Hedging risk factors in a liability driven investment solution  Sept. 2010

Liability Driven Investing (LDI) is growing in popularity as more pension plans seek to protect against a decline in funded status. DB Advisors’ Pension & Portfolio Solutions Americas group explains the techniques used in LDI solutions to hedge liability risk factors.

Plan sponsors’ desire to protect pension assets from volatile markets has fuelled interest in Liability Driven Investing (LDI), a framework for managing defined benefit pension assets that focuses on reducing the risk of asset returns falling short of liabilities. The success of an LDI solution depends in significant part on identifying the risk factors that cause liabilities to change over time, and then constructing an asset portfolio to hedge those risks effectively.

In this paper, we examine the most important liability risk factors that LDI managers must consider, explain their corresponding asset hedges, and assess some of the challenges associated with implementation. We then consider how an LDI solution is constructed.

LDI overview
The goal of LDI differs from that of traditional pension management. Typically, pension managers target a total return and seek to optimize asset returns per unit of risk over the long-term. LDI managers, in contrast, seek to reduce the expected cash contributions required by the sponsor to maintain funded status for a given level of surplus risk — which can be defined as the volatility of funded status or the tracking error between asset returns and liabilities.

LDI has been discussed for over 30 years, but it has grown in popularity recently. More plan sponsors are looking to the approach as a way of managing enterprise risk and ensuring that future pension benefits can be funded. The increased focus on LDI can be attributed in part to recent market volatility and the 2006 Pension Protect Act (PPA), which establishes more stringent funding requirements and specifies how pension liabilities are valued. Plan sponsors — both public and private — have become acutely aware of the adverse impact that pension funding shortfalls can have on their organizations.

Fig. 1 identifies the key liability risk factors and the corresponding asset hedges. We examine the risk factors and hedges in detail below.

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AA credit spreads <10-year and >10-year maturities
The 2006 Pension Protection Act (PPA) in the U.S. specifies that pension liabilities be valued using a discount rate derived from a yield curve of investment grade (AA rated) corporate bonds. As a result, the present value of pension liabilities changes with the AA credit yield curve. As part of the LDI solution, a plan may therefore seek to hedge its spread duration exposure — i.e. the sensitivity of the value of an asset or liability to changes in credit spreads.

Pension liabilities falling due within 10-years can be hedged by constructing a cash-matched portfolio of AA corporate bonds. As the AA credit spread changes, the present value of the bond portfolio should move in near lock-step with the liabilities. Hedging longer-dated liabilities is more difficult because there are very few AA corporate bonds with maturities beyond 10 years. Therefore, sponsors must use other methods than cash-flow matching to hedge spread duration.

One of the challenges of hedging spread duration is that it typically requires some form of leverage: either accounting leverage through the use of derivatives such as credit default swaps (CDS); or economic leverage from holding riskier (more volatile) assets, such as equities that are correlated to credit spreads. These hedges are discussed briefly below. We should note here, though, that implementing the hedges is not straightforward and requires a degree of expertise. This is because both involve basis risk — i.e., the risk that liabilities and the assets used to hedge them will not change in value symmetrically, therefore failing to offset each other.

**CDS**
Long-term (>10-years) spread duration risk inherent in pension liabilities can be hedged by selling CDS on a diversified pool of corporate bonds, effectively providing the CDS buyer with insurance on the credit quality of the bonds. The hedge works as follows: If credit quality improves, credit spreads will tighten and increase the present value of pension liabilities (assuming all other variables are held constant). To compensate for this, the cost of insuring the basket of corporate bonds will decline, allowing the CDS seller to profit by buying back the credit insurance at a lower price than it sold it for. The profit should offset the increase in the liabilities. If credit spreads widen, the present value of pension liabilities will decline but the plan sponsor will lose on the CDS, again leaving its overall funding position unchanged.

**Equity exposure**
Another way to hedge long-term spread duration is through equity exposure. The regression line in Fig. 3 shows that equities tend to be negatively correlated with credit spreads: when credit spreads tighten, equity returns tend to be positive. Tightening spreads increase the value of pension liabilities, but this can be offset by an increase in the value of equity assets held by the plan. Our research suggests that the equity allocation required to hedge spread duration is in the range of 10% to 25%, much less than the 60% to 70% allocation typically held by pension plans.

