# PENSION LIABILITY ALLOCATION™ 2: IMPLEMENTING LIABILITY-DRIVEN INVESTING

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*The first half of this two-part paper introduced the concept of pension liability allocation and illustrated its use in quantifying asset / liability mismatch risk. This concluding half discusses how pension liability allocation may be extended to implement a liability-centric framework for reviewing, validating or revising a pension plan's current investment policy. This new approach is contrasted with traditional asset allocation methodology. Pension liability allocation efficient frontiers are developed to display the plan sponsor's full range of risk choices.*

## INTRODUCTION

In the prior paper "Pension Liability Allocation 1: Quantifying Asset / Liability Mismatch Risk", pension liability allocation was introduced and defined as the ratio of a plan's hedged assets to its unhedged assets, expressed as a percentage of liabilities, where hedged / unhedged is expressed relative to the particular liabilities of the plan. Pension liability allocations were used to quantitatively determine pension risk arising from two common sources: (1) fixed-income duration mismatch and (2) equity mismatch.

The case study in the prior paper illustrated the use of pension liability allocation as an effective pension risk metric. Having outlined a risk definition, an investment policy / strategy – setting framework is workable with appropriately chosen reward measures. The remainder of the paper discusses an alternative asset-allocation approach, where its clear liability-focus is significantly different from the asset-centric perspective of traditional asset allocation. As such, the described approach presents a natural framework for implementing liability-driven investing that has recently been getting extensive attention in the financial press (Pension & Investments, April 2006).

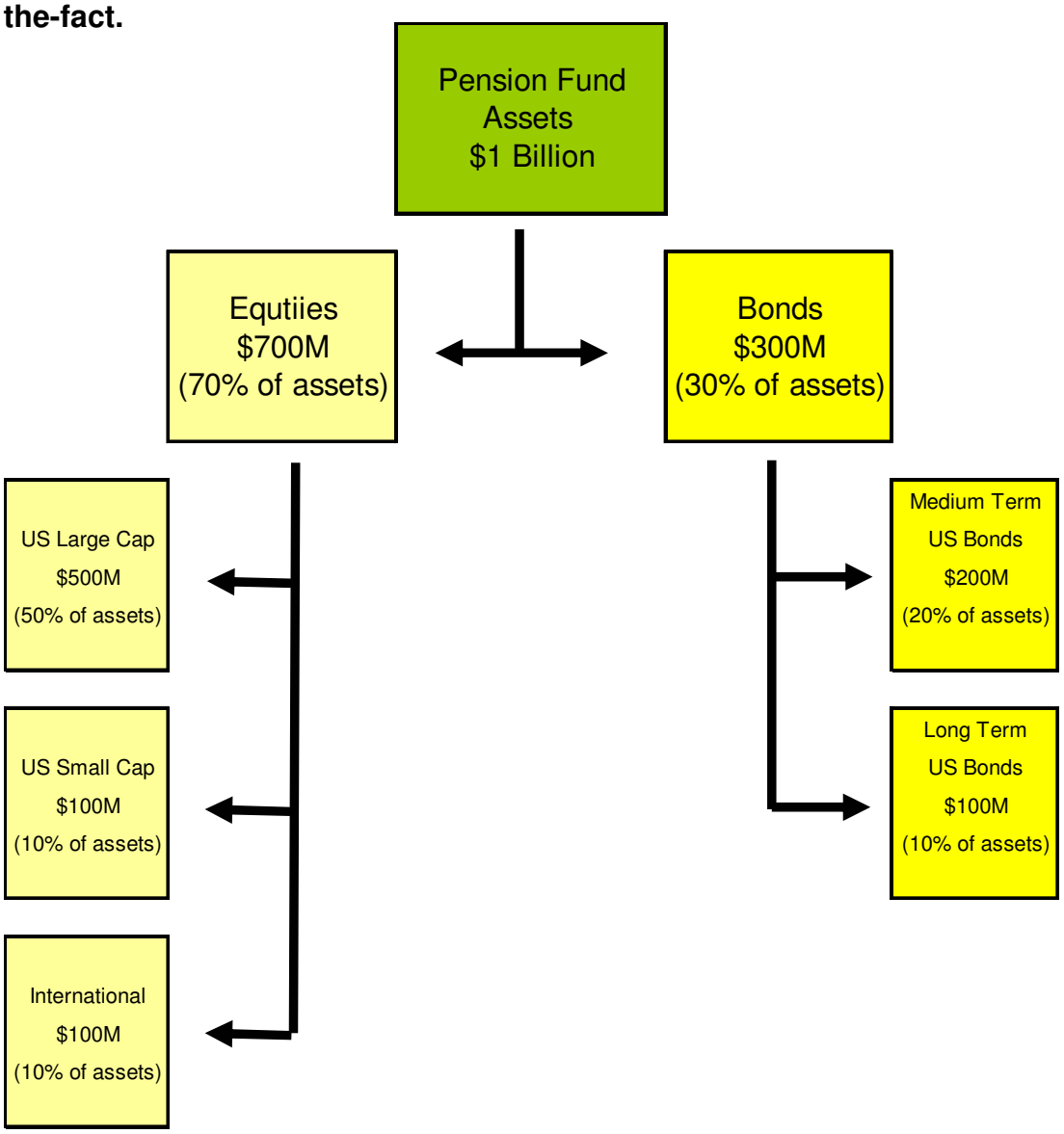
## CONTRAST WITH TRADITIONAL ASSET ALLOCATION

