BANK OF AMERICA

WORKPLACE BENEFITS

Next-generation liability-driven investing

This paper is written assuming the reader already possesses a basic understanding of LDI and the relevant terminology. For a review of the basics, please see our white paper *Foundations of Liability-Driven Investing*. For a broader understanding of how pension investment strategies can be customized for a specific plan, please refer to our white paper *An Investor's Guide to Pensions*.

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Executive Summary

The core focus of liability-driven investing (LDI) is to reduce risk by hedging interest-sensitive liabilities. As pension risk management strategies have evolved over the last two decades, LDI has taken on a more prominent role for single-employer pension plans. Implementation approaches for LDI have become more sophisticated along the way as well. This paper outlines and explores modern approaches to LDI for pension plans, whether the goal is efficiently constructing a very tight liability hedge or tactically implementing a more active strategy to potentially earn outsized returns while hedging.

This paper begins by exploring the interaction between a plan's projected cash flows and the ever-contorting yield curve to build a foundation for understanding liability risk. Full asset-liability immunization is discussed as a theoretical approach with practical limitations. Next, there is a demonstration of how dollar durations can be used to measure how much interest rate risk is hedged for a given plan (that is, its hedge ratio). By applying those concepts together, a more complete model for evaluating the effectiveness of an LDI strategy is presented, clarifying not just how interest rate risk is being hedged broadly, but also the potential exposure to changes in the shape of the yield curve.

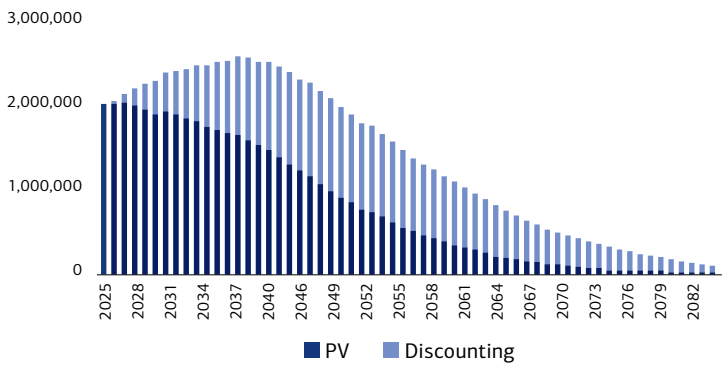
With that framework for analyzing LDI strategies established, the focus of the paper shifts to practical implementation techniques and advanced tactics for active management. First, there's an illustration of how LDI implementation requires balancing various key objectives. Next, there's an evaluation of full bond matching approaches versus fund-based approaches, highlighting the advantages associated with each. Then, active strategies are considered for various objectives, including the tactical management of duration weights, credit exposures and yield curve positioning. Finally, the role of LDI is considered in two contrasting end-state solutions for well-funded frozen pension plans: plan termination versus hibernation.

Cash flows and the yield curve

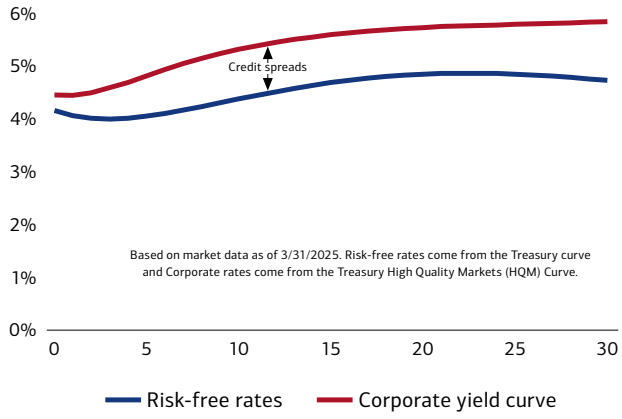
An actuary determines a pension liability for a plan by:

- Developing a projection of expected benefit payments based on census data and actuarial assumptions
- Discounting those cash flows to a measurement date using a discount rate based on bond yields

Project liability cash flows



Yield curve illustration



For illustrative purposes only.