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**Figure 3: Monthly change in AA credit spreads vs. monthly Russell 1000 return**

![Figure 3](image)

Source: DB Advisors Pension & Portfolio Solutions
**Duration**

For most sponsors, duration — i.e. the price or value sensitivity of a stream of cash flows to a change in interest rates — is the most important risk factor inherent in pension liabilities. An LDI solution will seek to hedge this risk by matching the duration of assets to that of liabilities on a dollar-weighted basis.

Pension liabilities are long dated and typically have durations ranging from 12 years to 17 years, depending on the average age of the company’s workforce and the ratio of active employees to retirees. The younger the workforce and the higher the ratio of active employees to retirees, the greater the duration of pension liabilities tends to be.

The duration of liabilities maturing in 10 years or earlier is best matched with a credit portfolio. Liabilities that extend beyond 10 years can be hedged with an asset portfolio of zero coupon bonds (e.g. 30 year zeros), interest rate swaps and bond futures. The challenge for the LDI manager is that 30 years is the longest term available on any U.S. Treasury security, which is shorter than the length of most pension liabilities. For this reason, a barbell-type structure is often required, as explained below.

When matching liability duration, an LDI manager will often divide pension liability streams into maturity buckets, as shown in Fig. 2 below. Note that the duration of the asset portfolio equals or exceeds the duration of the liability in each of the buckets except the 31+ year bucket.

The duration of the 31+ year portfolio bucket is so low (1%) because there are very few securities with maturities greater than 31 years. To match the total liability duration of 16.6 years shown in Fig. 2, therefore, the sponsor must heavily overweight the portfolio assets in the 21 year to 30 year maturity bucket. In this example, almost half of the portfolio assets are in this bucket (hence the use of the term barbell), even though only about one-fifth of liabilities fall within the bucket.

Convexity

Convexity — a measure of how duration changes with interest rates — is another important risk factor to consider when designing an LDI solution. Pension liabilities tend to be very convex, which means that when rates decline, the present value of liabilities becomes more sensitive to changes in rates; when rates rise, it becomes less sensitive.

This phenomenon had significant implications during the recent financial crisis. Sponsors that had implemented LDI solutions by matching asset and liability duration sometimes fell short of hedging their convexity exposure. As rates began to decline at the onset of the crisis, duration-matching ensured that fixed income assets increased to compensate for the rise in liabilities. However, as rates continued to decline, the...
greater convexity of liabilities meant that liability duration began to increase more than the duration of fixed income assets. As a result, asset gains could not keep pace with the rise in liabilities and funded status deteriorated.

This is illustrated in Fig. 4 below, which shows the present value of two fixed income portfolios — one more convex than the other — as a function of interest rates. Note that at an interest rate of 5% both portfolios have the same present value and duration (depicted by the slope of the curves at that point). As rates decline, the value of the more convex portfolio rises faster than the less convex portfolio. This illustrates how differences in convexity can result in a wide difference between asset and liability values as rates change. In constructing the asset portfolio, the LDI manager will aim to match convexity as well as duration. Incidentally, the duration-matched portfolio shown in Fig. 2 was designed to also hedge convexity: asset portfolio convexity was approximately 194, not far off the liability convexity of 213.

**Figure 4: Comparison of highly convex portfolio vs. lower convexity portfolio**

![Graph showing present value vs. interest rate for two portfolios](image)

Source: DB Advisors Pension & Portfolio Solutions

**Inflation**

Many pension plans are subject to inflation risk. Pension liabilities may be linked to employees’ average salary over the last few years of employment, or a plan may make periodic cost of living adjustments (COLA). Inflation risk is partially offset by the nature of the pension liability discount rate: while higher inflation can mean an increase in liability cash flows, it also tends to increase the interest rate used to discount liabilities.

A key consideration is that the inflation effects on pension liability cash flows are permanent. In periods of higher inflation, pension benefit cash flows increase. However, the discount rate also increases, which offsets the higher pension cash flows and so the present value of liabilities remains fairly constant. But when inflation declines or there is deflation, pension benefit cash flows rarely or ever decrease; the discount rate also tends to decline, but since there is no corresponding decrease in the pension benefit cash flows, the present value of liabilities increases due to the lower discount rate.