Extensive literature exists relating to pension fund investment policy setting. Waring (2004) provides a comprehensive reference list. Unfortunately, none of the prescribed approaches has gained wide-spread acceptance and use in industry practice, likely due to the inherent complexity common in such approaches. Pension liability allocation shows promise in being relatively straightforward, with the advantage of closely paralleling the traditional asset allocation approach frequently used in investment policy setting.

While there are close similarities between traditional asset allocation and pension liability allocation, it is instructive to step back and compare / contrast both approaches. Figures 1 and 2 below present both models.

Figure 1 displays the traditional asset-centric approach to asset allocation. In the process of reviewing ABC plan's investment policy, a 70 / 30 stock / bond portfolio is considered. Effectively, the process allocates 70% of the fund's assets to equity classes, and the remaining 30% to fixed income securities. Eventually, the plan sponsor compares various risk and reward metrics (hopefully including surplus-based measures) relative to other candidate mixes. Should the plan sponsor decide that this particular policy is optimal relative to others, it may then be adapted as the plan's investment policy.

**Figure 1: Traditional asset allocation directly assigns pension dollars between asset classes. Liability-matching concerns are examined after-the-fact.**



Briefly, the traditional asset allocation approach involves the assignment of pension dollars to asset classes, both equities and fixed income. Candidate portfolios are constructed by varying percentages allocated to equities and fixed income, with allocations to a pre-selected subset of asst classes. After a reasonable number of alternative asset portfolios are selected for evaluation, various metrics are calculated for comparison, after which one portfolio is selected as the revised (or validated) investment policy. Clearly, considerations involving liabilities or liability-matching are considered only after the actual construction of the portfolios. It can be reasonably hypothesized that this asset-class assignment-first, liability analyses-last approach has resulted in the typical equity-laden, market duration bond portfolios that remain common among pension plans.

**FIGURE 2: Pension liability allocation initially assigns pension dollars between hedged and unhedged liabilities, before determining the optimal allocation to available asset classes that will satisfy the targeted hedge factor.**

