LGIM America

Liability Driven Investing

Revisiting the Client-Led Solution Framework

Liability driven investing (LDI), managing pension investments in a manner that defines and identifies solutions to reduce risks relative to pension liabilities, has become recognized as a best practice for defined benefit pension plan sponsors. The trend toward LDI has accelerated as companies recognize that taking on non-core financial risk to leverage shareholder returns using the pension plan is less effective than leveraging returns in the core business. LDI can add value for all plan sponsors. For some plan sponsors, LDI is nice to have, for others LDI is critically important.

This paper describes various approaches to LDI, from the most basic to more customized solutions. Highlights include:

- Most plan sponsors start with simpler approaches and incrementally move toward more customized solutions over time.
- LDI solutions typically include increasing exposure to fixed income, extending fixed income duration and utilizing both a Treasury and a credit component.
- The greater the proportion of equity in the overall portfolio, the more the balance between Treasuries and credit in the fixed income portfolio should tilt toward Treasuries.
- Hedging most of the plan's interest rate risk and part of the plan's credit spread risk can improve outcomes.
- The specific application of LDI most appropriate for each sponsor depends on the sponsor's goals for the plan, risk tolerance and resources to devote to the solution.
- Actively managing the LDI program to reflect opportunities can further enhance funded status outcomes.

Introduction – Liability Driven Investing

While the actual implementation of each plan sponsor's liability driven investing strategy varies considerably, there is one consistent implication for how plan sponsors now approach asset allocation. The first order asset allocation decision is no longer focused on the split between equities and core fixed income but rather is focused on deriving the split between a Return-Seeking Asset (RSA) and a Liability-Hedging Asset (LHA) component. The RSA component seeks to generate returns in excess of the expected liability return (growth in the present value of the liability attributable to the passage of time—similar to the discount rate on the liability). The LHA component is focused on risk reduction by hedging risks in the liability that the sponsor does not wish to accept (i.e., interest rate risk and credit spread risk) and typically consists of long duration bonds, and, increasingly, interest rate derivatives.

The use of LDI has grown over time as plan sponsors have experienced the pain of large fluctuations in funded status and the negative impact this can have on the balance sheet, income statement and cash flows. Plan sponsors with a large commitment to RSA are subject to equity market variation and shocks which can result in substantial funded status volatility. Even plans that focus on LHA are subject to funded status risk.

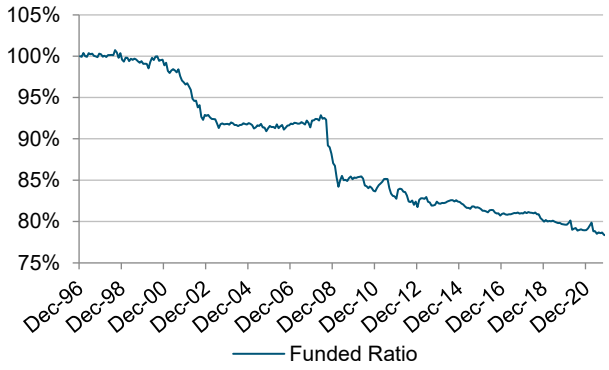
The biggest year-to-year liability risk plan sponsors face is the pension discount rate falling, causing an increase in the present value of the pension liabilities. Importantly, pension discount rate risk can be caused by two different market scenarios—Treasury rates falling and/or credit spreads narrowing. We refer to the former as interest rate risk and the latter as credit spread risk. Each of these risks needs to be explicitly managed.

While interest rate risk can be managed in a relatively straightforward manner, it is crucial to realize that credit spread risk is not so straightforward to manage. This is

because while credit spread risk is very real and can have very real economic consequences, pension liabilities do not actually have default risk. In other words, if you buy credit to manage this credit spread risk you are exposed to real losses on your assets when a bond defaults or is downgraded, whereas you do not have an offsetting benefit (default) in your liabilities by paying less in benefit payments.[1] This is a deficiency in the way pension discount rates are developed, but accounting and funding guidelines and regulations both specify that pension discount rates be based on corporate bond yields.

The issue of the drag that defaults and downgrades can have on funded status is most easily seen by tracking a plan's funding ratio over time where the plan was invested in long duration credit (A or better credit quality) that matched the duration of the plan's liability. *Figure 1* tracks the funding ratio of this hypothetical plan using this basic immunization strategy.[2]

Figure 1: Historical funding ratio performance for a long credit immunization strategy



Source: LGIM America, using sources of Bloomberg and Bank of America Merrill Lynch (BofAML).[2] Data as of December 31, 2021.

Clearly, the long credit immunization strategy is not risk-free. The strategy has significantly underperformed the liability since December 31, 1996. Importantly, most of the underperformance occurs during periods of economic stress when the RSA component (i.e. equities) of the portfolio is struggling and corporate cash flow is weak. Essentially, investing in a basic long duration credit index exacerbates the funding ratio pain when plan sponsors can tolerate it the least.

This does not mean that sponsors should avoid credit and invest only in Treasuries. It does highlight the importance of understanding the goals of the LDI program and designing the program in a way that captures the liability hedging aspects of LDI while minimizing the drag on funded status that can result from downgrades and defaults.

