



Fundamentals of liability-driven investing

Vanguard research

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- In Vanguard's view, a liability-driven investing (LDI) approach is appropriate for all *traditional*, private defined benefit (DB) plans. The approach assumes that all asset-allocation decisions take into account the impact on relevant plan metrics, such as liability tracking error and funding-ratio volatility.
- An LDI approach is based on managing the risks and returns relevant to the DB plan. LDI strategies focus on managing interest rate risk by increasing asset and liability correlations.
- LDI does not require a 100% bond portfolio. Risk aversion will vary with plan structure and company circumstances, and bond allocations and durations should increase with risk aversion.
- We suggest asset-liability modeling (ALM) when implementing an LDI strategy. ALM studies are forecasts of plan assets, liabilities, and pension metrics that are used to inform the asset-allocation decision.
- This paper reviews the theoretical concepts supporting an LDI strategy and provides practical suggestions for building an LDI portfolio.

Vanguard believes that a liability-driven investing approach is appropriate for all traditional, private defined benefit plans. An LDI approach assumes that all asset-allocation decisions take into consideration the effect on relevant plan metrics. Although modern portfolio theory underlies an LDI strategy, the theory is applied within a different risk framework for LDI. Managing assets within a DB risk framework involves managing interest rate risk and its impact on the plan. Expected and downside risk are important to take into account in terms of funding-ratio volatility, liability tracking error, and contribution variability. This paper begins with a review of the theoretical concepts of LDI. We then provide guidance on building and implementing an LDI portfolio.

LDI theory: Views on risk and return

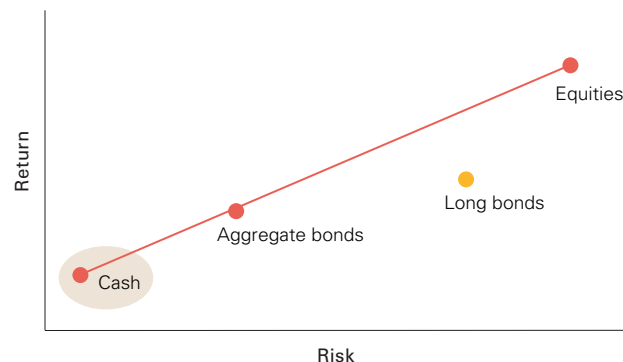
A different take on risk

DB plan sponsors have a different risk perspective from that of other institutional or personal investors. A pension plan's primary objective is to fund the plan liability; therefore, the level and volatility of funding are the relevant risk measures for DB plan sponsors.

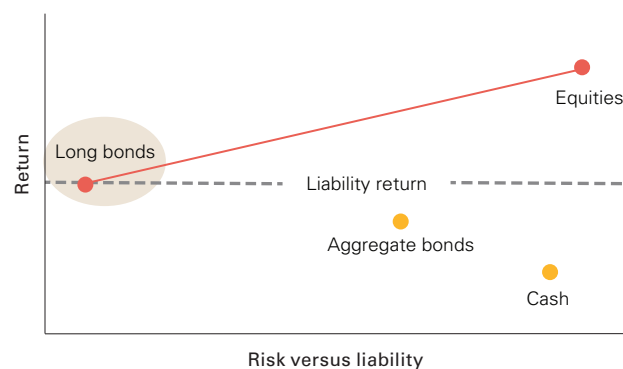
Figure 1 illustrates how the risk perspective for an LDI strategy varies versus those for traditional, absolute-return strategies. The latter strategies (see Figure 1a) have an objective of maximum return for a given level of risk, with risk measured as asset volatility. In such a framework, cash is the low-risk asset, as illustrated in the absolute-return (mean-variance) efficient frontier. In contrast, the liability efficient frontier replaces asset risk with *risk versus the liability*, or liability tracking error (see Figure 1b).¹ Also, this frontier represents the highest return for a given level of liability tracking error. Because the pension liability is highly correlated with a long-term corporate bond, the low-risk asset for DB plans is a long-term bond.