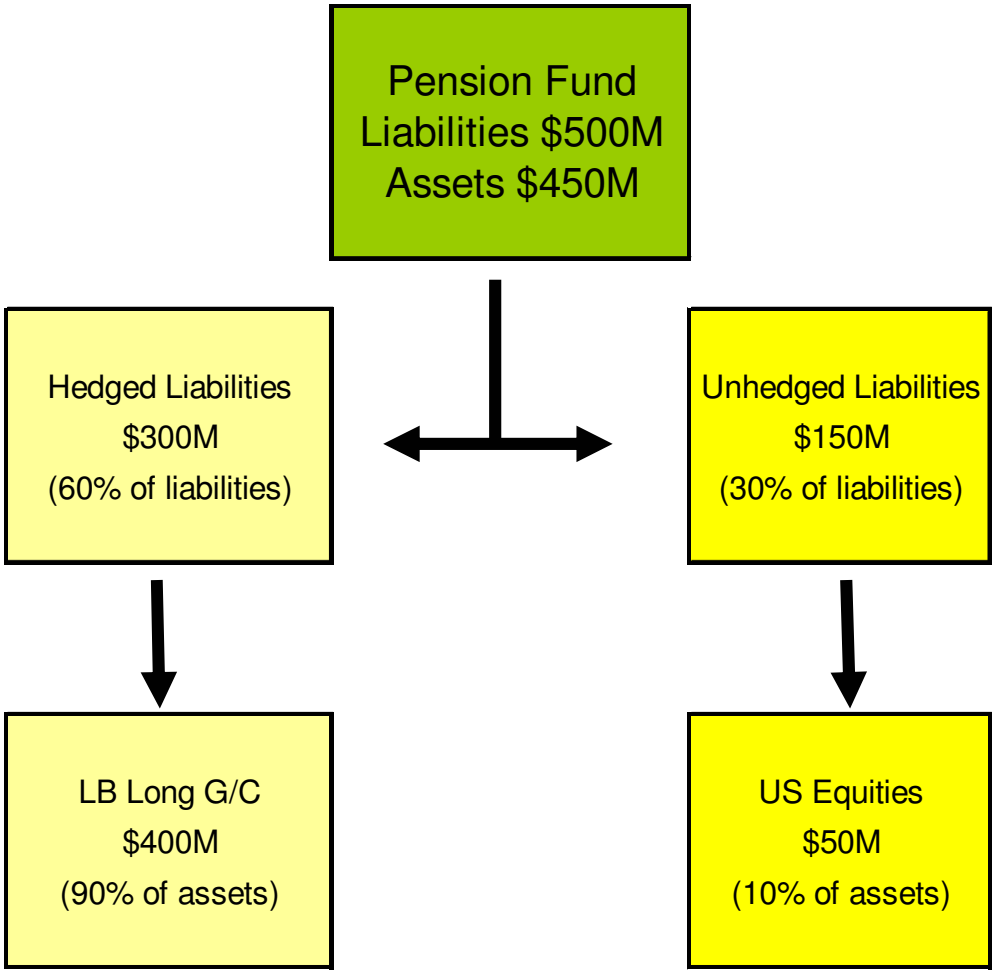


Figure 2 illustrates the liability-allocation process to construct a candidate investment policy for XYZ's pension plan. A target 60 / 30 pension liability allocation is considered, implying the plan sponsor wishes to review a policy where 60% of its liabilities are hedged, 30% are unhedged and the remaining 10% is unfunded. Clearly, XYZ's plan liabilities are immediately considered in creating this and any other target portfolio under this approach.

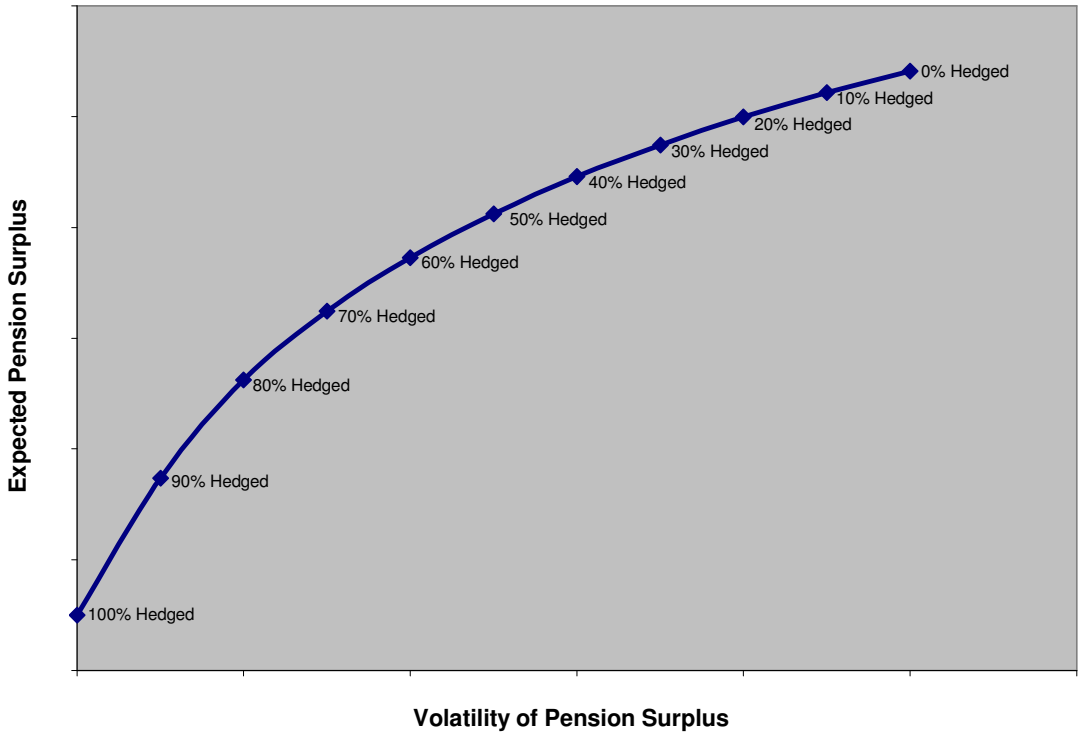
In Plan XYZ in Figure 2, a 60 / 30 pension liability allocation is included as one of the investment policies for consideration. Ultimately, the algorithm determines that allocations of 90% of asset dollars to a Lehman Long Government / Corporate benchmarked-portfolio and the remaining 10% to US Equities satisfy the 60% liability-matching target.[1]

