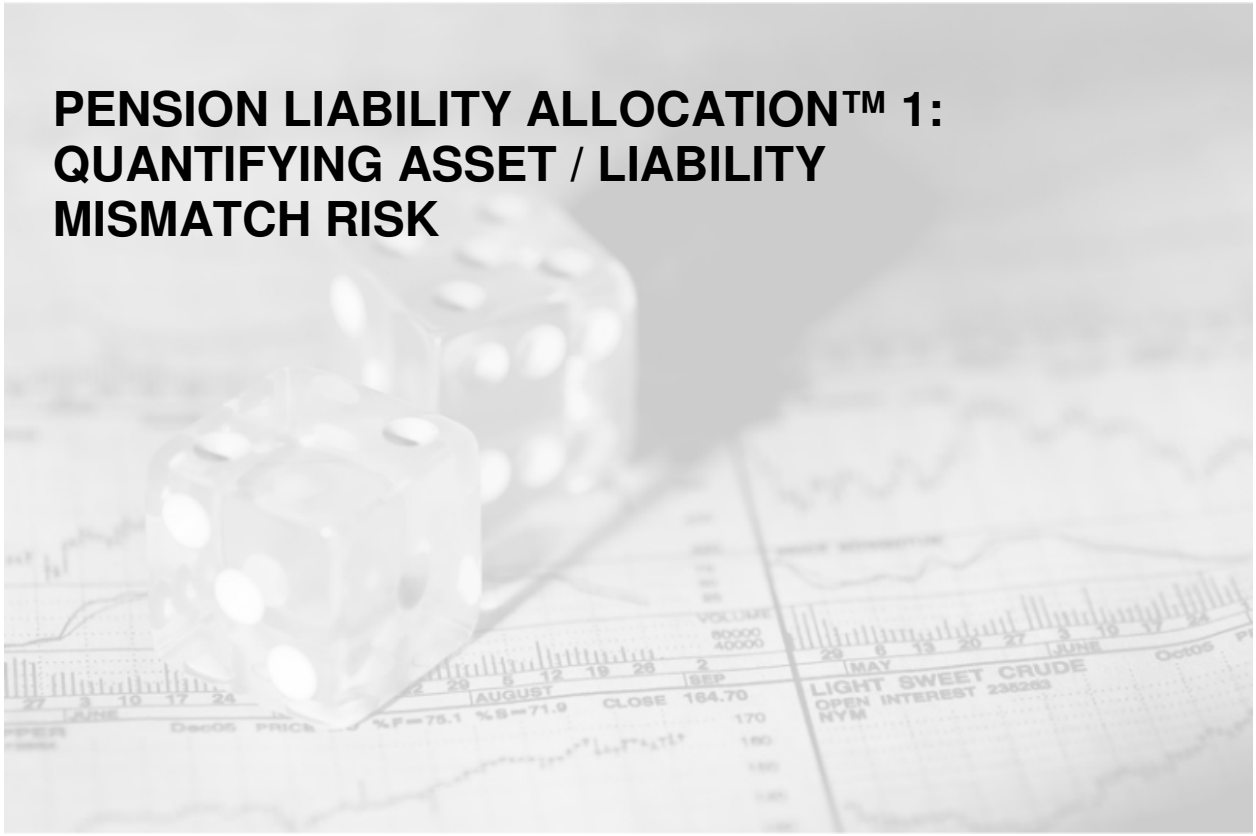
PENSION LIABILITY ALLOCATION™ 1: QUANTIFYING ASSET / LIABILITY MISMATCH RISK



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With the heightened interest in pension risk management arising from the painful experience of the so-called 2000-2002 "Pension Perfect Storm", defined benefit plan sponsors are seeking effective means of measuring pension risk in their current and alternative investment strategies. In this first of a two-part paper, the concept of pension liability allocation is introduced as a compact, convenient measure of pension risk that encapsulates plan-specific liability and surplus factors in conjunction with asset allocation and investment overlays. Liability allocation is then used to quantify risk from two general types of asset / liability mismatch: (1) fixed income duration mismatch, and (b) equity mismatch.