Pension plans and plan sponsors come in many shapes and sizes which can have a significant impact on the sponsor's approach to managing pension risk and the role that LDI plays in the approach. One key element is whether the size of the plan and resulting pension risk is large relative to the size and risk tolerance of the plan sponsor. For some plans, the pension plan and risk are quite small and spending time focusing on pension risk is not as important as other aspects of their business and financial risk management. For other sponsors, pension risk can be significant relative to the size of the enterprise, and the use of LDI and other pension risk management tools are important aspects of the financial management of the enterprise.

In our experience, transitioning from a traditional "60/40" (60% equities, 40% core fixed income) policy to an LDI policy is typically done in phases. In the first phase, liabilities are implicitly recognized as an important investment consideration which results in the core fixed income allocation being recognized as an inefficient use of capital. This is because core fixed income is not completely effective at hedging liabilities (duration is too short) and is ineffective at seeking returns in excess of liabilities (yield is too low). Therefore, the first phase simply constructs the LHA component by switching the fixed income benchmark to a market-based long duration benchmark and does not typically need to utilize derivatives. We will address LDI implementation issues and provide our views on how to select an appropriate benchmark later in this paper. In our experience, market LDI benchmarks are a combination of a long duration credit component and a long duration Treasury component. As a result, we focus on three key benchmarking considerations, including how benchmarks may change as plans de-risk and the LHA component grows and the RSA component shrinks. First, and most importantly, we discuss the split between the credit

1 LGIM America.

2 Asset returns are based on the Bloomberg US Long Credit A-AAA Index. Liability returns are based on a duration neutral (relative to the asset benchmark) blend of the BofAML Retired US Pension Plan AAA-A Index and the BofAML Young US Pension Plan AAA-A Index. Hypothetical back-tested performance results do not present the actual returns of any account or strategy managed by LGIMA. The results depicted are hypothetical, selected by LGIMA and were compiled with the benefit of hindsight. These results are based on simulated or hypothetical assumptions that have certain inherent limitations. Unlike the results in an actual performance record, these results do not represent actual trading. Because these trades have not actually been executed, these results may have under- or over-compensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated or hypothetical trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. No representation is being made that any account will or is likely to achieve profits or losses similar to these being shown. Past performance is not indicated of future results.

component and the Treasury component. Second, we discuss how to best implement the Treasury component. Lastly, we cover the construction of the credit component.

Section two of this paper addresses the second phase of LDI implementation, where the plan's liabilities are the ultimate plan level investment benchmark and focuses resources on taking only compensated risk relative to this explicit liability benchmark. This typically results in using a custom liability benchmark (scaled to reflect the target interest rate hedge ratio, credit spread hedge ratio and amount of capital allocated to the LHA component) for the LHA component. Efficient implementation of LDI using custom liability benchmarks typically requires plan sponsors to embrace derivatives and explicitly state target levels of the key risks that drive funding ratio volatility—equity market risk, interest rate risk and credit spread risk.

Section one: LDI—Market-based benchmarks

Key considerations for benchmarking

There are three key considerations relevant to market LDI benchmarking—strategic allocation of credit versus Treasuries, the Treasury component and the credit component.

Strategic (neutral) allocation of credit vs. Treasuries

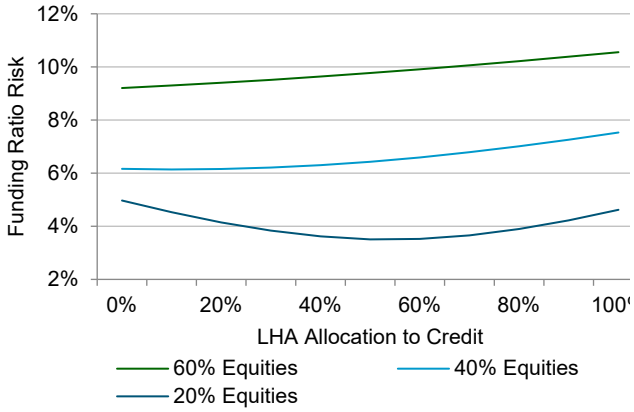
The first LDI decision is the strategic split between long duration credit and long duration Treasuries. If it were possible to get the yield on long duration credit without any defaults or downgrades the decision would be quite easy—put all of the money in long duration credit. However, this is difficult, if not impossible to do, so most plan sponsors, adopting an LDI framework, utilize some combination of Treasuries and credit. The larger and more equity-like the RSA component is, the larger the strategic allocation to Treasuries should be.

We measured the historical funding ratio risk of various splits between Treasuries and credit. We tested this for plan sponsors with a 60%, 40% and 20% allocation to equities to give an indication of how the appropriate split might change as plan sponsors de-risk. The historical time-series we analyzed was the period from December 31, 1996 until December 31, 2021. The historical backtest results are summarized in Figure 2.[3]

Depending on the allocation to equities, the LHA allocation to credit can have a varying impact on overall funding ratio risk.

- With a 60% hypothetical allocation to equities, our simulation found any LHA allocation to credit increases overall funding ratio risk. This is because the large allocation to equities has been historically highly correlated with the credit spread risk in pension liabilities and has therefore offset the liability volatility associated with credit spread movements. With a 40% hypothetical allocation to equities, our simulation found risk is low up to the point when the LHA component allocates around 40%-50% to credit. As the credit allocation increases beyond 50%, simulation results show risk begins to increase.
- With 20% hypothetical allocation to equities, our simulation resulted in risk being minimized at an LHA allocation to credit nearing 70%. Since there was not much equity exposure to offset the liability volatility associated with credit spread movements, our simulations found that our belief in a larger allocation to credit helps to minimize risk.