For accounting purposes, the discount rate typically reflects current yields available on AA-rated corporate bonds maturing in the future. The selected discount rate is most commonly based on a full yield curve. Therefore, the interaction between the projected cash flows and the daily changes to the corporate yield curve results in changes to a plan's liability. LDI seeks to hedge this risk by constructing an asset portfolio that closely matches the risk profile of the plan's liability. This paper will examine some practical approaches to doing that, but first, consider the theory behind asset-liability immunization.

Asset-liability immunization

Theoretically, one could construct a portfolio to fully satisfy the liability if projected cash flows were known with certainty and if an endless supply of bonds to choose from existed. Coupon and principal payments from the bonds would align with payments flowing out of the plan to participants. If that bond portfolio were established, the plan's liability would be immunized not just to changes in the level of interest rates, but to changes in the shape of the yield curve as well. Essentially, no matter how financial markets played out, the right amount of cash would flow from the assets to satisfy liabilities as they came due.

There are practical limitations to this approach that mostly confine it to the theoretical realm:

- Credit risk prevents full immunization. If a bond issuer defaults, then funds may not be available for pension payments when due.
- The required bonds may not be available. Corporate bond issuance is quite limited at longer maturities (20+ years). Most pension plan liabilities extend well beyond this timeframe.
- Pension payouts aren't known with certainty. They're based on long-term actuarial projections dependent on long-term assumptions of participant behavior, mortality and other factors.

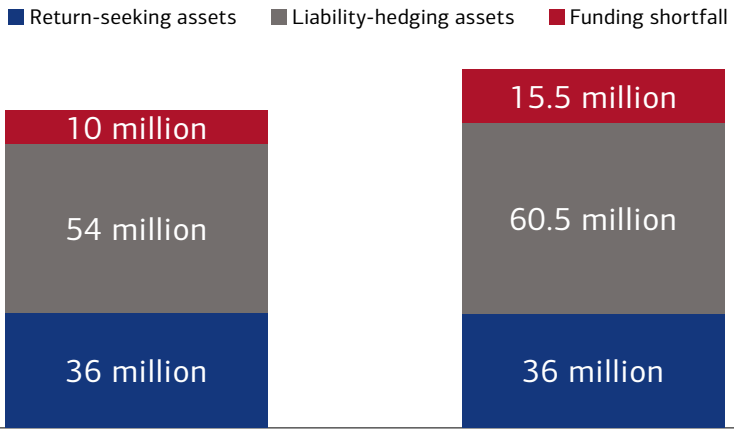
Because fully immunizing the liability with bond matching isn't actually viable for pension plans, this paper focuses on evaluating the effectiveness of practical LDI strategies that are commonly employed. To do this, a framework for comparing how LDI strategies that are hedge interest rate risk is presented next.

Dollar durations and hedge ratios

To understand how much interest rate risk is being hedged overall, dollar durations and hedge ratios must be calculated. The dollar duration measures how sensitive the liability and assets are to interest rates in dollar terms. This can help plan sponsors understand interest rate risk in more relatable terms (that is, losing $3 million is more tangible than losing "3% of funded ratio"). Then, dividing the dollar duration of the assets by the dollar duration of the liabilities determines the hedge ratio, the portion of overall interest rate risk being hedged. Hedge ratios can then be used to compare various LDI implementations, where higher hedge ratios generally imply that there is less overall interest rate risk.

Below is a simple example of a hedge ratio calculation for a hypothetical plan, where the height of each bar represents the plan's liability:

Interest rate risk



For illustrative purposes only.

Assumptions	Results
• Plan has $100 million in liabilities and $90 million in assets.	• The dollar duration of the liability is $12 million. This is 12 (liability duration) × $100 million (liability value) ÷ 100. The liability would increase by $12 million (12%) if interest rates fall 1%.
• The plan's liability duration is 12 years.	• The dollar duration of the assets is $6.5 million. This is 12 (asset duration) × $54 million (LDI assets) ÷ 100. The assets would increase by $6.5 million if interest rates fall 1%.
• Assets are invested 40% in equities and 60% in fixed income with an average duration of 12 years.	• The plan's hedge ratio is 54%. This is $6.5 million (asset dollar duration) ÷ $12 million (liability dollar duration). 54% of the liability's interest rate risk is hedged.

