fixed income are determined, we seek to further optimize risks by making decisions within those segments.

Design of the fixed income portfolio. In fixed income, we mitigate risks by investing in long-duration bonds, typically as long as or longer than the duration of the plan's liabilities. Next, we allocate between Treasury and credit bonds to mitigate interest rate risk and credit spread risk.[12] We may then determine whether the plan wants to invest in derivatives to hedge additional interest rate risk.

The primary focus of the fixed income portfolio is usually to hedge the overall duration of the liabilities first. This can be measured using an interest rate hedge ratio—the dollar value of the change in assets for a one-basis-point move in rates divided by the change in value of the liabilities for a one-basis-point change in rates.[13]

The secondary goals of a fixed income portfolio include matching the credit quality and curve exposure of the pension liability. These can be measured using a credit spread hedge ratio (similar to the interest rate hedge ratio but with weighting factors to account for credit spread correlations at various credit qualities) and key rate duration analysis across the curve.[14]

Design of the return-seeking portfolio. This step requires deciding how to allocate and therefore diversify between the various asset classes (such as equity, real estate, and private equity); regions (such as U.S., developed regions, and emerging markets); capitalization, styles, and sectors (such as large-cap, small-cap, growth, value, and technology); and active or passive managers, how many active managers to have, and how they diversify among securities in their portfolios. This process is often referred to as portfolio construction.

Once a portfolio or range of possible portfolios is selected, we next need to measure portfolio risk using a variety of methods to determine whether our risk tolerance goals are met. If none of the portfolios meet those goals, we must choose others or reassess our risk tolerance.

Numerical portfolio risk assessment methods[15]

Sensitivity analysis. This involves changing an input variable (such as interest rates) to see how sensitive the output (funding status) is to that change. Sensitivity analysis assumes the change occurs in only one input variable at a time.

Examples of sensitivity testing variables:

- What is the change in plan surplus for a 1% change in interest rates?
- What is the change in plan surplus for a 10% decrease in the value of the equity allocation?
- What is the change in plan liability for a change in participant behavior relative to a given assumption such as the impact of a longer mortality table or an increased early retirement rate?

Scenario testing. This considers both the sensitivity of the output to change in an input variable and the likely probability distribution of these variables. Scenario analysis allows for changes in multiple input variables and often looks at multiple scenarios such as the base case, worst case, and best case. Stress testing may be considered a subset of scenario testing.

A common scenario test is to rerun the portfolio (both assets and liabilities) to mimic the changes during certain economic conditions, such as the global financial crisis or the tech bubble. This test would affect many assets and determine whether the portfolio could withstand well-known adverse circumstances. **Figure 4** shows a sample scenario sensitivity analysis.

Figure 4. Sample scenario sensitivity analysis for funding status

Projected funding status, December 31, 2020

Growth assets return	Change in interest rates: –2.0	–1.0	0.0	1.0	2.0%
20%	93	97	100	104	107
10	91	94	97	101	104
0	89	92	95	97	100
–10	87	89	92	94	96
–20	85	87	89	91	93

Improvement in funding status
Decline in funding status

Note: Return is over the course of one year from January 1, 2020, to December 31, 2020.
Source: Vanguard, 2020.

12 See Dutton and Plink (2018) and Gannon and Dutton (2019) for further discussion.
13 A basis point is one-hundredth of a percentage point.
14 See Gannon and Dutton (2019) for further discussion.
15 See *CFA Level III Program Curriculum* for more information.

Simulation analysis (often called mean variance or stochastic modeling). This uses a set of predefined assumptions to provide a probability distribution of outcomes for funding status or asset returns. To perform a simulation analysis, we develop a forecast distribution (mean, variance, and correlation) for all asset classes or economic variables. We then simulate the process many times (10,000, for example) to develop a set of stochastic future scenarios showing the distribution of possible future outcomes.

Value at Risk (VaR) analysis. VaR is often measured in terms of 1-in-20 worst-case outcome over a one-year period. The risk question might be, what decline in surplus over the next year is exceeded by only 5% of the simulations in the analysis? **Figure 5** is a VaR analysis showing that the total VaR (net risk) for the sample pension plan surplus is approximately $50 million, attributable to various sources such as interest rates and equity exposure. The plan sponsor then knows the largest source of overall risk. In most cases, this will be equity risk, followed by interest rate and then credit spread risk.