Figure 2: Historical hypothetical funding ratio risk for various splits between credit and Treasuries



Source: Bloomberg, Bank of America Merrill Lynch. Data as of December 31, 2021. Note: Funding ratio risk is the annualized standard deviation of monthly funding ratio returns. Funding ratio returns are equal to annualized monthly funding ratio returns. We use long duration indices and index results, not LGIM assumptions. We test 60/40, 40/60 and 20/80 allocations. Monthly funding ratio returns calculated as (asset return – liability return) / (1+ liability return). Equity returns are equal to the return of the S&P 500 total return index. Returns of the long duration corporate bond strategy are equal to the returns of the Bloomberg Capital Long Credit (credit quality A or better) index. Cash returns are equal to LIBOR. Liability returns are based on a duration neutral (relative to the corporate bond benchmark) blend of the BofAML Young US Pension Plan AAA-A Liability index and the BofAML Retired US Pension Plan AAA-A Liability index. Treasury based interest rate hedge returns are based on a duration neutral (relative to the liability benchmark) blend of the BofAML Young US Pension Plan Treasury Liability index and the BofAML Retired US Pension Plan Treasury Liability index minus LIBOR.

In addition to looking at funding ratios from 1996 to 2021, it

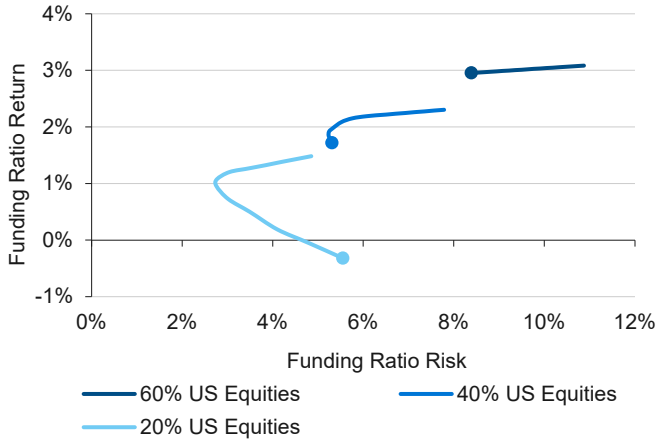
3 Hypothetical back-tested funding ratio risk does not present the actual risk or returns of any account or strategy managed by LGIMA. The results depicted were compiled with the benefit of hindsight and are qualified in their entirety by the disclosures at the end of this presentation. Past performance is not indicative of future results.

is also important to analyze risk during periods of economic stress. It is during these difficult economic periods that the LHA component needs to help buoy funded status and not make things worse. We analyzed the hypothetical historical maximum funding ratio drawdowns[4] during the credit crunch from July 1, 2007 to March 31, 2009 for various splits between credit and Treasuries. Our findings reinforced the observations above on the optimal level of credit exposure in the LHA component.

We have only considered implications for funding ratio risk so far. We also need to consider the potential long-term excess returns credit may provide over Treasuries. Essentially, we need to analyze the impact of investing in credit vs. Treasuries on funding ratio risk and funding ratio return. In order to measure the impact on funding ratio return we make assumptions for the long-term returns of liabilities, long duration credit, long duration Treasuries and equities.[5]

Based on these return assumptions, along with the historical volatilities we have discussed, we can now analyze the hypothetical risk-reward tradeoff of the credit vs. Treasuries decision. Figure 3 summarizes the simulated results of this hypothetical risk-reward tradeoff.[6]

Figure 3: Hypothetical risk-reward tradeoff for various splits between credit and Treasuries[6]



Source: LGIM America. Data as of December 31, 2021.

The circles represent the risk and reward for an LHA allocation of 0% credit and 100% Treasuries. The lines reflect the path the risk-reward tradeoff takes as we increase the LHA allocation to credit. Return increases as we move assets from Treasuries to credit which is assumed to provide an excess return over the long-term. However, as previously discussed, the simulation shows risk also increases as the LHA allocation to credit increases beyond what was needed (in addition to the equity portfolio) to offset the impact of changing credit spreads on the liability.

Where on these risk-reward curves is the most appropriate place to be? In this hypothetical case of a 20% or a 40% allocation to equities, there are clearly some inefficient choices—those at the bottom of the curve offer a lower expected return (relative to the top of the curve) for a given level of risk. The efficient part of these curves spans from the minimum risk portfolio to the maximum return portfolio. In our view, the primary objective of the LHA component is to reduce funding ratio risk, therefore, we recommend anchoring the strategic LHA allocation to credit near the minimum risk portfolio.

For plan sponsors with high equity allocations, minimum risk portfolios have a lower LHA allocation to credit. This may cause concern for plan sponsors who are counting on large LHA allocations to credit in order to hit a particular long-term return target. For these plan sponsors, we suggest revisiting the target allocation to equities (as opposed the LHA split between credit and Treasuries) as this tends to be a more efficient lever to pull in order to achieve a certain target return. The discussion has revolved around the long-term strategic split between credit and Treasuries. This split should be based on long-term expectations of risk and return and should be separate from tactical views based on the relative value (i.e. views on credit spreads) of credit vs. Treasuries. With that being said, we recognize that there are periods of time when credit spreads are quite wide (i.e. late 2015) or quite narrow (i.e. 2004-2006, 2018). We support the use of significant discretion (i.e. +/- 25%) around the strategic (neutral) LHA split between credit and Treasuries to take advantage of these environments and better control funding ratio outcomes.