When hedging inflation, equities and U.S. government TIPS (Treasury inflation-protected securities) can be adequate long-term hedges against inflation. Another possibility is inflation swaps, where the sponsor pays Libor plus a spread and receives the difference between a future level of the Consumer Price Index (CPI)
and an initial CPI level. Finally, sponsors can hedge inflation risk through investment in real assets such as real estate and commodities.

**Actuarial risk**
Actuarial risk is the risk that assumptions in an actuarial model may lead to estimations that differ from outcomes. For example, if plan participants live longer on average than expected, liabilities will be larger than forecast, thereby adversely impacting funded status (all else equal). The growth characteristics of equities over the long-term have often been used to defray potential costs from actuarial risk. However, the lack of correlation between equities and actuarial risk factors means that equities are not an adequate short-term hedge.

Some insurance companies have begun to offer longevity swaps to hedge actuarial risk, although the cost tends to be prohibitively high for most plans. In a longevity swap, a mortality index level for the workforce is established. If workforce mortality levels exceed the index, the insurance company pays the plan an amount proportional to the overshoot, thereby offsetting the higher liability payments. However, like most insurance policies, the initial index is typically well above the current level. For the sponsor to receive a meaningful payment on the swap, employee life expectancy would have to increase significantly. This is akin to the deductible of an insurance policy.

**Plan design**
Lastly, sponsors are subject to risks arising from changes in plan design. These can include changes in the dynamics of payment options such as cash outs versus long term annuities, and fluctuations in early retirements due to workforce restructurings. These risks tend to be highly idiosyncratic and there are no capital markets instruments that can hedge them.

Having discussed the key liability risk factors and their corresponding hedges, in the next section we consider how an LDI solution is put together.

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**What does an LDI solution look like?**
Once a pension plan (or its actuaries / advisors) has identified and quantified its liability risk factors, the next task is to construct the LDI solution. As we discuss below, there are different degrees of LDI solution and each plan must determine which is most appropriate for its individual circumstances. But that said, most LDI solutions typically comprise two distinct elements: a risk management component and a return seeking component.

**Risk management**
The primary function of the risk management component is to control surplus volatility (or the tracking error between assets and liabilities). The goal is to ensure that assets move relatively in tandem with liabilities under various economic conditions, particularly different interest rate and credit spread environments. This component is comprised primarily of U.S. government securities, inflation-linked bonds and high grade corporate bonds of varying maturities that approximate the plan’s liability cash flows. Credit and interest rate derivatives are often also used to fine-tune the hedging of duration, convexity and credit spread duration.

**Return seeking**
The purpose of the return seeking component is to defray the growth of the pension liabilities in excess of the interest cost. Sources of the liability growth component include annual service costs, inflation factors built
into the liability promise, and actuarial risk. The return seeking component is primarily comprised of riskier assets (e.g. global equities), and alternative investments (e.g. hedge funds, private equity and real estate) as well as other total return oriented alpha strategies. The equity portion of the return seeking component is also used to hedge long-term credit spread duration.

What degree of LDI solution is appropriate?
While it is often possible to reduce asset / liability tracking error or surplus risk to just a few percentage points, not all pension plans want a comprehensive hedge.

Many sponsors have stuck to a typical 65% equity / 35% bond allocation but moved toward an LDI approach by changing their fixed income benchmark from the shorter duration Barclays Aggregate Index\(^1\) to the longer duration Barclays Long Government Credit\(^2\). While the plan’s bond allocation will be more closely duration-matched with liabilities under this approach, overall asset returns may not track liabilities closely because plan performance will be driven primarily by the (much larger) equity allocation.

Other plan sponsors have opted for a more comprehensive LDI solution, hedging duration, convexity, spread duration, inflation and longevity risks using physical instruments and derivatives. Under this approach, the success of the LDI solution is determined by the degree to which total assets (rather than just fixed income assets) move in tandem with — and outperform — liabilities over time.

The degree of LDI hedge depends on the return objectives and risk tolerance of the plan sponsor\(^3\), which are themselves a function of the plan’s funded status and size. A full hedge may not be desirable if the pension plan is under-funded, for example, because asset returns will rarely exceed liabilities, essentially locking in the pension deficit. That said, where the size of the plan is small and the financial health of the firm is strong, sponsors can tolerate a higher level of asset / liability risk. They may still make the strategic decision to implement LDI, but could do so opportunistically and over time to avoid locking in a deficit.