Other target portfolios defined in terms of liability allocations are considered in this framework. Figure 3 shows a liability-allocation efficient frontier that parallels the asset-efficient frontier frequently used in the traditional asset-allocation approach. However, unlike the typical asset-efficient frontier which shows optimal portfolios with varying levels of equity and fixed income allocations, the pension liability allocation efficient frontier displays investment policies resulting in varying levels of hedged and unhedged liabilities. Thus, the optimal portfolios in the frontier start at 100% hedged in the southwest corner, then proceeds north-east such that hedged ratios decline, until eventually the maximum surplus-risk portfolio (0% hedged) is reached.

Portfolios in the north-east corner of the liability-allocation efficient frontier will likely be similar to those in an asset-efficient frontier: heavily laden with equities and equity-like securities that have low to zero correlation with liabilities. Portfolios in the south-west corner will likely be different from those in the asset frontier. Customized bond portfolios matching all or majority of liability cash flows will be required to reach the 90 to 100% hedged factors. Asset-only efficient frontiers rarely include customized liability-matched portfolios; minimum asset-risk portfolios will be comprised of cash and industry benchmarked bond (i.e., Lehman Brothers Aggregate Index).

Based on the discussion of duration mismatch in the prior paper, such benchmark implementations only provide 60 to 80% hedging, resulting in these portfolios residing below the frontier. Effectively, the requirement for 90 to 100% hedged targets forces the inclusion of customized liability cash-matched bond strategies that are often completely disregarded in traditional asset allocation. Consequently, the pension liability allocation framework extends the typical frontier to the left, requiring the inclusion of specialized cash-matched bond portfolios. At the very least, the use of this novel framework forces the plan sponsor to consider these strategies that would otherwise have been excluded using the traditional approach.

**Figure 3: Pension liability allocation efficient frontier displays the full spectrum of candidate portfolios for setting investment policy.**




After the selection of candidate portfolios from the pension liability allocation frontier, a similar analytical comparison of various metrics is performed as in the traditional asset allocation process. Various measures of risk, reward and efficiency (ratio of reward to risk) involving assets, liabilities and surplus over the short and long-term will be calculated and compared. When the plan sponsor's financial standing, benefits philosophy and desired funding policy are incorporated into the analytics, an appropriate investment policy suited to the plan and enterprise may be rationally selected.

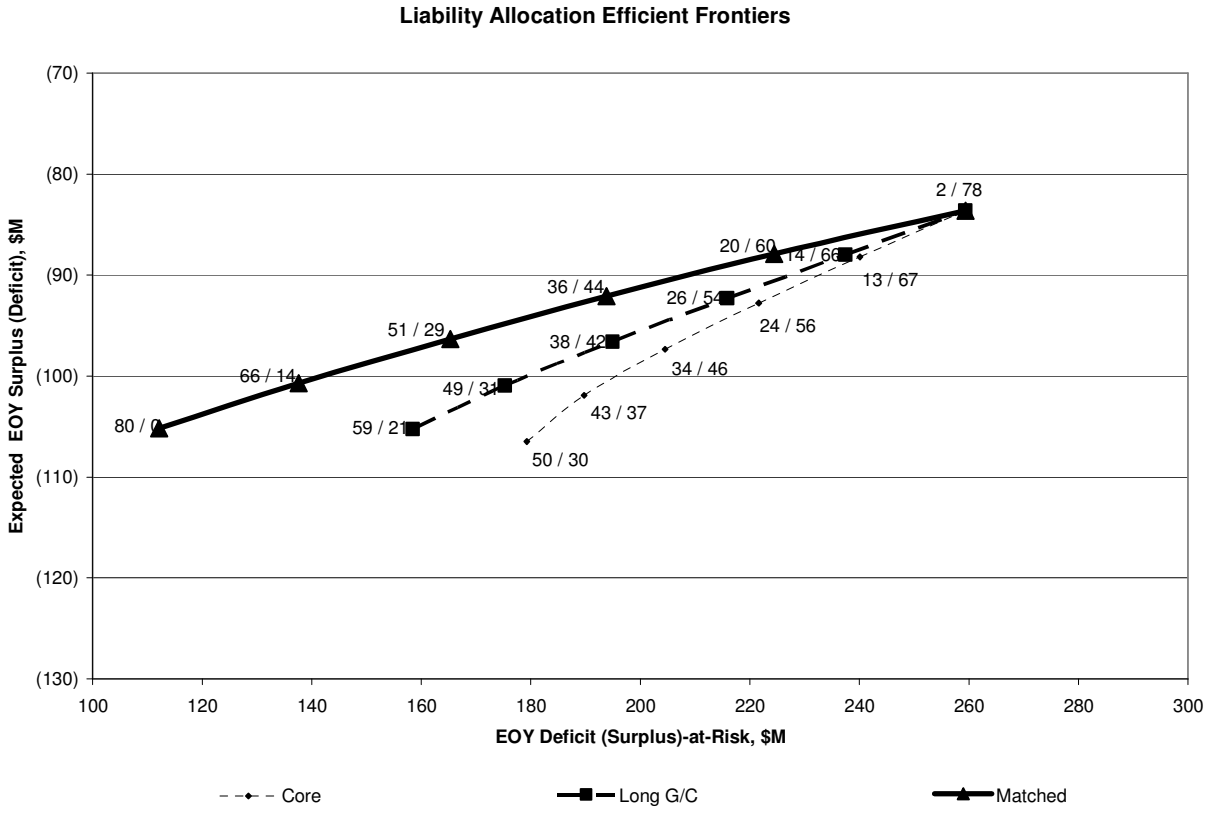
Some may argue that the new approach presented is not materially different from the traditional approach, especially when the allocation to asset classes is only deferred to the second stage. However, the step of selecting investable assets for the plan's available dollars is inevitable. It is the new framework's conscious attention to plan liabilities in the target portfolio construction stage that distinguishes it from the current asset allocation process. The traditional process, in some respect, suffers from the proverbial adage of "putting the cart before the horse"'; liability concerns are only considered after the portfolios have been constructed and selected. The pension liability allocation framework on the other hand, initiates target portfolio construction with liabilities front and center.