Figure 1. Risk perspective for LDI

a. Absolute-return efficient frontier



b. Liability efficient frontier



Source: Vanguard.

Important: The projections or 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. Distribution of return outcomes from VCMM is derived from 10,000 simulations for U.S. equity returns and fixed income returns. Simulations are based on market data and other information available as of December 31, 2013. VCMM results will vary with each use and over time. (See Appendix II, on page 7, for more details.)

Notes on risk: All investing is subject to risk, including the possible loss of the money you invest. Past performance is no guarantee of future returns. Investments in bond funds are subject to interest rate, credit, and inflation risk. 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. The performance of an index is not an exact representation of any particular investment, as you cannot invest directly in an index.

¹ Note that the return-to-risk relationships are not linear. The frontiers are drawn in Figure 1 as straight lines for simplification and illustration purposes.

Return variation with LDI portfolios

For many investors, the higher the return for a given level of return variation, the better. This is not always the case with DB plans, for which high asset returns are valuable to the extent that they keep up with the liability. If the liability return exceeds the asset return, then the funded status will decline and contributions will rise. In fact, higher-returning portfolios are often inefficient in terms of liability tracking error, because assets with higher expected returns often have low correlations with plan liabilities. And, as illustrated in Figure 2, LDI portfolios typically have high asset volatility. But high asset volatility has little impact on funded status, so long as the asset portfolio is built to correlate highly with plan liabilities.

Why interest rate risk matters

LDI strategies typically focus on managing interest rate risk for three primary reasons:

- The risk is hedgeable.
- The risk is the largest driver of change in pension liabilities.
- The risk is uncompensated and should be avoided.

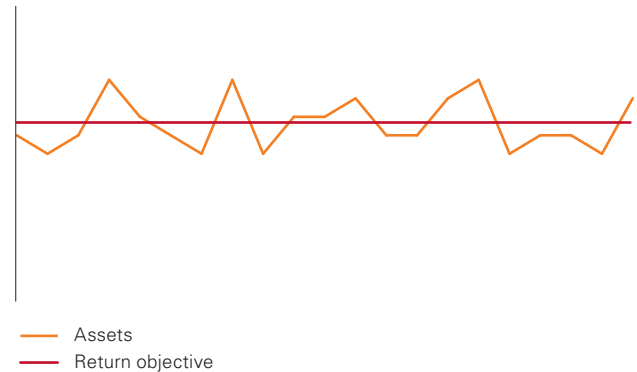
Other risk factors, such as wage increases, and mortality rates, are not as easy to hedge, generally speaking.² To manage such uncertain risks, a plan sponsor should work with the plan actuary to anticipate the costs that may result over time. In contrast, it is possible to hedge interest rate risk using plan assets by extending portfolio duration to match the long duration of liabilities. And because liabilities are based on present values, interest rates (discount rates) have typically accounted for the large majority of liability change.

Asymmetrical risk in funded status

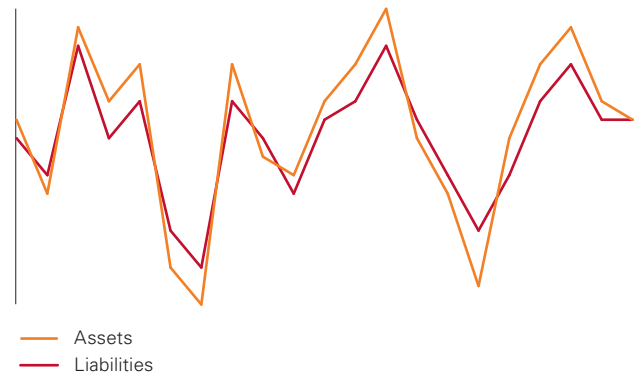
Risk with respect to overfunding is not proportionately rewarded, because—except in limited situations—plan assets must be used only to fund plan liabilities or to increase plan benefits. At lower funded levels and absent large contributions, plan sponsors may choose to adopt higher-risk portfolios in hopes of realizing a higher expected return to improve their funding level. The reward for this, potentially reduced required contributions or a lowering of PBGC (Pension Benefit Guaranty Corporation) insurance premiums, is proportionate to the risk of not meeting