Framing the decision
Plan sponsors thinking about implementing LDI should consider two questions: to what degree should liability risk factors be hedged; and, what constitutes successful implementation? The answers will depend chiefly on several criteria, including:

- Size of the plan relative to firm’s capital structure
- Funded status
- Plan status (e.g. open, closed to new participants or frozen)

Other considerations include correlation effects between the pension’s asset allocation and the firm’s underlying business, which may be prevalent in firms with highly volatile business cycles. While there is no set prescription, Figs. 5 and 6 below provide an initial framework for the decision-making process. Fig. 5 shows the recommended degree of LDI hedge based on the size of the plan relative to the size of the firm’s capital structure and the plan’s funded status. Fig. 6 shows the recommended degree of LDI hedge based on the plan status and funded status.

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\(^1\) Approximate 4.5 year duration
\(^2\) Approximate 10 year duration
We define the degrees of LDI solutions qualitatively as “Max LDI”, “Moderate LDI” and “Light LDI”. Max LDI indicates a solution designed to provide the best hedge possible of the liability risk factors, thereby minimizing surplus volatility or tracking error between assets and liabilities. At the other end of the spectrum, Light LDI provides a solution that hedges some of the liability risk factors while providing opportunities for out-performance by taking alpha and beta risk. Alpha risk may include alternative investment strategies such as hedge funds, tactical allocation, private equity and real estate. Beta risk may include equity exposure beyond that required to hedge spread duration, tactical long or short duration exposure based on a view of future interest rate movements, and other beta exposures such as commodities. Moderate LDI falls in between Max and Light LDI in terms of managing surplus volatility.

Companies with pension plans that represent a small portion of the capital structure may have capacity within their enterprise risk budgets to take on more pension surplus risk in an attempt to add value and defray liability costs. Conversely, companies with pension plans that represent a large portion of the capital structure may not have capacity within their enterprise risk budgets to take on pension surplus risk. The lower left quadrant in Fig. 5 shows that an over-funded plan that represents a large part of the firm’s capital structure should use a Max LDI solution and reduce as much of the pension asset / liability risk as possible. This is because the slightest asset / liability mismatch would consume an inordinate amount of the firm’s enterprise risk. It is often not worth risking the financial stability of the firm to defray pension costs.

An example
To illustrate why the size of liabilities relative to a company’s capital structure is important in determining the appropriate degree of LDI solution, consider the following example. It concerns a large U.S. based telecom firm (call it TelCo), whose pension plan’s asset / liability profile was highlighted by Pensions & Investments earlier this year. TelCo’s pension benefit obligation (PBO) was approximately $27.9 billion, its market capitalization was $7.7 billion and its pension plan was $3.1 billion over-funded (pension assets = $31.0 billion). If TelCo had a typical pension allocation of 65% equities and 35% intermediate term bonds and a liability duration of 15 years, then a 150 bps decline in interest rates coupled with a -20% return of equities

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4 Tactical beta exposures as described here can also be considered alpha. The intent is to not get in a theoretical discussion as to what constitutes alpha and what constitutes beta within a pension portfolio.
5 Pensions & Investments, June 14, 2010.
would result in a pension shortfall of approximately $6.5 billion. If TelCo’s stock also suffered a 20% decline, its pension shortfall would exceed its market capitalization.\(^6\)

Such a drastic change in funded status would adversely impact TelCo’s balance sheet, income statement and most likely its credit rating, thereby increasing its borrowing costs and possibly the future viability of the enterprise as a going concern. The key point being that this scenario would have resulted mostly from decisions made regarding TelCo’s pension plan, rather than its core business. Fortunately, it appears that Telco had implemented an LDI solution, since its pension asset allocation is 64% fixed income, 8% real estate, 11% private equity and just 17% public equity\(^7\) and so such an economic scenario would not have nearly such a deleterious impact on the enterprise.

Following the recent economic crisis, few firms had a fully funded pension plan at the end of 2009. In fact, many large cyclical and industrial firms would have fallen into the lower right quadrant of Fig. 5, where the pension plan represents a large portion of the capital structure and the plan is significantly under-funded. Many of the firms that fall in this category are also in financial distress.