In summary, we find that the appropriate long-term strategic split between credit and Treasuries is dependent on the size and composition of the RSA component of the overall portfolio and the long-term objectives of the plan sponsor. Based on a typical liability profile and the various risk and return assumptions we have made, we find that an LHA allocation anywhere from 25% credit (60% equities) to 75% credit (20% equities) may be appropriate.

Treasury component

With the acknowledgement that there is likely to be at least some allocation to a Treasury component, we can now focus on how to appropriately benchmark the Treasuries.

4 Maximum funding ratio drawdown is defined as the drop-in funding ratio from its highest point to its lowest point.

5 Long-term return assumptions as of December 31, 2021: Liabilities (5.30%), Long Treasury (4.10%), 15+ STRIPS (4.55%), Long Credit (5.10%), Equities (8.30%).]

6 Hypothetical backtested funding ratio risk and funding ratio return does not present the actual risk or returns of any account or strategy managed by LGIMA. The results depicted were compiled with the benefit of hindsight

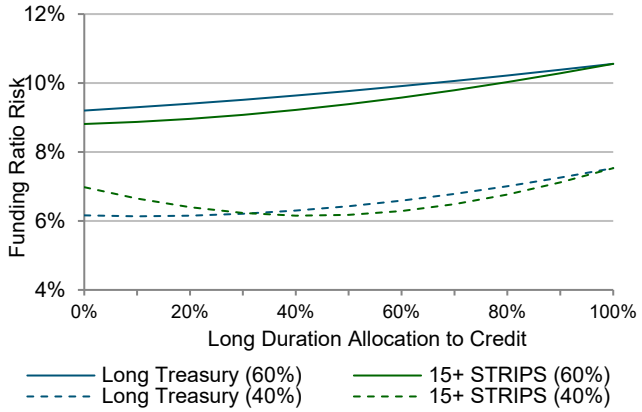
Based on our experience we see sponsors choose between two options:

1. A Treasury benchmark that is very similar in interest rate duration profile to the long duration credit benchmark, or
2. A Treasury benchmark that is meant to maximize interest rate duration exposure and therefore reduce the interest rate duration mismatch as much as possible between assets and liabilities.

Based on the same historical data series (1996-2021), we have been working with, we start by evaluating the impact these two options have on funding ratio risk for various LHA allocations to credit vs. Treasuries. For option one (Long Treasury) the Treasury returns are based on a Treasury portfolio that matches the interest rate duration of the long duration credit portfolio.[7] This can be thought of as a close proxy for the government component of the Bloomberg US Long Government/Credit Index. For option two (15+ STRIPS) historical returns are based on a portfolio of US Treasury STRIPS with a maturity of 15+ years. Figure 4 summarizes the results.[8]

Figure 4 shows, for sponsors with a 60% allocation to equities, using a 15+ STRIPS benchmark can significantly reduce risk relative to a long Treasury benchmark. In our view, this is because 15+ STRIPS have almost twice the duration of the long Treasury benchmark and, therefore, eliminate more of the interest rate duration mismatch between assets and liabilities. This is especially true in our simulation when there is a significant LHA allocation to Treasuries.

Figure 4: Hypothetical impact of different Treasury benchmarks for various splits between credit and Treasuries (60% and 40% equities)



Source: Bloomberg and Bank of America Merrill Lynch. Data as of December 31, 2021.

Lower exposures to equities show a similar risk reduction benefit of using 15+ STRIPS instead of the long Treasury benchmark. The only difference is at very high allocations to Treasuries, the benefits of using 15+ STRIPS are diminished due to providing more than enough duration.

The other factor to consider when setting the long-term strategic Treasury benchmark is the impact on long-term returns. With 60% equities, using 15+ STRIPS instead of the long Treasury benchmark shows higher return and lower risk in our simulated analysis.

Some market participants believe interest rates may rise and find it uncomfortable to consider such a long duration Treasury benchmark. However, we believe it is important to separate tactical views from strategic benchmarking decisions. If one has a view that rates will rise, then this can be reflected by holding a shorter duration Treasury portfolio. This should be acknowledged as an active investment decision versus the strategic benchmark.

We believe that using the 15+ STRIPS benchmark makes sense for many plans. In our experience, the exception to this would be a situation where using 15+ STRIPS would either increase the interest rate duration of plan assets beyond the point where it reduces risk, and/or introduce a large interest rate duration mismatch at certain points along the curve.

Credit component

The last issue to consider is how to most efficiently construct the benchmark for the LHA allocation to credit. We recommend a credit benchmark over a corporate-only benchmark to allow for more credit risk diversification.

For most clients, we also recommend managing the overall credit quality of the fixed income portfolio by combining a full investment grade (AAA to BBB) credit portfolio with a larger Treasury portfolio. This approach offers better diversification, larger opportunity for active management, and alignment with end-game solutions. Nevertheless, we have found that clients that want to minimize tracking error vs. accounting liabilities will may benefit from having a higher quality (AAA to A) benchmark, combined with sector and issuer diversification limits which are aimed at to mitigating downgrade/default concentration risks.