In the illustration above, the liability increases by $12 million from $100 million to $112 million when interest rates fall 100 basis points. At the same time, the liability hedging assets increase by $6.5 million from $54 million to $60.5 million. For every dollar the liability increases, the liability hedging assets increase 54 cents — a hedge ratio of 54%.

This example illustrates a fairly common situation for a frozen and underfunded pension plan. Even with fixed income assets invested to match the liability duration, a large portion of the liability's interest rate risk may remain underhedged. Still, in a scenario where interest rates fall and drive the liability higher, the fact that a significant portion of assets also grows in a corresponding way mitigates the effect on the funded status of the plan.

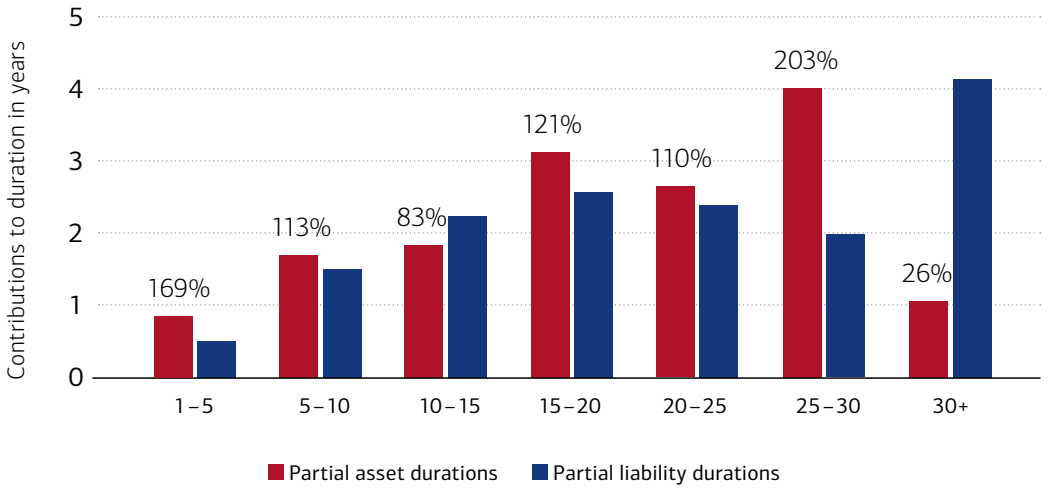
Key rate durations

In constructing a liability hedge, the first goal is to hedge interest rate risk generally, but more nuance is required. Consider a pension plan with a duration of about 13 years, right in line with the overall duration of the Bloomberg/Barclays long credit index. A plan sponsor could just invest in a long credit fund to match overall duration. This would hedge much of the interest rate risk, but such a simplistic approach could significantly expose the funded status of the plan to changes in the shape of the yield curve. To understand yield curve risk, key rate durations (KRDs) need to be considered.

A KRD is a measure of the sensitivity of the pension liability (or the price of a bond) to changes in yields at a specific maturity on the yield curve. For example, the 10-year KRD of a liability reflects how the value varies in response to changes in the yields at 10 years.

Analyzing a pension liability through the lens of KRDs requires segmenting the liability and the yield curve. This can be done in a variety of ways. For example, intervals of five years could be used, as shown in the example below. Using a greater number of smaller segments may allow for more precise analysis, but the additional complexity isn't rewarded beyond a certain point.

Charting key rate partial durations



The example above is illustrative but demonstrates a realistic hedging profile for many pension plans given the practical challenges and constraints involved. At the longest end of the yield curve (30+ years), hedge ratios are typically low because fewer assets are available to hedge ultra-long-duration liabilities. That may be partially balanced by overhedging at long durations where it's easier to find bonds, namely from 20 to 30 years. Being overhedged at the short end of the yield curve is common too because most bonds have coupon payments that contribute to the hedge at the short end of the curve.