While asset allocation varies equity / fixed income weights for target portfolios, liability allocation varies hedged / unhedged ratios. As intimated in the above discussion, the perspective of pension liability allocation is to minimize surplus risk (i.e., maximize the hedged liability ratio) at the maximum (surplus) return feasible, while the traditional objective function arguably has been to maximize (asset) return at the minimum (asset return) volatility. The pension liability allocation process forces the inclusion of liability-hedging assets.

## Pension Liability Allocation Efficient Frontiers

In the equity / liability mismatch discussion from the prior paper, six portfolio liability allocations with varying allocations to equity and a long bond index were calculated to illustrate the quantification of mismatch risk. This section builds on that analysis, albeit with a slightly expanded perspective of investment policy setting.

**Figure 4: Pension liability allocation efficient frontiers using different bond portfolios; liability allocations are indicated beside each portfolio.**



The six portfolios used in the equity / liability mismatch discussion are graphically shown along the middle, dashed frontier (Long G/C). The vertical reward axis displays expected end-of-year surplus (deficit), while the horizontal risk axis displays the deficit (surplus)-at-risk (95$^{th}$ percentile end-of-year deficit)[2]. The liability allocation for each portfolio is labeled at each point.

Increasing levels of equity risk may be examined by sliding northeast along the frontier, noting the decrease in the hedged factor as increments of non-liability matching equities are added. When alternative fixed income implementations are considered, multiple frontiers are possible. When the sub-optimal (for pension plans) US Core Fixed bond implementation is used, the degraded performance is readily apparent with the downshifted, dotted frontier (Core). When the risk-free asset (bonds matching longest liability cash flows) is combined with the risky (equity) asset, the optimal portfolios are generated. The solid-lined, upper-most frontier represents various levels of equities, with the remaining funds allocated to the longest liabilities.

The improved risk / reward tradeoff in the customized portfolio should alert plan sponsors to the potential benefits of bond investing beyond traditional benchmark indices. The risk-reduction benefits from moving from 100% US Core-Fixed to a Long-Bond index, and finally to the cash-matched strategy was already highlighted in the bond duration mismatch section. However, even when only a portion of the available funds is allocated to fixed income, significant risk reduction may still be feasible. In the typical asset allocation 60 / 40 mix, the same shifts on the 40% (of assets) bond allocation increase the hedged factor from 24% to 26% to 36%; note that the risk reduction is accomplished with assets equal to only 32% of liabilities (40% x 80% funded ratio).

In fairness, it should be pointed out that the analysis implicitly assumes that fixed income securities consistent with the discount yield curve are available with nil transaction costs. Standard benchmark strategies do have the advantage of straightforward and cost-efficient implementation. Customized benchmarks will require specialized attention and investments, which consequently translate into higher costs. Since the potential risk-reduction advantages of such strategies are significant, investment managers who are able to offer cost-efficient customized solutions should readily succeed with receptive plan sponsors desiring to minimize pension risk.

