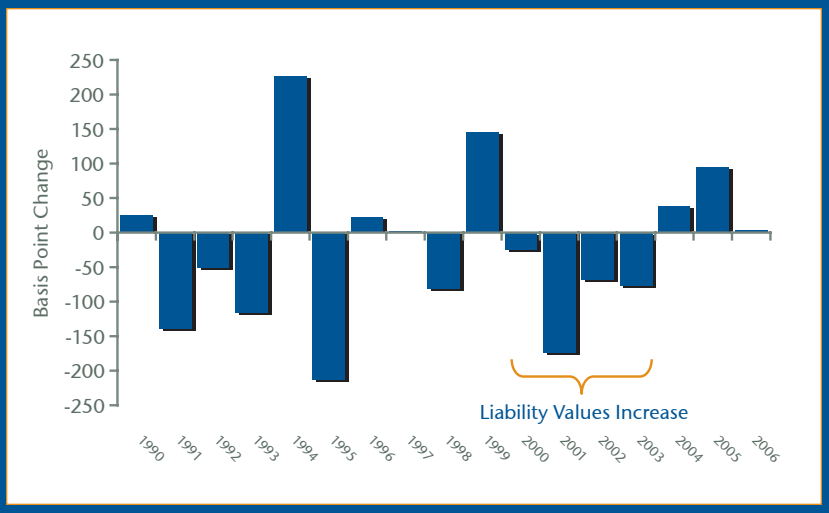
Dollar Duration Matching:

A Framework for Evaluating Liability Driven Investment (LDI) Strategies

by Jon Taylor, Managing Director, Principal Global Investors

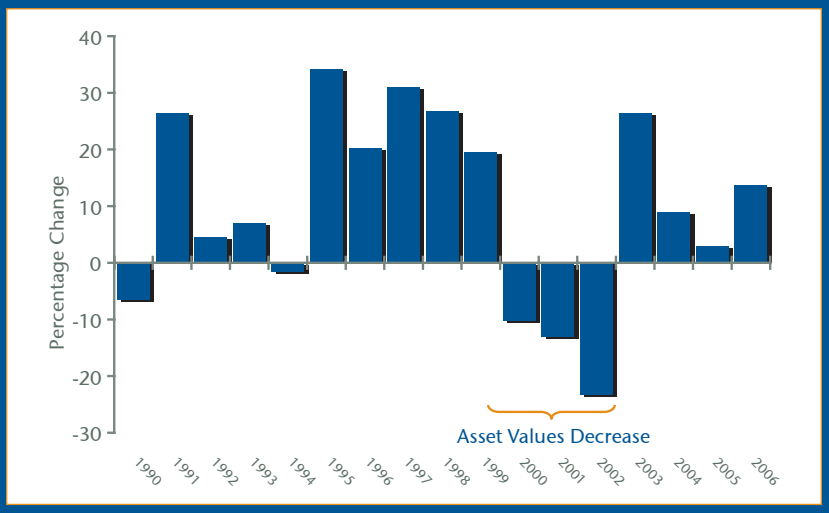
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Exhibit 1: Annual Changes in AA Corporate Bond Yields



Source: Citigroup Yieldbook, Principal Global Investors

Exhibit 2: S&P 500 Annual Returns



Source: Bloomberg, Principal Global Investors

Dollar Duration Matching:

A Framework for Evaluating Liability Driven Investment (LDI) Strategies

The mismatch between the duration, or interest rate sensitivity, of plan assets and plan liabilities is now a significant focus of both corporate and public pension plans. The magnitude of the mismatch was brought to the fore in 2000, 2001 and 2002 when interest rates fell sharply (see Exhibit 1) and equity markets registered negative returns (see Exhibit 2). The decline in interest rates resulted in a major increase in the value of liabilities without a commensurate increase in the value of plan assets. Equities registered negative returns, while the typical bond portfolio provided only modest protection against falling interest rates as the bulk of pension plan fixed income assets were benchmarked against duration targets that fell far short of the liability durations of typical plans.

During the period of 1991 to 1993, interest rates also fell sharply, but equities registered positive returns, thus offsetting, to some extent, the increase in liability valuations. This was also true in 1995, when equities registered very strong gains, offsetting the increase in liability valuations due to falling interest rates. What was different in 2000 to 2002 was that equities failed to provide an offset for the increase in liability valuations. This period has been dubbed the “perfect storm” because of the confluence of financial market events that seriously damaged funding levels in corporate and public pension plans.