Figure 2. Return variation for total-return versus LDI portfolio

a. Total-return portfolio has narrow range versus return objective



b. LDI portfolio moves with liability



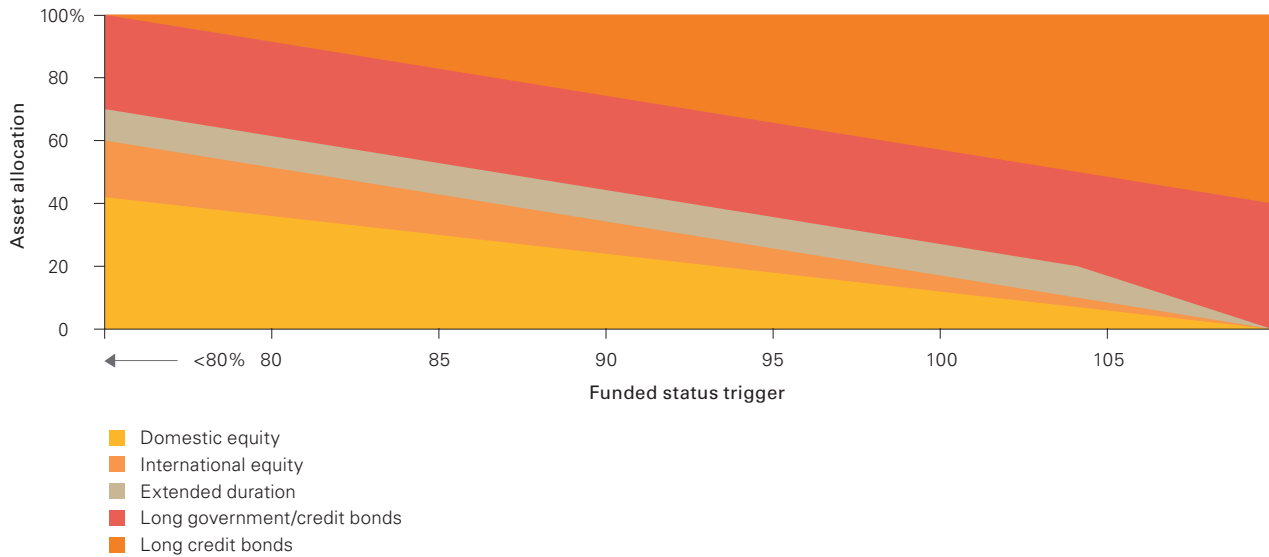
Source: Vanguard.

return expectations when the plan is underfunded. But as plans reach full funding, the risk begins to outweigh the potential benefit of higher returns. At or above the maximum funding level, surplus can become “stranded,”³ while the downside risk remains, so the primary investment objective should then be to *maintain* that level of funding, as opposed to improving it. This asymmetry of pension risk highlights the importance of an integrated plan for managing plan assets and liabilities.

² Longevity swaps and/or annuities can be purchased to hedge longevity risk, but these vehicles/products introduce their own set of expenses and risks.

³ Maximum funding level (MFL) is 100% plus the amount of surplus the plan can expect to use over the expected life of the plan. Funding above the MFL can lead to *stranded surplus* because, except in limited situations, plan assets must be used only to fund plan liabilities or to increase plan benefits. If excess assets do revert to the sponsor at termination, then a 50% excise tax is applied on top of the standard corporate rate.

Figure 3. Sample glide path: Frozen plan



Source: Vanguard.