Recall from the first part of this paper that minimum pension-risk portfolio for this 80% funded plan was a customized bond portfolio geared to match the longest liability flows with duration of 18.9 years. While total plan liability duration was 15.8 years, assets matched to the longest 80% of liabilities have duration 18.9 years. Table 1 displays the duration of varying percentages of the longest liabilities of the sample plan used above. This can provide guidance on how long the duration of bond portfolios might reach to minimize surplus volatility when

investment policy dictates lower proportions of assets to fixed income securities. In fact, the customized liability-matched bond portfolios in the above liability allocation efficient frontier have such durations. Thus, for this fairly typical frozen plan, fixed income allocations equal to 20 to 40% of liabilities can warrant bond portfolios with 25 to 30 year durations.

**Table 1**
**Duration of Longest Liability Cash Flows**

| % of Longest Liabilities | Duration (years) |
|---|---|
| 100% | 15.8 |
| 80% | 18.9 |
| 60% | 21.9 |
| 40% | 25.5 |
| 20% | 30.5 |

The frontiers illustrated above show risk and reward over the short-term (one year). In comparing strategies, the plan sponsor needs to look at additional metrics that relate to assets (annual returns, standard deviation and selected percentiles of annual returns, downside-risk), liabilities (expected and volatility of funded ratio) and financials (levels and volatility of required funding policy contributions and accounting expense). Moreover, the plan sponsor also needs to consider projected long-term results, particularly with respect to cost and accounting impact[3]. While the short-term reward give-up might appear negligible or acceptable, compounding does magnify the cost of more conservative policies over the long term. Table 2 shows a subset of metrics the plan sponsor may consider; the values shown correspond to the efficient frontiers in Figure 4.

While comparing the above metrics, plan sponsors consider a multitude of other factors outside of the investment arena in adopting one specific strategy as the plan's investment policy. Micro-factors include policies involving corporate benefits, funding and accounting policies, as well as actuarial assumptions and methods. Macro-factors typically involve the financial footing of the corporate

## Table 2: Pension Metrics for Alternative Portfolios

| Portfolio | Core - 0% Eqty | Core - 20% Eqty | Core - 40% Eqty | Core - 60% Eqty | Core - 80% Eqty | Long G/C - 0% Eqty | Long G/C - 20% Eqty | Long G/C - 40% Eqty | Long G/C - 60% Eqty | Long G/C - 80% Eqty | Matched - 0% Eqty | Matched - 20% Eqty | Matched - 40% Eqty | Matched - 60% Eqty | Matched - 80% Eqty | Matched - 100% Eqty |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset Alllocation % | 0 / 100 | 20 / 80 | 40 / 60 | 60 / 40 | 80 / 20 | 0 / 100 | 20 / 80 | 40 / 60 | 60 / 40 | 80 / 20 | 0 / 100 | 20 / 80 | 40 / 60 | 60 / 40 | 80 / 20 | 100 / 0 |
| Liability Allocation % | 50 / 30 | 43 / 37 | 34 / 46 | 24 / 56 | 13 / 67 | 59 / 21 | 49 / 31 | 38 / 42 | 26 / 54 | 14 / 66 | 80 / 0 | 66 / 14 | 51 / 29 | 36 / 44 | 20 / 60 | 2 / 78 |
| Expected EOY Surplus ($M) | (106.5) | (101.9) | (97.3) | (92.8) | (88.2) | (105.3) | (100.9) | (96.6) | (92.3) | (88.0) | (105.2) | (100.7) | (96.3) | (92.1) | (87.9) | (83.6) |
| Surplus-at-Risk (5th Percentile EOY Surplus) | (179.3) | (189.7) | (204.5) | (221.6) | (240.1) | (158.5) | (175.2) | (194.9) | (215.9) | (237.4) | (112.1) | (137.6) | (165.3) | (193.8) | (224.4) | (259.3) |

sponsor and the size of the pension obligation relative to corporate net worth. By weighing the risk / reward metrics over the short and long term in conjunction with the above considerations, the plan sponsor is enabled to select the appropriate investment policy that ensures participants' pension security.