Plan sponsors need a framework for assessing the magnitude of the duration mismatch and the potential impact this mismatch might have on a plan’s funding status. Dollar duration matching provides a useful framework for assessing the magnitude of the mismatch and also provides an effective framework for assessing various LDI strategies. The framework enables one to readily assess the potential impact of changes in interest rates on plan funding status and also provides a methodology for assessing duration mismatch reduction strategies.

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Measuring the Interest Rate Exposure of a Typical Defined Benefit Plan

Let's consider a typical, moderate sized retirement plan and assess the duration mismatch and possible liability driven investment (LDI) strategies that can be employed to mitigate the interest rate risk of the plan. We will assume that the plan is fully funded with liabilities of $10 billion funded by assets of $10 billion. The duration of the liabilities is 15. For simplicity, we will assume that the plan has 60% of plan assets invested in the S&P 500 Index and 40% invested in the Lehman Aggregate Bond Index. Currently, the duration of the Lehman Aggregate is 4.7 years.

By computing the dollar duration of plan liabilities and plan assets, we can ascertain the dollar impact on the portfolio of changes in interest rates assuming other factors are held constant.

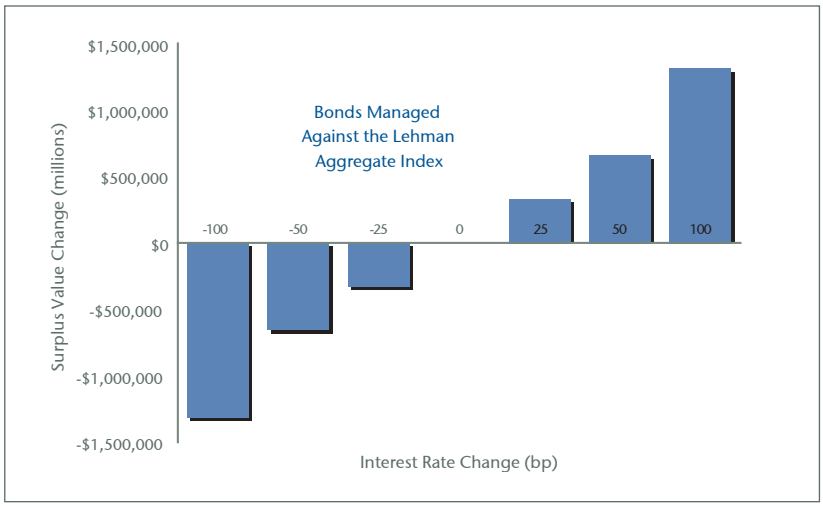
Dollar duration can be computed as follows:

- Liability dollar duration = ($10.0 billion) * (100.0 %) * 15 = $150.0 billion
- Asset dollar duration: ($10.0 billion) * (40.0%) * (4.7) = $18.80 billion

Assuming, as we do in this example, the plan has 40 % in bonds managed against the Lehman Aggregate, a 100 basis point (bp) drop in interest rates will result in a deterioration of the plan's funding status of $1.312 billion (see Exhibit 3 below) computed as follows:

((Liability $ Duration of $150 bn) - (Asset $ Duration of $18.8 bn)) * 0.01 = $1.312 bn

Exhibit 3: Exposure to Interest Rate Risk



Source: Principal Global Investors

The bonds in the portfolio only insulate 12.5% of the duration risk of the liabilities. In effect, the plan sponsor has an active bet that interest rates will remain static or increase, or that gains from equities will be sufficient to offset any increase in liability valuations due to a decrease in interest rates.

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It should be noted that this dollar duration analysis does not factor in convexity and its impact on both liabilities and fixed income assets. For small moves in interest rates, the effect of convexity is modest, but for large moves it can be material.

Assessing the Duration of Non-Fixed Income Assets

So far, this analysis assumes that equities do not respond to moves in interest rates or that their response is offset by other factors as was the case in 2000 to 2002. Under most market conditions, this overstates the risk as equities are generally sensitive to interest rate changes and, as such, would offset some of this risk.

If you factor in the interest rate sensitivity of equities and other assets into the equation, the amount of fixed income duration needed to match the liabilities diminishes. For example, consider equities. Companies generate a stream of earnings out into the future that are discounted to determine a current fundamental or fair value for a company. The discount rate used to discount these earnings is determined, in part, from market interest rates and, as such, is sensitive to changes in market interest rates. Thus, because equities generate cash flow far out into the future, they are often considered to be long-duration assets.