Finally, when adjusting yields to calculate the KRDs of the LDI portfolio, it's important to consider the source of the change. Interest rates can change because of both risk-free rates and credit spreads. This distinction doesn't affect the KRDs of the plan's liability since it's typically determined using corporate yields. LDI strategies frequently use a combination of corporate and Treasury bonds, meaning that changes in credit spreads won't affect the entire portfolio. This must be considered when selecting investments for use in an LDI strategy.

LDI implementation: A balancing act

Constructing an LDI portfolio requires a series of decisions that don't necessarily have clear-cut answers. Objectives will need to be established first, then trade-offs must be accepted and managed. Additionally, it is important that plan sponsors understand what LDI can and can't do. LDI, while it cannot actually immunize the assets, can reduce funded status volatility effectively. LDI strategies will be subject to tracking error and surplus (or deficit) returns based on their construction and the features of the liability to be hedged.

There are possible variations as discussed later in this paper, but broadly speaking, LDI strategies are usually constructed so that:

1. The portfolio's duration (and KRDs) is aligned relative to the liability's duration (and KRDs)
2. The portfolio's yield is aligned relative to the liability's discount rate
3. The portfolio's credit quality is aligned relative the liability's implied quality

This can be a complicated task to execute due to numerous practical constraints. It is often not possible to fully satisfy all these objectives simultaneously, so they must be prioritized or balanced. Consider the following key trade-off that most LDI implementations must deal with:

Situation:

- Pension cash flows often stretch decades into the future, where there are few appropriate high quality credit bonds available, but they're discounted using AA yields.
- Governmental bonds or Treasury STRIPS are necessary to hedge the longest-duration portions of liability, so they're included in the portfolio.
- Treasury bonds don't have credit risk, though, and thus they can't be used to hedge credit spreads. They'll also generally have yields well below the plan's discount rate.

Potential solution:

- Pension plans often invest in lower quality bonds, such as those with A or BBB ratings. These bonds make up a huge portion of the bond market and offer higher yields than higher rated bonds.
- By combining these higher and lower quality bonds together, pension plans can build LDI portfolios that have an "average" quality level similar to the liability and perhaps a similar yield as well.

Limitations:

- Credit spreads aren't hedged at longer durations, where Treasury STRIPS are predominantly used.
- It still may not be possible to achieve the desired yield.

Trade-off:

- Plans must balance the desire to hedge longer duration liabilities and achieve a high hedge ratio with the need to have higher yields and a credit quality that's aligned with the liability's implied quality.

There is no perfect solution, which is why implementing an LDI strategy may be best described as a balancing act. By balancing dollar durations, KRDs, yield/discount rate and quality, an extremely good LDI portfolio can be built.

Organizations that can optimize these elements and effectively manage the trade-offs through different market environments will be able to implement LDI strategies very effectively.

LDI implementation styles

The goal of LDI is to reduce interest rate risk. However, interest rate risk isn't a singular concept. Risks can be found at all points along the yield curve and in changes of credit spreads relative to risk-free rates. This means that most plan sponsors will have to decide how to focus their LDI portfolio. At Bank of America, we categorize these options as styles of LDI implementation.

Consider the following two examples:

1. A well-funded plan with sufficient assets available to hedge the full liability will generally seek to hedge across the full yield curve.
2. An underfunded plan with a smaller allocation to LDI probably won't be able to hedge the full yield curve. For this plan, decisions will have to be made on which aspects of the hedge to prioritize.

From these two examples, the first plan will favor the cash flow matching style described below. For the second plan though, the appropriate style isn't as clear cut. Any of the styles listed below may make sense depending on the plan sponsor's goals and objectives.

Three styles have become more common than others. Here, these styles are defined and compared in a way that illustrates their approaches and trade-offs.