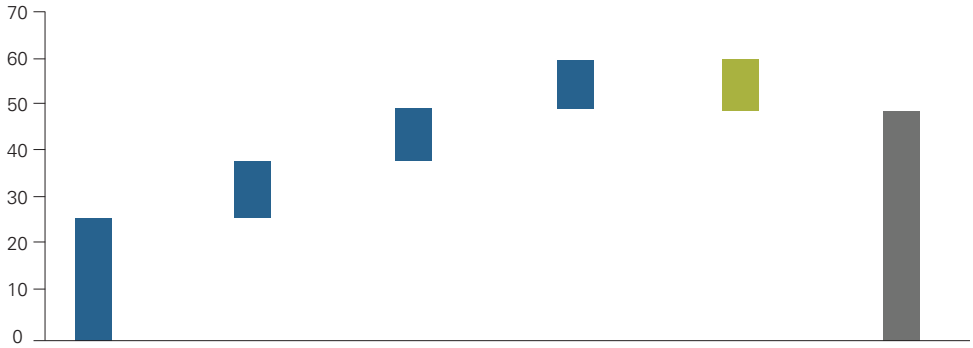
Stochastic forecasting for a multiperiod asset liability study. This technique uses capital market forecasts to create many future economic scenarios (as many as 10,000), each typically lasting up to ten years. Each scenario can be thought of as a possible economic future. We project the future growth of the asset portfolio and progression in plan liability year by year and compare those values to determine key pension measurements such as the plan's funding status or required contributions. The results of all scenarios are aggregated into a distribution, which is then summarized to review with the investment committee.

Possible scenarios include the following:

- For a particular investment strategy (usually starting with the current portfolio), what is the distribution (5th percentile, median, and 95th percentile) for a given measurement, such as funding status at Year Ten or the cumulative required contributions over the ten-year study?

Figure 5. VaR analysis

Surplus Value at Risk (VaR) analysis as of December 31, 2019



Portfolio A	Market	Term structure	Credit spread	Other	Diversification	Total VaR
Surplus VaR (USD millions)	26	12	11	12	–11	50

Notes: Value at Risk is a measure of the potential loss in plan surplus or increase in plan deficit at a 95% probability (or 1-in-20-year outcome). It represents a 2-standard-deviation movement in funding position. Market risk is risk due to exposure to the beta in equity markets. It generally affects all equity-based securities. Term structure is risk due to exposure to the term structure of interest rates. It generally affects liabilities and fixed income securities. Credit spread is risk due to exposure to the movement of yields on credit bonds relative to Treasury bonds. It generally affects liabilities and credit-based fixed income securities. Other risks are those related to the difference between holdings and their market benchmarks (such as industry, style, or region). They also include security selection, currency holdings, and other residual risks. Diversification is the beneficial impact of investing in diverse markets and sectors. However neither diversification nor asset allocation can guarantee a profit or prevent loss.

Source: Vanguard, 2019.

- How do other portfolios (at higher equity allocations or increased diversification of asset classes, an increased fixed income allocation or a long-duration profile to hedge more interest rate risk, or a glide-path investment strategy) compare to the current one? Do these strategies improve key pension measurements and more closely align with stated risk tolerances? What is their impact on the distribution of required cumulative contributions or ending funding status? Do they improve the median but increase the worst-case outcomes, or vice versa?

Figures 6a and 6b display sample asset liability modeling output for a pension plan. In this case, the output could be used to evaluate the impact of different investment strategies through the range of projected future funding statuses and contribution requirements.

Qualitative overlay for risk management. Risk should not be determined solely by standard deviation or numerical indicators. It is necessary to step back and coordinate how the behavior of the available asset classes fits with the design of the pension plan. For instance, a frozen plan with high annual benefit payments or a popular lump-sum provision may want to avoid or limit its allocation to illiquid asset classes even if they provide a good return profile. The time horizon of the plan is not likely to align with that strategy.