Section two: Custom liability benchmarking

Having addressed market-oriented benchmarking in Section one, we can turn our attention to the three key considerations we believe are most relevant to custom liability benchmarking—the appropriate benchmark for the

7 Long Treasury returns are based on a duration neutral (relative to the Liability benchmark) blend of the BofAML Retired US Pension Plan Treasury Index and the BofAML Young US Pension Plan Treasury Index.

8 Hypothetical backtested funding ratio risk does not present the actual risk or returns of any account or strategy managed by LGIMA. The results depicted were compiled with the benefit of hindsight

LHA component, the decision to move from market-based benchmarking to custom liability benchmarking, and how hedging can be implemented via a synthetic equity approach.

What is the appropriate benchmark for the LHA component?

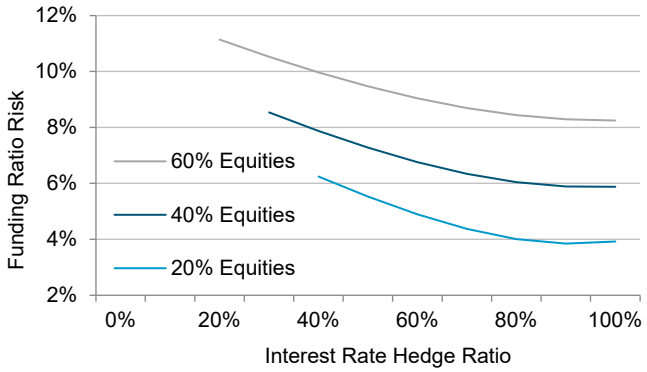
There are two critical decisions that need to be made when constructing a benchmark for the LHA component of a liability benchmarking LDI solution. First, how much of the liability interest rate risk should be hedged—in other words, what is the strategic interest rate hedge ratio? Second, determining how much of the liability credit spread risk should be hedged—we refer to this as the strategic credit spread hedge ratio.

Strategic interest rate hedge ratio

We start with the strategic interest rate hedge ratio. In our experience we found that this decision is mostly driven by a combination of what the risk reduction benefits are of increasing the interest rate hedge ratio and the level of liquidity risk introduced as derivatives are increasingly needed when increasing the interest rate hedge ratio.

Looking first at the benefits of interest rate hedging, we measured the historical funding ratio risk of various interest rate hedge ratios. We tested this for plan sponsors with a 60%, 40%, and 20% allocation to equities to give an indication of how the appropriate interest rate hedge might change as plan sponsors de-risk. At this point we simply assume that half of the physical assets held within the LHA component are allocated to long duration corporate bonds. The other half is allocated to cash and a Treasury- based hedge used to attain the various levels of interest rate hedging. When determining the interest rate hedge ratio we assign zero duration to the equities. The historical time-series we analyzed for this purpose was for the period from December 31, 1996 until December 31, 2021. The simulation results of the historical backtest are summarized in Figure 5.[9]

Figure 5: Hypothetical historical funding ratio risk for various interest rate hedge ratios—aggregate period



Source: LGIM America using Bloomberg and Bank of America Merrill Lynch. Data as of December 31, 2021.

The graph shows that, for all equity levels, risk is reduced by increasing the interest rate hedge ratio. This is not a surprising result as increasing the interest rate hedge ratio reduces the duration mismatch between asset and liabilities and therefore reduces the impact that changes in interest rates can have on the plan's funding ratio. It is worth noting that there are diminishing amounts of risk reduction as the interest rate hedge ratio approaches 100%. This is because equity volatility increasingly dominates the overall funding ratio risk as interest rate risk is reduced. Said differently, as the level of interest rate hedging approaches the optimal point, the remaining interest rate risk is largely diversified away by the remaining and dominant equity exposure. Therefore, the last few incremental amounts of hedging offer less risk reduction. Further, and consistent with the above, the overall risk reduction benefits of interest rate hedging increase as the equity exposure is reduced. With 60% equities, the benefits of going from 20% interest rate hedged to 100% interest rate hedged are a 36% reduction in risk. With 20% equities, the benefits of going from 40% interest rate hedged to 100% interest rate hedged are 45% reduction in risk. What can be seen here is that a large (i.e. 60%) exposure to equities can overwhelm interest rate risk and therefore limit the benefits of increasing the interest rate hedge ratio and removing all interest rate risk.

Another consideration is how the risk reduction benefits of interest rate hedging can change depending on the market environment. During the period we studied, the correlation between the RSA component and the interest rate risk in the liability was negative. This negative correlation is equivalent to assigning equities a negative duration. This negative duration is precisely why you notice in Figure 6 that risk is reduced all the way up to a 100% interest rate hedge ratio. However, there are periods of time when this correlation is positive and it is important to consider what impact this can have on the risk reducing benefits of interest rate hedging. When one assumes zero correlation between the RSA component and the interest rate risk, the optimal strategic interest rate hedge target is equal to the actual funded status percentage (i.e. 90% funded plan's target would be 90%).