Cash flow matching LDI	Long first LDI	Targeted hedge ratio LDI
The classic style that attempts to match a portion of the full liability cash flows fairly uniformly.	This style attempts to match the liability cash flows but prioritizes the longer-duration cash flows first.	This style targets a specific hedge ratio, relative to the liability cash flows. A hedge ratio target of 100% is common, but other targets may be appropriate.
Potential benefits: • Hedges interest rate risk across the full yield curve, which should minimize the impact of a steepening or flattening yield curve. • Results in a liability-hedging asset duration approximately equal to the liability duration.	**Potential benefits:** • By matching the longer duration cash flows first, higher hedge ratios can be achieved than with the cash flow matching approach. • Avoids overhedging because shorter-duration cash flows are prioritized once longer durations are fully hedged.	**Potential benefits:** • Allows plans to target a specific amount of interest rate hedge, which can be useful for active strategies. • Potentially allows underfunded plans to achieve high hedge ratios, minimizing overall interest rate risk.
Potential drawbacks: • Leaves a portion of the overall liability interest rate risk unhedged for underfunded plans. • Hedging shorter-duration cash flows may be viewed as inefficient because they're less sensitive to changes in interest rates.	**Potential drawbacks:** • With very little hedging at the short end of the yield curve, the plan is exposed to risks from contortions in the yield curve. • Hedging the longest cash flows has practical limitations because there are very few bonds with maturities beyond 30 years.	**Potential drawbacks:** • Without a uniform liability hedge, yield curve risk may remain. • For poorly funded plans, there are practical limitations on the level of hedge ratios that can be targeted due to the limited availability of bonds with extremely long maturities.

The style that is most appropriate for a pension plan will depend on the financial position of the plan and the goals and objectives of the plan sponsor. Asset/liability modeling (ALM) can help assess how each style performs in different economic environments. Working with a provider that understands how the styles differ will help a plan sponsor get the most out of their LDI portfolio. The selected LDI style can also impact what funds or securities are appropriate for the portfolio implementation approach. The next section discusses two of the most prominent implementation approaches.

LDI implementation approaches

When building an LDI portfolio, there's no prescription requiring a certain approach. Any fund, security or product that helps a plan sponsor re-create their liability's risk and return profile may be appropriate. As LDI has continued to evolve, two differing approaches have gained popularity: Fully Custom LDI and Fund-Based LDI.

Fully Custom LDI	Fund-Based LDI
Implementation style: Individual bonds with a wide range of maturities are purchased by the plan and held in a separate account.	**Implementation style:** Several investment funds (mutual funds, exchange-traded funds (ETFs), etc.) are purchased by the plan and blended to create LDI exposure.
Potential benefits: • Customization allows the portfolio to be finely tuned to the liability's risk and return profile, achieving a tighter hedge of KRDs across the yield curve. • The plan owns the individual securities. Separate accounts provide greater transparency to the underlying investments. • Well-built custom LDI portfolios should require fewer trades in the future.	**Potential benefits:** • The liability's risk and return profile can be reasonably approximated using a small number of funds. • Funds tend to charge lower fees than the cost of hiring a separate manager, especially for smaller plans. • Many investment funds, such as ETFs, are highly liquid, so repositioning the portfolio is simple. This can be important when employing more active strategies.
Potential drawbacks: • Due to the expertise required, a specialized LDI manager is typically necessary. • Hiring an LDI manager may be more expensive than executing a fund-based approach, though that may not always be the case.	**Potential drawbacks:** • Many plan sponsors may not have the necessary expertise to execute a fund-based approach. • Due to the simplified nature, the hedge may be less effective in immunizing against changes in the shape of the yield curve.

Derivatives* can be used to complement either approach.

- Treasury STRIPS and interest rate swaps are the most commonly used.
- Derivatives are often used to achieve leverage in order to hedge more interest rate risk with a lesser asset amount. This is important if a plan sponsor is looking to achieve a high hedge ratio without dedicating as much of the plan's assets to liability hedging.
- Derivatives can also be used to adjust the hedging profile at specific durations on the yield curve, either to tighten the overall hedge or to take tactical positions.