Finally, risks should also be judged in the context of the sponsor's characteristics. Examples include the size of the liability versus the sponsor's market capitalization, the size of pension expense relative to the sponsor's net income, and the size of the contributions compared with the annual cash flow from operations. Risks placed in context can more easily be prioritized and managed along with an organization's non-pension plan risks.

Figure 6a. Ten-year forward-looking projected funding status from asset liability modeling

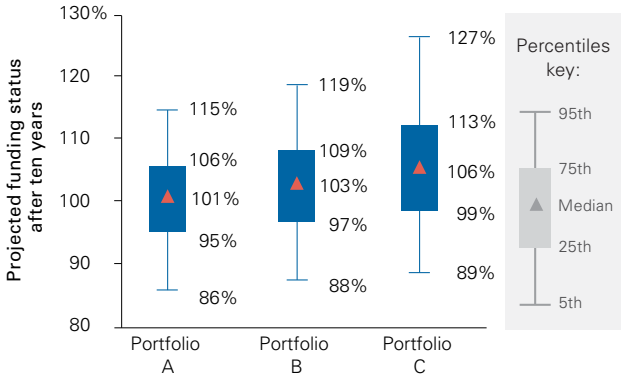
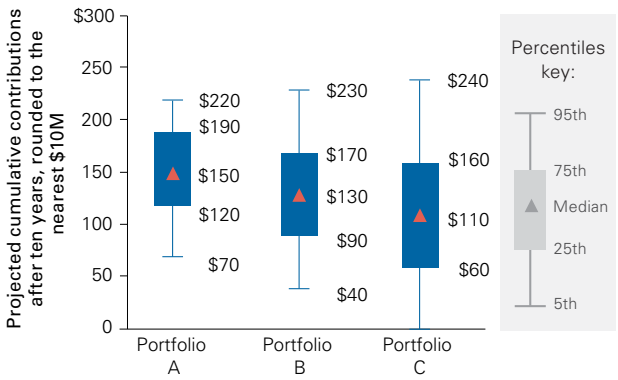


Figure 6b. Ten-year forward-looking projected cumulative contributions from asset liability modeling



These figures show the range of outcomes for three asset allocations, Portfolios A, B, and C. Figure 6a shows that Portfolio C has higher projected funding statuses at comparable percentiles than do Portfolios A and B. However, a plan sponsor would evaluate this output in the context of projected contributions as well, as shown in Figure 6b, and in conjunction with shorter-term volatility analysis such as one-year VaR analysis. Figure 5 shows an example of VaR.

Notes: This figure projects assets and liabilities using our capital market assumption on a ten-year basis for a distribution of funding status (assets/liabilities).

The examples shown are hypothetical and for illustrative purposes only. They are not based on any actual portfolios.

IMPORTANT: The projections or 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 derived from 10,000 simulations for U.S. equity returns and fixed income returns. Simulations as of December 31, 2019. Results from the model may vary with each use and over time.

For more important information regarding VCMM please see additional disclosures at the end of this paper.

Sources: Vanguard, Vanguard Capital Markets Model. Data are as of December, 31, 2019.

Conclusion

Trends in pension risk management over the last decade or longer have greatly shaped the design of pensions and the way they invest. The number of closed and frozen pension plans has risen to limit the growth rate of sponsors' pension liabilities. Corporate plans have increased their allocations to long-duration fixed income (often reallocating from public equities and alternative asset classes) to better match the plans' liability movements and lower their risk profile.[16]

The big takeaway for sponsors is that if a one-year decline of 10% in funding status is unacceptable and less than 60% of the pension's assets are invested in hedging interest rate risk, it may be time to review the plan's investments and possibly the pension risk management framework. As our survey results indicate, there is a serious disconnect between plan sponsors' risk tolerance in theory versus in action. Following a defined and documented risk management process can help align the competing goals of managing risk and pursuing a desirable rate of return on assets.

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Appendix

About the Vanguard Capital Markets Model

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 Vanguard Capital Markets Model® is a proprietary financial simulation tool developed and maintained by Vanguard's primary investment research and advice teams. 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 from as early as 1960. 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.

16 See Dion and Gannon (2019) for further discussion.

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