The last issue to consider is whether these target hedge ratios are practical to implement. The risk plan sponsors worry about is that interest rates rise causing mark-to-market losses on the interest rate derivatives used to

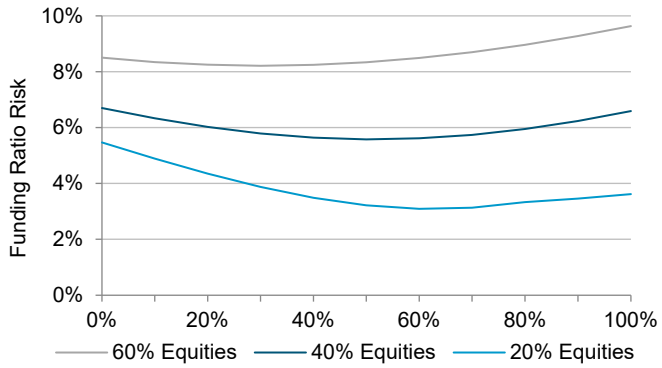
[9] Hypothetical back-tested funding ratio risk does not present the actual risk or returns of any account or strategy managed by LGIMA. The results depicted were compiled with the benefit of hindsight.

implement the hedge. These mark-to-market losses need to be collateralized on a daily basis, so there needs to be sufficient collateral set aside to meet these collateral requirements.

To address this return, we conducted some stress testing for the hypothetical portfolio with 60% in RSA and 40% in LHA and found the risks to be manageable for most situations in our analysis. So, we believe hedging up to 90% (or even 100%) of the interest rate risk is practical.

It is worth considering how a plan's funded status and liability profile may impact the practicality of the recommended interest rate hedge ratios. The higher the plan's funding ratio the more assets there are to hedge the liability and therefore the easier it is managing the derivatives-related liquidity risk. With respect to the plan's liability profile, the longer the plan's liability duration the more volatility the hedging portfolio will have and therefore the more difficult time managing the derivatives-related liquidity risk. So, for underfunded plans with longer than average liability profiles, these practical implementation considerations can result in lower recommended interest rate hedge ratios.

Figure 6: Hypothetical historical funding ratio risk for various credit spread hedge ratios—aggregate period



Source: LGIM America using Bloomberg and Bank of America Merrill Lynch. Data as of December 31, 2021.

Strategic credit spread hedge ratio

We can now turn our attention to the second important benchmarking decision—what should the target credit spread hedge ratio be? As mentioned above, this decision is highly influenced by the size and composition of the RSA component.

Below, we summarize our research and recommendations on the topic. To provide analysis, we follow a similar approach to analyzing the impact of interest rate hedging—we measure the historical funding ratio risk of various credit spread hedge ratios. We tested this for plan sponsors with a 60%, 40%, and 20% allocation to equities to give an indication of how the appropriate level of credit spread hedging might change as plan sponsors de-risk. We assume that the overall target interest rate hedge ratio is static as we increase the level of credit spread hedging. For this analysis we assume a 90% static target interest rate hedge ratio. While maintaining the respective allocation to equities, we then evaluate the impact on the plan's funding ratio risk of increasing the credit spread hedge until we attain a credit spread hedge equal to the static target interest rate hedge ratio of 90%. We do this by first moving the physical hedging assets from cash to the long duration corporate bond strategy we have been modeling throughout the paper. Then, once the physical assets held within the LHA component are exhausted we assume that we can actually get synthetic exposure to long duration corporate bonds via a total return swap where the pension fund pays LIBOR and receives the total return on the long duration corporate bond strategy. When determining the credit spread hedge ratio we assign zero duration to the equities. The historical time-series we analyzed was for the period from December 31, 1996 until December 31, 2021. The results of the historical backtest are summarized in Figure 6.[10]

With 60% equities, very small increases in the credit spread hedge ratio increases overall funding ratio risk. This is because the large allocation to equities has been highly correlated with the credit spread risk in pension liabilities and has therefore offset the liability volatility associated with credit spread movements. The first 20%-30% increase in the credit spread hedge ratio has little impact on risk. After that point, further increases to credit, increase risk on an accelerated basis.

With 40% equities, risk is reduced up to the point when the credit spread hedge ratio approaches 40%-50%. As the credit spread hedge ratio increases beyond 50% risk begins to increase. This is because a 40%-50% credit spread hedge ratio combined with a 40% equity allocation has essentially offset the liability volatility associated with credit spread movements.

With 20% equities, risk is minimized with a credit spread hedge ratio of about 60%. Since there was not much equity exposure to offset the liability volatility associated with credit spread movements, a larger allocation to credit is necessary to minimize risk.

In addition to looking at funding ratio volatility over the past 22 years, it is also important to analyze risk during periods of economic stress. It is during these difficult economic periods that the LHA component needs to help buoy funded status and not make things worse. For this we analyzed

[10] Hypothetical bactested funding ratio risk does not present the actual returns of any account or strategy managed by LGIMA. The results depicted were compiled with the benefit of hindsight.

historical maximum funding ratio drawdowns during the most recent credit crunch (July 1, 2007 to March 31, 2009) for various credit spread hedge ratios. Just as too much credit can increase funding ratio risk, it can also exacerbate the funding ratio pain during the worst possible times. We found in analyzing the data that the credit spread ratios developed above (20% at 60% RSA, 40% at 40% RSA, and 60% at 20% RSA) work well in periods of economic stress as well. At this point we can safely say this credit spread hedge ratio decision is an important one and is dependent on the size and composition of the RSA component.