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[1]Duration measures the approximate percentage change in value for a 100 basis point change in interest rates. Duration is a first approximation and is only accurate for small changes in interest rates. For large interest rate moves, the estimation of the percentage change in value for changes in interest rates can be improved by adding an adjustment for convexity. Convexity is an important consideration when considering LDI strategies. Liabilities possess positive convexity. That is, changes in value are greater for interest rate declines than for commensurate interest rate increases. A typical bond portfolio also possesses positive convexity, and as such, contributes positively to any liability hedge. It should be noted, however, that some fixed income instruments such as mortgage backed securities possess negative convexity which needs to be factored into the analysis when they are included in any LDI strategy.

Other factors, however, can at times swamp their sensitivity to interest rates. This was the case in 2000, 2001 and 2002. Equities were significantly overvalued going into the technology, media and telecommunications market correction. As a result, sharply falling interest rates over the next three years were not sufficient to generate positive equity market returns as might have been expected. The equity market's sensitivity to interest rates was swamped by valuation considerations. Typically, however, equities will provide a partial hedge against changes in interest rates over longer time frames. In fact, all financial assets that generate a cash flow stream are sensitive to changes in interest rates.

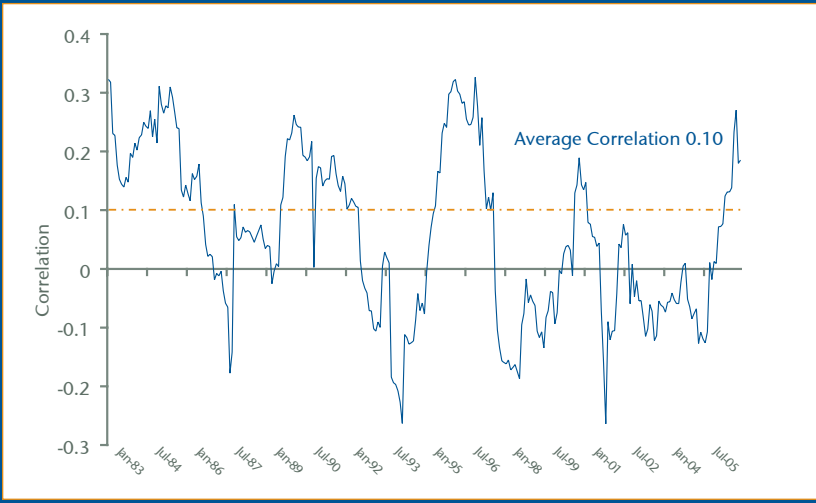
One way to factor in the interest sensitivity of equities and other assets into the equation is to impute dollar duration for these assets. This can be done by looking at historical correlations between equity index price changes and bond index price changes. Thus, for example, the average rolling three year price correlation between the S&P 500 and the Lehman Long Government/Corporate Index (duration 11.0 years) was 0.10 over the sixteen year period from 1990 through 2006. (See Exhibit 4) Thus, given that equities constitute 60% of the portfolio, the implied dollar duration of the equities in the portfolio is $6.6 billion, computed as follows:

(($10.0 bn) * (60.0%) * (0.10 * 11)) = $6.6 billion

This approach, of course, assumes that their price correlation is due entirely to their interest rate sensitivity which we know is not the case, but it is probably not a bad approximation. Also, keep in mind that estimates of the sensitivity of non-fixed income assets to interest rates can be very unstable over time and vary considerably. (Again, see the three-year rolling correlations of the S&P 500 price change with the Lehman Long Government/Credit price change, presented in Exhibit 4.) Nevertheless, we know that other assets, and particularly equities, are sensitive to interest rates and this should be factored into any strategy that attempts to deal with the duration mismatch between liabilities and assets.