* Derivative instruments may at times be illiquid, subject to wide swings in prices, difficult to value accurately and subject to default by the issuer. The risk of loss in trading derivatives, including swaps, OTC contracts, and futures and forwards, can be substantial. There is no guarantee that this objective will be achieved. The use of hedging strategies may, in certain circumstances, cause the value of a portfolio to appreciate or depreciate at a greater rate than if such techniques were not used, which in turn result in significant loss.

Active hedging strategies

Investors with strong convictions on interest rates, credit spreads or future changes to the shape of the yield curve may find a more active approach appealing. Since the primary purpose of LDI is to hedge liability risk, potentially taking on more risk by actively managing the LDI assets may counter that goal. Still, for investors who have the appetite and understand the risks involved, taking advantage of anticipated market changes could result in better performance. In this section, options for actively managing a hedging strategy and related considerations are presented.

Some available strategies:

1. Duration exposure can be tactically managed based on forward-looking views on interest rates. If there's an expectation that interest rates will rise, holding shorter-duration assets will be beneficial. If interest rates instead are expected to fall, more long-duration fixed income will be beneficial.
2. The balance between governmental bonds and corporate bonds can be actively managed based on the current level of and views on potential changes to credit spreads. Likewise, bonds of different credit qualities or even from different industries or issuers can be either overweighted or underweighted based on forward-looking views.
3. Yield curve positioning can be tactically managed as well to reflect anticipated changes in the shape of the yield curve. Yield curve positioning will usually affect the overall hedge ratio, so the interplay between these different effects must be considered.

Key considerations

1. The plan sponsor's overall risk tolerance must be considered first. The risk budget could be shared between different types of risks, and diversifying risk exposures provides benefits.
2. Active hedging strategies could either be built into the investment policy statement by specifying target hedge ratios, or they could be implemented with an outsourced chief investment officer (OCIO) provider's discretion. Investing LDI assets to match the liability's duration is a common benchmark.
3. Duration management strategies should consider the shape of the yield curve and levels of forward rates as the market-implied view on future interest rates. When the yield curve is more upward slopping, the forward rate structure implies that intermediate duration interest rates are expected to rise, so an anticipated modest rise in interest rates may not be sufficient to support underweighting duration. An upward sloping yield curve makes holding long-duration fixed income more attractive with higher available yields and the potential for excess returns from sliding down the yield curve.
4. The hedging strategy must be cognizant of practicalities. For example, there's a limit on duration with corporate bonds. STRIPS can extend duration further than corporates, but they don't hedge credit risk, which is important, too.
5. Dynamic hedging strategies require very careful monitoring and speedy execution. This can be hard to achieve in many service models. Daily asset-liability monitoring and outsourced implementation are likely necessary for most plans without dedicated staff.

Since the primary emphasis of LDI is risk management through interest rate hedging, any tactical reflection of market views should be implemented with discipline. Active strategies could be harmful if market views aren't at least somewhat reliable.

End-state solutions: Termination versus hibernation

For mature pension plans, LDI typically makes up a large portion of the overall asset allocation. The appropriate style and implementation may depend on the plan sponsor's preferred end state.

Termination eliminates a pension plan with a full settlement of all plan liabilities through a combination of lump sums paid to participants and annuities bought from insurance companies.

a) Annuitization costs through insurance companies are affected by interest rates, much like pension liabilities. Plans approaching termination are generally de-risked by implementing a significant amount of LDI in an attempt to minimize uncertainty in termination costs.

b) The hedging profile will likely need to be adjusted at different stages in the process, such as when interest rates for anticipated lump sum payments "lock in."

c) A fully custom implementation may be preferable for larger plans (those over $250 million) as discounts can be obtained from insurers when purchasing annuities using assets in-kind (actual bonds) rather than cash.

   i) Insurers may prefer to receive bonds to maintain the liability hedge through the transaction process.

   ii) Transaction costs associated with buying and selling a large portfolio of corporate bonds can be significant. These costs can be avoided through an asset-in-kind transaction.