We have considered funding ratio risk so far. We also need to consider the potential long-term excess returns credit may provide over Treasuries. We analyzed the trade-offs of varying the level of credit spread hedging within a custom benchmark context and found very similar results to those describe in *Section one* of this paper (see Figure 4).

In summary, we find that the appropriate long-term credit spread hedge ratio is dependent on the size and composition of the RSA component of the overall portfolio and the long-term objectives of the plan sponsor. Based on a typical liability profile and the various risk and return assumptions we have made, we find that anywhere from credit spread hedge ratio of 20% (60% equities) to 60% (20% equities) may be appropriate.

Is it worth it to move from market-based benchmarking to custom liability benchmarking?

After discussing what the appropriate level of interest rate and credit spread hedging are for a particular plan, we often get the same follow-up question—is it worth introducing the complexity and costs of utilizing a liability benchmark and the derivatives that may come along with a custom liability LDI solution? This is a fair question that deserves attention. We start by analyzing the risk and return implications of moving from market-based LDI to custom liability LDI. While we see a wide variety of market-based LDI solutions, we make the simplifying assumption for this analysis of modeling the market benchmark LHA as if it was passively invested in the Bloomberg Long Government/Credit index. We utilize the same time-series we have been using throughout this article. Figure 7 summarizes the key funding ratio statistics for comparing market-based vs. custom liability benchmarking approaches for various levels of equity exposure in another hypothetical backtest.

We see that, for all levels of equity exposure, a reduction in funding ratio risk of close to 30% or more has been achieved by moving to a custom liability solution. This is a meaningful reduction in volatility. Further, in our experience, custom liability LDI adopters also focus their attention on how well a particular strategy holds up during periods of economic stress. In these scenarios, we have seen significant benefits that come with a custom liability LDI solution, as can be seen in the last two columns of Figure 7. For example, with 60% equity exposure, this particular plan's funding ratio would have been improved by 9-10% during the 2000-2002 recession and the 2007-2009 credit crunch. The risk reduction benefits are less significant as the equity allocation is reduced. This is because, as the equity allocation is reduced, the credit spread hedge increases more in the custom liability LDI solution which dampens the benefits as credit performed poorly during these economic stress periods, especially during the 2007-2009 credit crunch.

Custom approaches add the most value when the plan's liability profile (and duration) is not well aligned with available standard market benchmarks.

Beyond the risk reduction benefits we have discussed, there are additional benefits that come along with a custom liability LDI solution. These include the risk monitoring and performance reporting benefits that come along with moving away from market benchmarks to using a custom liability benchmark. This is important because, by adopting an LDI framework, plan sponsors are switching their investment objective from long-term asset-only return to the objective of either matching performance of the liabilities or outperforming it by some margin. With this shift in objective, it is important to have a liability benchmark in place for the overall plan as well as for the LHA component (although the benchmark for the LHA component needs to be scaled to reflect the target interest rate hedge ratio, credit spread hedge ratio, and amount of capital allocated to it). Doing so will allow the plan's investment committee to assess how much risk they are taking relative to liabilities, whether or not they have achieved their plan level liability-relative objective, and whether or not their hedging program has

Figure 7: Hypothetical risk reduction benefits of custom liability benchmark—mature liability profile

FR risk reduction by LHA approach				Percent improvement in funded ratio during crisis periods		
Equity Allocation (%)	Long Gov't/ Credit	Custom Liability Benchmark	Risk Reduction	4/1/2000 - 9/30/2002	7/1/2007 - 3/31/2009	1/1/2020 - 3/31/2020
60	10.9%	8.2%	24.2%	10%	9%	3%
40	7.8%	5.6%	27.5%	6%	5%	3%
20	4.8%	3.1%	35.3%	2%	2%	4%

Source: Hypothetical results from Bloomberg and Bank of America Merrill Lynch.

been successful. This is all part of good investment governance for LDI adopters. An essential element to good governance is simply having the relevant information for an investment committee to determine what risks they are taking and if the decisions that they have made are working. Utilizing an explicit liability benchmark for overall plan performance and performance of the LHA component does may help facilitate good investment governance.

While the benefits associated with a custom liability approach need to be balanced with any additional costs and derivatives related risks, we generally find the additional benefits outweigh the costs.

Can hedging be implemented via a synthetic equity approach?

For clients that choose to rely on derivatives to implement a custom LDI solution, we have seen two different ways of implementing the target hedge ratios and equity exposure. Traditionally, LDI adopters have implemented their desired interest rate and credit spread hedge ratios by utilizing interest rate and credit derivatives within the LHA component to extend duration and attain the desired levels of hedging. This way most of the capital can be freed up for physical investment in equities and other return-seeking assets allowing the plan to maintain their long-term expected return. We refer to this method of implementing custom LDI as synthetic liabilities.

We have also seen plan sponsors utilize a different approach which we refer to as synthetic equities. Using this approach, most of the capital is allocated to physical long duration bonds in order to achieve the target hedge ratios without having to use interest rate and/or credit derivatives. The target equity exposure is then achieved by utilizing a portfolio of equity derivatives (i.e., equity futures) which are only partially backed by cash collateral. The rationale for this approach is typically the belief that physical bonds are a better liability hedge than interest rate and credit derivatives, and that equity derivatives aim to cheaply and effectively deliver the returns of a physical equity investment.