**Investment Overlays, Interest Rate Derivatives and Duration Pools**

Recently, a new range of innovative asset products have been introduced to defined benefit plan sponsors. Alternative asset classes such as private equity and hedge funds are attracting significant pension investments, while portable alpha strategies have attracted sponsors intent on maximizing return from active management. Interest rate instruments such as swaps and futures are being considered for efficiently extending bond durations beyond what is feasible with the longest 30-year bonds or zeroes. Moreover, investment banks have pooled such instruments into duration buckets to facilitate plan sponsors in developing customized bond portfolios[4].

The pension liability allocation methodology can readily incorporate such strategies for plan sponsor evaluation. By a careful analysis of the investment product, specifically its correlation (or non-correlation) with plan liabilities and integrating such into the algorithm, the impact on the hedged and unhedged factors will affect the resulting pension liability allocation. For example, a portfolio with an interest rate swap overlay will have a higher hedged liability allocation compared to the same investment strategy without the overlay. By examining the changes in pension liability allocation, the plan sponsor can evaluate the pension risk-reduction ability of any proposed investment strategy relative to any potential cost-increase.

**What Liabilities?**

Implicit in all the discussion here is the assumption of a well-defined pension liability. Given one set of fixed liability cash flows and a specified discount-rate methodology that is investable[5], a pension risk-free portfolio is theoretically feasible. However, in practice, there is a multitude of liability definitions that vary both in assumptions used to generate cash flows as well as in the discounting algorithm.

In the US, current practice[6] for determining required minimum contributions generally involves the calculation of two definitions of liabilities. The first, commonly termed actuarial liability, typically involves a fixed discount rate that is tied to the expected investment return. In this case, since the discount rate is not tied to market bond yields, the effective duration of this liability is zero (and therefore not hedge-able). The second liability definition is termed current liability; liability cash flows are discounted using a weighted four-year average of

30-year government bonds. The weighted nature of the discount rate makes the liability difficult if not impossible to hedge. A further complication is that all cash flows are discounted at the one discount rate; there is no 5-year fixed-income instrument available in the market that will change one-for-one with the 30-year T-Bond (disregarding the weighting problem previously mentioned). Clearly, a funding policy tied to either of the above two liabilities cannot have a pension risk-free asset[7].

Plan sponsors also pay close attention to pension liabilities impacting their financial statements. Two liability definitions are mandated by the US Financial Accounting Standards Board (FASB); the definitions only vary by cash flows, with discounting methodology the same for both. Cash flow definitions vary on whether the impact of future expected salary increases are included (projected benefit obligation or PBO) or not (accumulated benefit obligation or ABO). Generally, the PBO impacts the income statement with respect to pension expense, while the ABO affects the balance sheet with potential reductions to shareholder equity[8]. Prescribed discounting methodology involves a full market-based yield curve of high quality corporate bonds. As such, accounting liabilities in theory may be hedged using fixed income securities reflective of the high quality corporate yield curve.

Other liability definitions (e.g. pension liability defined by the PBGC for calculating insurance premiums charged to the plan sponsor) exist in US practice, but plan sponsors typically focus on the funding and accounting definitions. Ideally, the plan sponsor would want one liability definition that would allow for some degree of hedging applicable to both funding and accounting. While accounting liabilities are market-based and permit hedging strategies, there is no guarantee that the calculated accounting liabilities would be equal or greater than funding liabilities. A more conservative, higher-quality yield curve choice for discounting may provide for a single, hedge-able liability target sufficient for both concerns[9].

In setting and implementing a liability-driven investment policy involving full or partial hedging of pension liabilities, it is critical that the asset securities intended for hedging be consistent with the liability valuation methodology. Fixed income securities valued off a yield curve different from the discount curve used by the actuary will likely result in asset / liability mismatches. Moreover, particular attention should be given to how cash flows beyond 30 years are discounted, recalling that the longest liabilities carry the largest risk; actuaries tend to use the 30-year rate to discount all later cash flows which may present hedging complexities. Clearly, closer interaction between investment managers and actuaries will be a prerequisite for any successful liability-driven investment implementation. Both parties will be challenged as such, based on traditional practice of minimal interaction between the actuary and the investment manager(s).

## SUMMARY AND CONCLUSION

There is currently strong interest in pension risk minimization while plan sponsors are only starting to recover from their disastrous 2000-2003 experience. Moreover, anticipated reforms in both funding (recently passed Pension Protection Act of 2006) and accounting (FASB phase 1 pension accounting proposal) portend more volatile pension results and more severe consequences in terms of higher required employer contributions as well as greater financial balance sheet impact. Moreover, the recent move to higher long bond yields away from historical lows has made long-bond investing more palatable to plan sponsors.