Building the glide path

For many plan sponsors, LDI is implemented through a phased glide path, which “derisks” as funding level improves. This approach adapts investment strategy to the constraints of pension-risk asymmetry. The first step in developing the glide path is to set the maximum funding level (MFL) relative to liabilities. That decision is based on several factors, but primarily the plan’s status—that is, whether it is open, closed, or frozen. In general, frozen plans are the most at risk for stranded surplus, because there are no new benefits accruing, and most of the plans will seek to terminate eventually. Thus, MFLs will be lowest for frozen plans and highest for open plans, with closed plans in the middle. As a result, frozen plans will have faster derisking glide paths, and open plans can derisk more slowly. Within this framework, chosen portfolios vary with sponsors’ willingness and ability to take on risk.

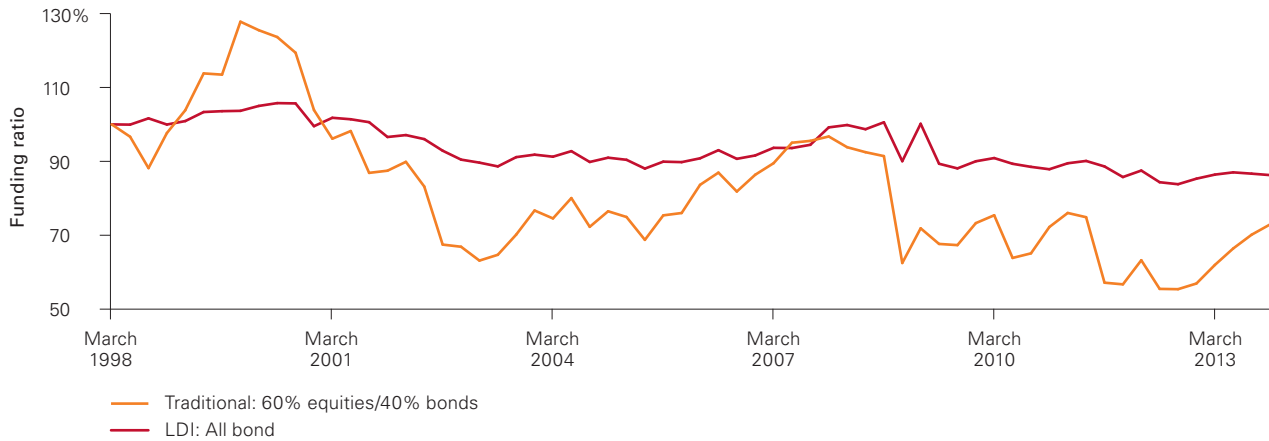
Figure 3 illustrates a sample glide path for a frozen plan. Because the plan is frozen, the MFL is relatively low, and the plan derisks quickly, moving to 100% bonds when the plan is 105% funded. However, since this plan is underfunded (below 80%), a sizable equity allocation (60%) is maintained initially. But as the funded status improves, the plan derisks by increasing the long-bond allocation and decreasing the equity allocation.

Implementing an LDI portfolio

Impact of asset allocation on funded status

The objective of LDI strategies is to manage funding-ratio volatility, thereby avoiding contribution surprises or a large negative impact on sponsors’ financial statements. Asset allocations with durations close to liability durations can dampen funding-ratio volatility considerably, as illustrated in Figure 4. The figure charts the historical funding ratio for two extreme portfolios: an all long-bond immunized portfolio and a traditional 60% equity/40% broad-market U.S. bond portfolio. The immunized portfolio has a current duration of approximately 15.5 years, to match the liability duration. In contrast, duration of the traditional portfolio is about 2.2 years. As the figure shows, funding-ratio variations of 15% or more in one year were typical over the five years through December 31, 2013, for the traditional portfolio, while the funding ratio for the immunized portfolio was relatively stable. As explained previously, no liability is perfectly hedgeable, but owning a 100% bond portfolio with equivalent duration and a reasonable yield-curve match can substantially lower the funding-ratio volatility, as Figure 4 illustrates. Actually, the 100% bond allocation eliminates the other biggest source of liability tracking error—equity risk, because the duration of equity is volatile and unstable.