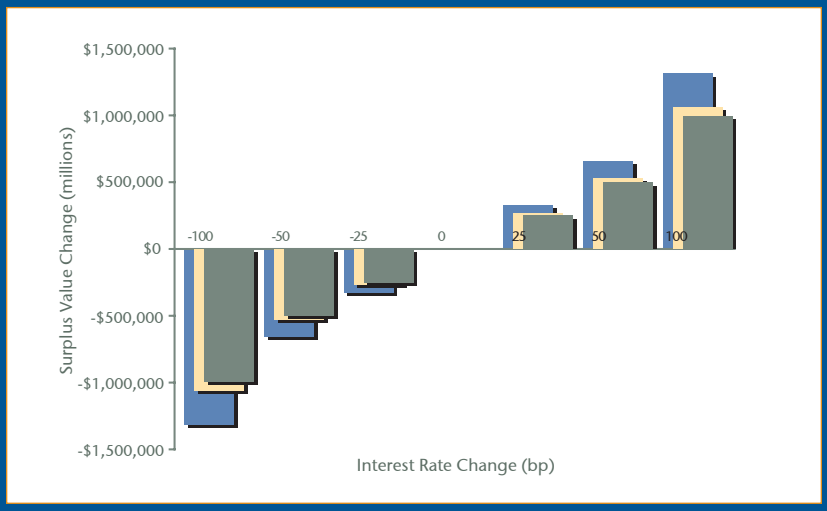
The plan assets have combined dollar duration of $25.4 billion and cover 16.9% of the duration risk of the plan using this methodology.

Exhibit 4: Rolling Three Year Correlation
of the Lehman Long Government/Credit Index
vs. the S&P 500 Index (Price Changes)



Source: Lehman Live and Principal Global Investors

Exhibit 5: Interest Rate Risk Mitigation Strategies:
Moving to a Long-Duration Bond Mandate
and Factoring in the Interest Rate Sensitivity of Equities



Source: Bloomberg, Principal Global Investors

Strategies for Mitigating Duration Mismatch

Once a plan has assessed the degree of mismatch between the duration of assets and liabilities, the next step is to explore various strategies for mitigating the mismatch. An obvious first step is to extend the duration of the bond portfolio. This can be done by shifting the fixed income allocation to a long duration mandate. By shifting to a long duration mandate managed against, for example, the Lehman Long Government/Corporate Index, the duration risk of our hypothetical plan can be reduced by 16.8% (see Exhibit 5). This is because the duration of the Lehman Long Government/Corporate Index is around 11 vs. the Lehman Aggregate Index duration of 4.7.

Computing the Dollar Duration of the Long-Duration Bond Portfolio

- Long-Duration Bonds: **($10.0 billion) * (40.0%) * (11.0) = $44.0 billion**

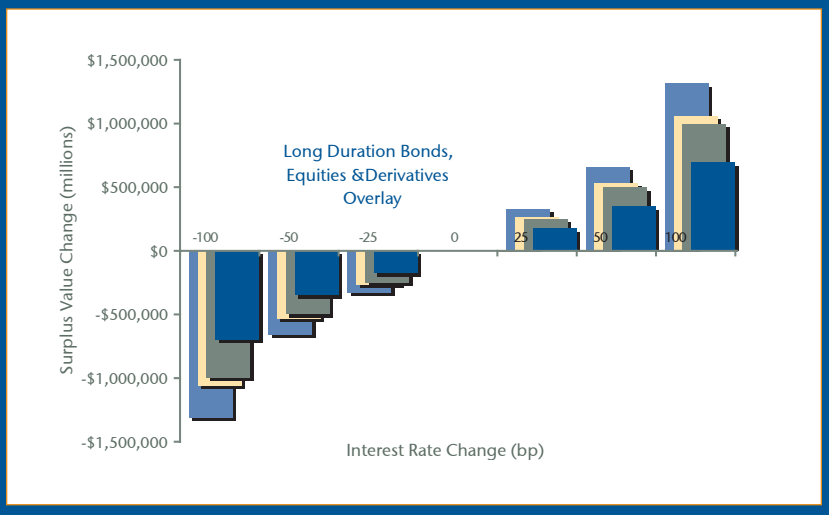
The long-duration bonds and the other assets in the portfolio net off $50.6 billion of the dollar duration of the liabilities or 33.7%. This still leaves $99.4 billion unhedged. In Exhibit 5, the gray bars now represent the interest rate sensitivity of the plan's surplus after factoring in the interest rate sensitivity of equities and moving the bond mandate to a long duration mandate.

Derivatives Overlay Strategies

A possible next step for the plan will be to consider a derivatives overlay strategy to reduce the mismatch further.

The major attraction of a derivatives overlay strategy is that it can be implemented without radically disturbing underlying portfolios. This will be very attractive for multi-manager situations. There are many advantages to using derivatives to reduce the mismatch between plan liabilities and plan assets. First and foremost is efficiency. The interest rate derivatives market is deep, liquid, and highly efficient and has performed well during periods of financial market stress. Derivatives, such as Treasury futures, interest rate swaps, options and swaptions provide an efficient mechanism for extending asset duration and hedging inflation risk. Derivatives are also very cost effective and allow for a high degree of precision when implementing a liability driven investment strategy.