This growing emphasis on pension risk control requires an effective tool for measuring risk. Traditional asset allocation ratios are not sufficiently fine-tuned to distinguish varying levels of liability-matching, particularly customized cash-matched bond portfolios. Even appropriate liability-based metrics such as surplus-at-risk require additional values for framing risk correctly. Section 1 introduced the concept of pension liability allocation, while Sections 2 and 3 discussed the use of pension liability allocation to succinctly summarize pension risk from two common sources of risk: duration mismatch and equity mismatch. The pension liability allocation by itself provides significant risk information: (1) the size of the hedged factor provides a quick sense of the investment policy's aggressiveness or conservatism, (2) the unhedged factor indicates the fraction of risk this particular strategy takes relative to the maximum pension risk portfolio, and (3) the sum of the hedged and unhedged factors sum up to the plan's funded ratio. Plan sponsors, credit rating and regulatory agencies, and investment analysts can use pension liability allocations to conveniently assess pension risk inherent within any plan of interest.

This part of the paper extended pension liability allocation from a pension-risk measurement tool to an investment-policy setting framework. The discussion contrasted the liability-focused, pension risk-minimizing philosophy of pension liability allocation versus the asset-centric, asset return-maximizing emphasis of traditional asset allocation. An anticipated change introduced by using pension liability allocation in the investment policy-setting process is the inclusion of more customized bond strategies specifically to address 90-100% hedged targets. Plan sponsors wishing to implement liability-driven investing will find the pension liability framework to be a natural framework for evaluating such strategies.

While arguments for and against branding pension liability allocation as a distinct allocation paradigm may be offered, the ultimate validation either way will come from the investment policies considered and eventually selected using pension liability allocation. While the ultimate policies may not be significantly different from those commonly used in current practice, the inclusion of customized bond portfolios and interest-rate overlays as potential strategies to satisfy high-hedged targets (and which otherwise would have been excluded under traditional asset

allocation) may justify the use of this new approach. Each and every plan sponsor in reviewing investment policy should: (1) know and understand the current policy's pension liability allocation and (2) consider and evaluate the option of a 100% hedged liability allocation. This will ensure that the plan considers the full range of risk positions from risk-free to the current risk level. The decision where to locate within this risk spectrum will ultimately depend on each plan sponsor's perception of such a policy's cost relative to benefits.

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**NOTES:**

[1] This rather surprising result of having to allocate 90% of assets to long bonds to hedge 60% of liabilities may be explained by three factors: (1) the imperfect liability match of the long bond index portfolio, (2) the unfunded position of the plan and (3) the negative correlation between stocks and long bonds /liabilities assumed in the calculation.

[2] Note the subtle difference in the axes (vertical is surplus while horizontal is deficit) to allow the liability allocation frontiers to track southwest to northeast as traditional asset frontiers do.

[3] Both funding and accounting standards are in a state of flux. Recently (August 2006), the Pension Protection Act of 2006 was finally passed by both houses of US legislature. The bill significantly revamps liability estimation and minimum funding regulation. The US Financial Standards Accounting Board (FASB) a two-phase revision of Financial Accounting Standard 87 (Employers' Accounting for Pensions). Phase 1 is expected to be announced by late 2006 for immediate adoption. See further discussion in following section.

[4] State Street Global Advisors introduced last April 2006 its Pooled Asst Liability Matching Solution, a series of duration buckets invested primarily in zero coupon swaps that provides plan sponsors a mutual fund-like alternative in customizing their bond allocations.

[5] Specifically, "investability" refers to a market-based yield curve with sufficiently liquid securities that provide a proxy / hedge to individual, annual liability cash flows. Discount rate methodologies using such market yield curves guarantee liabilities moving one-for-one with corresponding assets over the short-term.

[6] Following discussion refers to pre-Pension Protection Act of 2006 regulations.

[7] The Pension Protection Act of 2006 provided two liability discounting methodologies. The first involving a 3-point yield curve with 2-year smoothing does not allow for fully hedging the funding liability. The second option using a full corporate yield curve (based on the three highest credit ratings) without smoothing presents the potential for hedging the new funding target liability.

[8] Proposed FASB pension accounting reform set for late 2006 appears to make ABO irrelevant, and singles out PBO as the driving liability that will impact both the income statement and balance sheet.

[9] Ryan (2002) has long been a proponent of using the government bond yield curve to discount pension liabilities.

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## About Pension, Investment and Insurance Resource, L.L.C.

Pension, Investment and Insurance Resource, L.L.C. (Pi2Resource) specializes in asset / liability management, risk budgeting and pension liability allocation. Pi2Resource provides risk/return modeling, benchmarking, investment policy setting and implementation services for pension funds, insurance pools, endowments / foundations and other investment funds.

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