Beyond risk mitigation, it is also important to consider the potential impact of various approaches on returns. The potential benefit of the synthetic liability approach is that alpha may be earned on the physical investment in equities.

In summary, we find that in high target credit spread hedge ratio situations a synthetic equity approach can be the most efficient way to implement a custom liability LDI solution.

End game considerations

Increasingly, plan sponsors are considering their end game with regard to managing their defined benefit plans. Some want to exit the business of managing the plan and the risks inherent with plan management. These sponsors plan to fully transfer pension risk to annuity providers (through an annuity buy-out) or to participants through the payment of lump sums. For these sponsors, the end game is a full pension risk transfer.

Other plan sponsors want to minimize risks associated with plan management, but are not ready to shoulder the extra cost of an annuity buy-out. These sponsors want to manage the plans in a low-cost, low-risk way that is sustainable for the intermediate to long-term. For these sponsors, the current end-game is self-sufficiency.

For both types of sponsors, we see increasing interest in pursuing a Buy and Maintain Credit (BMC) Strategy. A Buy and Maintain Credit Strategy can help satisfy sponsors goals by scheduling investment cash flows to match future cash flows. This has the advantages of being low cost, low volatility, and structuring the portfolio in a way that prepares for an efficient annuity buy out. It can also include private credit, which can further improve outcomes.

Conclusion

Market benchmark approach

For plan sponsors working within a market benchmark LDI implementation, we believe that the biggest LDI challenge they face is how to maximize the reward-to-risk efficiency of the capital that has been allocated to the LHA component. We also believe that the answer to this question lies in getting the LHA benchmark right, both now and over time as the plan de-risks from the RSA component to the LHA component. This LHA benchmark is typically some combination of long duration credit and long duration Treasuries. Consistent with these two component structures, we posited that setting the appropriate LHA benchmark is achieved by recognizing the following:

1. The bigger and more equity-like the RSA component, the lower the neutral allocation to long duration credit.
2. Risk can be significantly reduced by maximizing duration (i.e. via STRIPS) instead of using a traditional long government benchmark. Importantly, we found this to be true even when capital allocation to LHA is low.
3. We recommend a credit benchmark over a corporate only benchmark. We also recommend using full investment grade benchmarks (inclusive of BBBs) over higher quality (A or better). As plans de-risk, using a custom liability benchmark can add value (this is discussed in more detail in the next section).

Based on the relevant risk-return assumptions, our views on appropriate market benchmarking are summarized in Figure 8 on the following page.

Figure 8: Summary of key LDI benchmark guidelines

RSA allocation	60%	40%	20%
LHA allocation	40%	60%	80%
Market LDI benchmark			
Credit	25%	50%	75%
Treasuries	75%	50%	25%
Treasury benchmark	15+ STRIPS	15+ STRIPS	Blend of Treasuries and 15+ STRIPS
Credit benchmark	Credit	Credit	Credit
Custom liability LDI benchmark			
Target hedge ratio			
Interest rate	90%	90%	90%
Credit spread	20%	40%	60%
Volatility reduction	high	higher	highest
Importance of liability benchmark	high	higher	highest

Custom liability benchmark approach

We find that successful custom liability LDI implementation is dependent on effectively determining:

1. The appropriate levels of interest rate and credit spread hedging
2. If the efficiencies gained via custom LDI exceed the costs that come with it, and
3. If synthetic equities or synthetic liabilities should be used to implement the desired set of derivatives exposures, if needed

We believe that the answers to these questions lie in maintaining a total portfolio perspective. We also find that the answers to these questions change as the plan sponsor de-risks the plan by moving assets from an RSA component to an LHA component. More specifically, we make the following three key observations.

First, we find that, strategically, the vast majority of interest rate risk should be hedged. We find this to be true even when there is a very large exposure to an RSA component. Further, we find that the strategic credit spread hedge ratio is dependent on the size and composition of the RSA component. The bigger and more equity-like the RSA component, the lower the strategic credit spread hedge ratio should be.

Second, we find that the risk reduction benefits and the importance of using a liability benchmark are significant, likely outweigh the costs, but are dependent on several factors—liability profile, funded status, and size of the RSA component. Importantly, the incremental improvement in funding ratios is especially large when needed the most—during periods of economic stress.

Third, using synthetic equities to free up capital to hedge with a physical corporate bond portfolio can increase the effectiveness of the credit spread hedge and may add to portfolio yield. Importantly, these benefits are only relevant for plan sponsors who desire a target credit spread hedge ratio beyond what can be achieved without freeing up more capital by synthesizing at least part of the RSA component.

Based on the relevant risk-return assumptions, our views on the key LDI implementation considerations are summarized in Figure 8 above. Whether the approach is using market-based benchmarks or custom liability benchmarking, LDI has clearly taken hold as a valuable and successful client-led solution. ■

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In order to match the index returns a fund would need to track the security weightings in a way that would exactly match the Index and that the economic and market conditions were sufficient to have allowed effective execution of replicate the risk and return characteristics of the index. There are a number of factors that could reduce our ability to track index positions perfectly, including small position sizes and/or available liquidity in some securities. We estimate the net effects of index- and trading-related factors on the passive components of the strategy would affect performance either favorably or unfavorably depending on the size of the portfolio.

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