Exhibit 6: Interest Rate Risk Mitigation Strategies: Moving to a Long-Duration Bond Mandate, Factoring in the Interest Rate Sensitivity of Equities and Adding a Derivatives Overlay Strategy



Source: Principal Global Investors

Derivatives entail cash flows and these cash flows need to be funded. Thus, there needs to be a source of liquidity that can be accessed. In the case of futures, initial and variation margin needs to be posted.[2] For swaps, while there is no initial cash outlay, interest payments are made periodically and collateral often needs to be posted between actual cash flow dates. With a typical interest rate swap, fixed payments are made semi-annually while floating rate payments are made quarterly. There are, however, many variations to the cash flow frequency. Collateral that can be posted generally consists of high quality bonds or cash. The amount of collateral required will be determined by changes in interest rates after the effective date of the swap and the quality of the securities posted.[3]

Additionally, to the extent the pension plan's asset portfolio is totally exposed to financial market risk already, any derivatives overlay will entail leverage.[4] Thus for the plan to preserve existing exposure to equities and other high expected return assets while at the same time reducing the duration mismatch further would entail some leverage.

Suppose that our hypothetical plan sponsor decides to reduce the asset and liability duration mismatch further by entering into an interest rate swap. For expositional purposes, lets look at 30-year zero coupon swap with a notional value of $1.0 billion. A 30-year zero coupon swap is selected because it will add meaningfully to the hedge because of the substantial duration afforded by the 30-year zero coupon structure.[5] On a dollar duration basis, this swap will add another $29.1 billion to the combined hedge. With this swap added to the duration mismatch mitigation strategies already employed, the plan now has over 50% of the plan's interest rate risk hedged (see Exhibit 6). The dark blue bars represent the sensitivity of the plan's funding status to changes in interest rates after imputing a duration estimate for equities and factoring in a move to long duration bonds and implementing an interest rate swap.

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[2]The notional value of a Treasury bond futures contract is $100,000 and the initial margin for institutional hedgers is $1000 or 1.0 percent of the notional value. Variation margin is transferred daily and reflects the gain or loss on the futures contracts. The duration on the Treasury bond futures contract tracks the cheapest-to-deliver bond that can be delivered to settle the contract at maturity. When this paper was written, the duration of the cheapest-to-deliver was 9.85.

[3]Swaps are traded within the legal framework of the International Swaps and Derivatives Association (ISDA) master agreement. As part of the standard ISDA, there is a Credit Support Annex that is negotiated between the counterparties which specifies the thresholds that trigger the posting of collateral when the value of the swap changes because of changes in interest rates. In addition, the Credit Support Annex also specifies crediting rates for different securities posted as collateral.

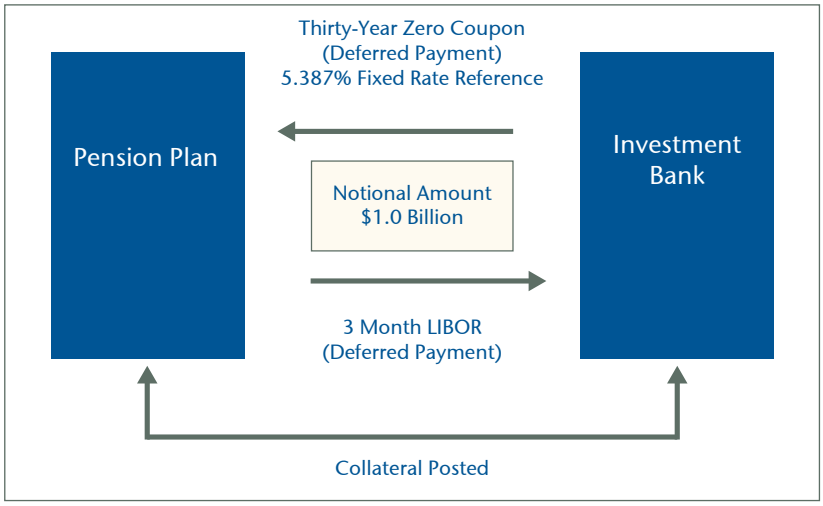
[4]In this case, leverage is defined as market exposure greater than one.