Figure 4. Funding-ratio volatility: Traditional versus LDI portfolios



Notes: Liability based on Citigroup Pension Liability Index (published by Society of Actuaries). “Traditional” portfolio is 36% Dow Jones U.S. Total Stock Market Float-Adjusted Index, 24% MSCI EAFE + Emerging Markets Index, and 40% Spliced Barclays U.S. Aggregate Bond Index and Barclays U.S. Aggregate Float Adjusted Bond Index. “Immunization” LDI portfolio is 80% Barclays U.S. Long Credit Bond Index and 20% Barclays U.S. Treasury Strips 20–30 Year Equal Par Index.

Sources: Vanguard, Barclays, and Citigroup.

ALM in the LDI

Implementing an LDI strategy means making asset-allocation decisions that take into account the impact on pension metrics. It does not necessarily require an all-bond portfolio or a portfolio that’s perfectly matched to the plan’s liability or cash flows. Returns still matter, but more important for the DB plan is how asset returns change relative to liability returns.⁴ Asset-liability modeling (ALM) can help sponsors manage the relevant risk-return trade-offs for their plans.

ALM studies consider the impact of asset allocation on the plan’s potential risks and costs. Modeling involves creating forecasts of assets, liabilities, and pension metrics to inform the asset-allocation decision. We suggest consideration of the distribution of results, including the median outcome as well as the potential downsides and upsides, of the particular allocation. Important metrics include liability tracking error, funding ratio, and contribution variability.

At Vanguard, ALM studies are conducted using the Vanguard Capital Markets Model, which generates forward-looking distributions of assets and pension metrics. We forecast relevant pension metrics for a

traditional portfolio, and additional portfolios with increasing liability sensitivity. As an example, Figure 5, on page 6, shows the liability-tracking-error forecasts for a closed DB plan with a 91% current (as of December 31, 2013) funded status. As illustrated in the figure, the range of results varies with the asset allocation. The portfolio phase with the best match to liabilities—Phase 3—has not only the lowest median tracking error of the portfolios (5.3%) but also the lowest downside risk (10.5%), measured with 5th-percentile results.

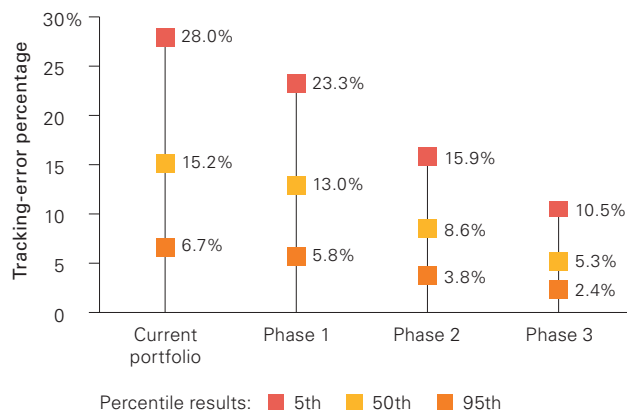
Consistent with the glide-path approach, the plan in Figure 5 should reallocate to the lower-risk portfolios as funding levels improve, while also considering plan status, sponsor constraints, and risk tolerance. For example, because this plan is underfunded, has not yet begun to derisk, and is closed but not frozen, a Phase-1 portfolio might be a good first step down the derisking path. Such a portfolio still maintains some exposure to equities to help improve funded status, but by moving from broad market to long bonds, tracking error is greatly reduced. Based on the distribution of various ALM metric forecasts, sponsors can determine the asset allocation that best aligns with their risk tolerance, company constraints, funded status, and plan status.