This creates a moral hazard since the company is incentivized to take on additional risk in the pension plan in an attempt to close the funding gap. The pension shortfalls of companies in this situation may be so large that it could take decades to recover deficits solely from operating earnings, which may in any case be under stress. Consequently, the firms’ best chance of achieving a fully funded pension plan within a reasonable timeframe is to have a high allocation to equities and a short duration exposure vs. liabilities, in the hope that equity markets rally and interest rates rise. If markets move adversely, equities decline further, interest rates continue to fall, and their core business deteriorates further, then the firms can attempt to exercise their moral hazard option by filing for bankruptcy and transferring their pension liabilities to the Pension Benefit Guaranty Corporation, where the liability would be covered by premiums from other plan sponsors\(^8\) and perhaps even U.S. taxpayers.\(^9\)

Some firms in the lower right quadrant of Fig. 5 do not fall into the moral hazard scenario, but they are still faced with the daunting challenge of closing a funding gap. This would need to be achieved by a combination of contributions along with taking enough surplus risk within the context of an LDI solution so that asset returns exceed the growth in their pension liabilities. Many firms in this situation have also decided to close their plans to new participants or even freeze the plan where no additional benefits accrue even to current participants.

For firms that fall in the upper right and left quadrants of Fig. 5, the risk in the pension plan is of much less consequence to the overall enterprise. A small plan that is under-funded (upper right quadrant) can afford to take on additional surplus risk to defray pension costs and close a funding gap. Similarly, a small plan that is over-funded (upper left quadrant) does not need to take on as much surplus risk but may want to take on some to help defray future pension liability costs, especially if the plan provides generous benefits.

A similar thought process applies to Fig. 6, which shows the recommended degree of LDI solution based on the plan status and funded status. Generally, a plan that is closed or frozen and over-funded should minimize its surplus volatility. This is because an increase in the plan’s funded status does not translate into a material increase in shareholder value since surpluses cannot be repatriated to the sponsor until the plan is completely wound down, while shortfalls become the responsibility of the shareholders.

\(^6\) DB Advisors Pension and Portfolio Solutions estimates.
\(^7\) Pensions & Investments, June 14, 2010
\(^9\) Note that the author does not condone this option and believes that legislation may need to step in to prevent such investment behavior that is incentivized by this moral hazard situation.
Next generation solutions: Dynamic LDI

Most of the LDI solutions being implemented today involve a static strategic allocation driven by the sponsor’s return objectives and risk tolerance. Any deviations to the strategic allocation are tactical in nature, designed to benefit from a market view, and thus are considered a source of potential alpha.

Next generation LDI solutions will make use of dynamic asset allocation. In these solutions, the strategic asset allocation is still driven by the sponsor’s long-term return objectives and risk tolerance, but deviations from that strategic positioning are determined according to risk criteria such as volatility and/or caps on losses. Dynamic LDI can be traced back to constant proportion portfolio insurance (CPPI) and stop loss strategies, which were popular with individual investors in the 1980s and 1990s. The basic principal of CPPI is to maintain the portfolio’s risk exposure at a constant multiple of the investor’s excess wealth above a certain floor. CPPI strategies were used to protect an investor’s principal or cap losses of what otherwise could be a risky investment. The application is extremely valuable to sponsors, given their highly risk averse nature that arises out of the asymmetric payoff of pension plans. Significant excess returns of assets in excess of liabilities often favor beneficiaries, since the company cannot repatriate surpluses back to the company and beneficiaries have successfully been able to obtain an increase in benefits. Conversely, shareholders bear the risk of pension shortfalls. This payoff asymmetry drives the sponsor’s risk-averse return objective to the extent that they should be willing to give up some upside return opportunity to provide some down-side protection.

Dynamic allocation strategies provide return profiles that satisfy this asymmetric return and risk objective. While historically these dynamic strategies have been used to protect principal, the application to LDI solutions is to protect pension surpluses. Such allocation strategies can also be combined with and jointly optimized with a contribution policy to ensure plan solvency and close funding gaps.

DB Advisors Pension & Portfolio Solutions team will return to the topic of dynamic LDI in an upcoming research paper to be released later in 2010.

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