[5]A 30-year zero coupon swap, because of its 30-year term, provides a duration of nearly 30. In this case, the duration of the fixed side is 30, and the modified duration is 29.35. Netting out the floating rate side of the swap leaves a net modified duration of 29.1. Moreover, while the tenor of the swap is 30 years, the swap can be terminated at any time. Typically, the swap is assigned to a dealer who quotes a price for cancelling the swap. The cost of unwinding the swap will be driven by the change in interest rates since the effective date of the swap.

Swaps generally entail periodic cash flows and the posting of collateral which must be accommodated throughout the life of the swap. Unlike plain vanilla interest rate swaps which entail a series of payments between the swap counter-parties over the life of the swap, a zero coupon swap entails no cash flows until maturity or when the swap is unwound if it is terminated early. However, because of the long tenor of the swap and because of the sensitivity of the fixed rate side to changes in interest rates, the posting of substantial collateral may be required during the life of the swap as the underlying value of the swap changes with changes in interest rates.

If interest rates increase, the pension plan will be required by the investment bank to post collateral, but if interest rates fall, the investment bank will be required to post collateral with the pension plan. Also, keep in mind that while an increase in interest rates will reduce the present value of the plan's liabilities, it will not generate any cash flow to fund additional collateral requirements or to pay for the change in the value of the swap should it be closed out.

Exhibit 7: Thirty-Year Zero Coupon Interest Rate Swap



Source: Principal Global Investors

For example, if interest rates increase by 100 bp, the mark-to-market value of the swap will change by $291.0 million or 29.1% of the notional value. If the swap were terminated at this point, the payment due on the swap would be the full $291.0 million. The overall liability position will improve by $1.5 billion with a 100 bp increase in interest rates, but this gain is not realizable and cannot serve as an offset for the loss on the swap.

While a long-duration bullet hedge such as the 30-year zero coupon swap explored here offers a very high duration per dollar of notional value, it can create a large mismatch with the duration profile of plan liabilities, thus making the plan vulnerable to twists in the yield curve. A more precise approach is to match key rate durations along the term structure (see Exhibit 8 below). This ensures that twists and non-parallel shifts in the yield curve result in minimal slippage in the hedge.

Exhibit 8: Optimize on Key Rate Durations



Source: Citigroup Yieldbook, Principal Global Investors

To the extent that the plan is exposed to inflation risk in the form of CPI linked benefits, a part of any derivatives overlay strategy should be comprised of inflation linked derivatives.[6] Inflation sensitive liabilities can be broken out and hedged separately with inflation sensitive derivatives.

In considering various duration mismatch mitigation strategies, one must be careful not to over hedge and recognize that liability estimation is an inexact science and that the interest sensitivity of non-fixed income assets varies over time. Thus, a full, exact hedge of plan liabilities is often not justified.

The use of leverage is a major issue for many plans. Presumably, the prohibition most plan sponsors have against employing leverage is driven by risk considerations. Ironically, employing leverage in an asset-liability management framework may, in fact, reduce surplus variability, and, thus, by implication reduce plan risk. Leverage is inherently a risk measure and needs to be evaluated in the context of the entire portfolio configuration.

[6]Inflation risk embedded in a plan's liabilities can be hedged using TIPS (out to 20 years), iSTRIPS and inflation swaps (liquid out to 10 years).

Conclusion

A duration mismatch between plan assets and plan liabilities constitutes an active bet on the part of a plan sponsor. That is, if a plan's asset duration is less than the duration of the liabilities that these assets are earmarked to fund, then the plan is betting that interest rates will increase or, if interest rates fall, that the return on other assets in the portfolio will more than offset the increase in the value of the liabilities due to the decline in interest rates. Dollar duration matching provides an intuitive and effective framework for assessing the magnitude of the duration mismatch and the potential impact this mismatch will have on the plan's surplus position. With dollar duration matching, a plan sponsor can assess various duration mitigation strategies and their impact on surplus volatility.

Index Descriptions

The Lehman Long Gov't/Credit Index is the long component of the Lehman U.S. Government/Credit Index, a widely recognized index that features a blend of U.S. Treasury, government-sponsored (U.S. Agency and supranational), mortgage, and corporate securities limited to a maturity of more than ten years.

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The Standard & Poor's (S&P) 500 Index is market-value-weighted index composed of 500 common stocks from a wide range of industries that are traded on the New York Stock Exchange, the American Stock Exchange, and the NASDAQ. An investor may not invest in this index.

The Lehman Aggregate Index is designed to measure the performance of approximately 6,000 publicly traded bonds having an approximate average of maturity of 10 years, including U.S. Government, mortgage-backed, corporate, and yankee bonds.

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