Hibernation is a strategy for maintaining a well-funded pension plan into the future while carefully managing funded status volatility and maintenance costs.

a) Since managing funded status volatility is a key goal, liability-driven investing is typically central to the investment strategy.

b) A portion of the asset allocation will typically still be dedicated to equities and other return-seeking assets to potentially produce excess returns for offsetting maintenance costs.

c) Striking the right balance in developing an investment policy for a given plan is best achieved through performing a comprehensive asset-liability study.

d) Given the emphasis on maintaining a reasonable expense level, LDI implementation approaches will need to be fee-efficient. Full bond matching may be possible for larger plans, but smaller plans might need to rely on the use of commingled funds.

e) Depending on a plan sponsor's risk budget, the implementation of some active hedging strategies with appropriate discipline may be rewarded.

Conclusion

Over the last two decades, LDI has taken on a more prominent role for most single-employer pension plans. Implementation approaches have become more sophisticated as a result. To execute an effective LDI strategy, it's important to understand the issues, nuances and trade-offs associated with LDI. These, in addition to other important LDI topics, were explored in this paper to best explain next-generation liability-driven investing.

For more information, please contact your Bank of America representative or visit go.bofa.com/workplacebenefits.

Appendix: Duration terminology

The primary goal of LDI is to hedge interest rate risk. Duration is a measure of that risk — that is, of how sensitive the plan's liability is to changes in interest rates. It's important to note, though, the term "duration" isn't a single concept. Different types of durations exist and serve different purposes. Included here are definitions of important duration measures and guidance for calculating them for a given plan.

a) **Macaulay duration** — A measure of interest rate risk that's easy to calculate. The Macaulay duration is found by calculating the weighted average timing of cash flows. It's easy to calculate from a payment stream. This measure of duration can be useful as a quick approximation, but ultimately doesn't directly capture changes in interest rates.

b) **Modified duration** — An approximation for interest rate risk that results from a simple adjustment to the Macaulay duration. Dividing the Macaulay duration by (1+ discount rate) produces the modified duration. The modified duration captures the change in the liability due to a change in interest rates. This measure of duration can be useful because the calculation is straightforward but may be less precise for certain types of cash flow projections.

c) **Effective duration** — An approach explicitly defined to measure changes in interest rates. For some pension plans, the modified duration and effective duration will be the same. For others, the modified duration may not capture actual interest rate risk well, particularly if the amount or timing of the cash flows depends on interest rate levels. For example, the modified duration may not fully capture interest rate risk for a cash balance plan that has an interest crediting rate tied to a market interest rate also including a floor or minimum rate. Though the calculation of the effective duration is more complicated, it provides a more accurate measure of interest rate risk for most plans.

d) **Convexity** — A measure of how the duration changes as interest rates change. The interaction between a pension plan's liability and changing interest rates is nonlinear. For a fixed set of projected cash flows, higher interest rates will lead to lower durations, and vice versa. Duration is a useful approximation, but accounting for convexity is important, particularly when considering longer time frames and large changes in interest rates. Some types of LDI implementation capture convexity better than others. However, convexity risk can be managed by closely monitoring the liability and adjusting the hedging assets as necessary. Set-it-and-forget-it approaches don't work as well, and convexity is a primary reason for this.

Investing involves risk, including possible loss of the principal value invested. Investments in foreign securities or sector funds, including technology or real estate stocks, are subject to substantial volatility due to adverse political, economic or other developments and may carry additional risk resulting from lack of industry diversification. Funds that invest in small or mid-capitalization companies experience a greater degree of market volatility than those of large-capitalization stocks and are riskier investments. Bond funds have the same interest rate, inflation and credit risks associated with the underlying bonds owned by the fund. Generally, the value of bond funds rises when prevailing interest rates fall and falls when interest rates rise. Investing in lower-grade debt securities ("junk" bonds) may be subject to greater market fluctuations and risk of loss of income and principal than securities in higher-rated categories. There are ongoing fees and expenses associated with investing. Bear in mind that higher return potential is accompanied by higher risk.