⁴ The change in liabilities can be viewed as a “return,” much like the change in assets. In both cases, return is simply the percentage change in the portfolio’s value, after adjusting for cash flows.

Figure 5. Liability-tracking-error forecasts for a closed DB plan

Portfolios	Current portfolio	Phase 1	Phase 2	Phase 3
U.S. equity	44%	44%	30%	15%
Non-U.S. equity	21	21	10	5
U.S. aggregate bonds	35	0	0	0
U.S. long-term credit	0	20	45	65
U.S. extended duration	0	15	15	15

Tracking error



Notes: Figure is based on hypothetical VCMM five-year cash-flow simulations. See Appendix I, for plan information and assumptions.

Sources: Vanguard, based on VCMM simulations.

Conclusion

Vanguard believes that an LDI approach—managing assets in consideration of liabilities—is appropriate for all sponsors of traditional, private DB plans. LDI strategies differ from total-return strategies in that they are based on managing risks relevant to pension plans. Interest rate risk is the largest risk for DB plans, because of the way interest rates affect plan liabilities. LDI strategies are based on managing interest rate risk and its impact on pension metrics such as funded status. Improving the match of assets to liabilities can potentially lower the variation in pension metrics, because long bonds correlate highly with pension liabilities. As a result, derisking with LDI often relies on larger/longer bond allocations. For many plan sponsors, a phased-in glide-path approach to derisking as funded status improves is most appropriate. ALM studies should be done to inform the asset-allocation decision and determine how and when to derisk. Risk tolerance will vary with plan status; the sponsor-company’s constraints, financial health, and idiosyncratic risks; as well as the market’s economic and regulatory environment. Larger/longer bond allocations are often recommended for sponsors with lower risk tolerance. The goal is to build an asset portfolio that matches a sponsor’s willingness and ability to take on risk with respect to the pension plan.

Appendix I. Plan information and assumptions for tracking-error forecast

Plan status: closed.

Initial funding ratio: 91%.

Liability duration: 17 years.

Time horizon for study: 5 years.

Appendix II. About the Vanguard Capital Markets Model

The Vanguard Capital Markets Model (VCMM) is a proprietary financial simulation tool developed and maintained by Vanguard's Investment Strategy Group. The VCMM forecasts distributions of future returns for a wide array of broad asset classes. These 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 markets, and certain alternative investment strategies. 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 December 31, 2013.

The VCMM is grounded in the empirical view that the returns of various asset classes reflect the compensation investors receive for bearing different types of systematic risk (or beta). Using a long span of historical monthly data, the VCMM estimates a dynamic statistical relationship among global risk factors and asset returns. Based on these calculations, the model uses regression-based Monte Carlo simulation methods to project relationships in the future. By explicitly accounting for important initial market conditions when generating its return distributions, the VCMM framework departs fundamentally from more basic Monte Carlo simulation techniques found in certain financial software. The reader is directed to the Vanguard research paper *Vanguard Capital Markets Model* (Wallick, Aliaga-Díaz, and Davis, 2009) for further details.

The primary value of the VCMM is in its application to analyzing potential client portfolios. VCMM asset-class forecasts—comprising distributions of expected returns, volatilities, and correlations—are key to the evaluation of potential downside risks, various risk-return trade-offs, and diversification benefits of various asset classes. Although central tendencies are generated in any return distribution, Vanguard stresses that focusing on the full range of potential outcomes for the assets considered, such as the data presented in this paper, is the most effective way to use VCMM output.

The VCMM seeks to represent the uncertainty in the forecast by generating a wide range of potential outcomes. It is important to recognize that the VCMM does *not* impose “normality” on the return distributions, but rather is influenced by the so-called fat tails and skewness in the empirical distribution of modeled asset-class returns. Within the range of outcomes, individual experiences can be quite different, underscoring the varied nature of potential future paths. Indeed, this is a key reason why we approach asset-return outlooks in a distributional framework.

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