INTRODUCTION

Defined benefit plan sponsors have long accepted the risk / reward tradeoff in favor of expected higher returns of public equities relative to the lower volatility of fixed income securities. The majority of pension plan assets remain invested in equity and equity-like classes, as evidenced by the still ubiquitous "60 / 40" stock / bond strategic asset allocation. According to the 2006 Pension and Investments survey, the largest 200 defined pension plans allocate 62.6% of their assets on average to domestic and international equities (Pension & Investments, 2006). The average for the largest 1,000 plans is insignificantly lower at 62.1%. Corresponding 2005 and prior year results show no discernable changes.

The reward aspect of the tradeoff is relatively straightforward to quantify; the forward-looking "equity premium" is calculated as the excess of expected equity returns over that of fixed income. While considerable debate might arise regarding the magnitude of the equity premium, it is widely recognized as being a positive value over the long-term. While historical equity premiums have been estimated between 4 to 6% per annum, a smaller excess has been generally accepted for predicting future results[1].

The risk aspect of the tradeoff is far more difficult to quantify. While most plan sponsors have the intuitive notion of greater risk due to higher volatility of portfolio returns, few have any quantified estimates of asset risk. Standard deviation of portfolio return remains the predominant measure of risk; however, standard deviation has long been disadvantaged by the fact that it requires additional mental juggling to arrive at final risk measures. Recently, risk measures that measure the tails of statistical distributions have been proposed. These percentile measures of risk are frequently referred to as "value-at-risk" and other similar "at-risk" metrics. Moreover, these asset-based risk estimates

remain detached from the ultimate corporate and participant concern, the pension liability.

Plan sponsors are very much aware that pension liabilities may be hedged fully or in part by appropriately selected fixed income investments[2]. The allocation of assets to equities should be viewed as the plan sponsor's (hopefully) conscious decision to accept a level of asset / liability mismatch in exchange for the anticipated positive return premium. However, while the pension asset / liability mismatch risk from equities is widely comprehended, the understanding remains on an intuitive level, rather than a tangible, quantifiable measure. While "surplus-at-risk" and related metrics are appropriate extensions of the "value-at-risk" concept to pension risk, they remain relatively uncommon. Moreover, these measures are largely plan-specific and require cross-referencing with other data points, making it especially difficult for comparing pension risk between different plan sponsors.

This paper introduces the concept of liability allocation, and its potential use as a convenient, concise and effective measure of pension risk. Moreover, pension liability allocation can serve as a liability-driven asset allocation framework that is gaining significant attention in the financial press (Pension & Investments, 2006).

This article is the first of a two-part a paper. Part I concentrates on the quantification of mismatch risk, discussed over 3 sections. Section 1 introduces the concept and provides a broad conceptual basis. Sections 2 and 3 discuss the use of liability allocation in quantifying risk from two general types of asset / liability mismatch: (a) fixed income duration mismatch, and (b) equity mismatch. While the use of pension liability as a framework for setting pension investment policy may be readily deduced from the discussion in Sections 2 and 3, Part II presents a formal process on how liability allocation may be adapted to implement a liability-centric asset allocation approach that can be used to review, validate or revise a pension plan's current investment policy.

1. PENSION LIABILITY ALLOCATION

The concept of pension liability allocation may be readily grasped by contrasting it with the widely understood asset allocation definition. When a pension plan is said to have a 60 / 40 asset allocation, the plan is invested such that 60% of its assets are in equity securities, while the remaining 40% is in fixed income. Now, when a pension plan is said to have a 60 / 40 liability allocation, the plan is invested such that 60% *of its liabilitie*s are matched by hedging assets, while the remaining 40% *of liabilities* are invested in non-matching assets.

Thus, a pension plan's liability allocation takes into account its investment policy (including any overlays such as derivative hedges) as it relates to the extent assets match (or do not match) the plan's specific liabilities. The pension liability

allocation is then the ratio of the plan's hedged liabilities to unhedged liabilities. A 100 / 0 pension liability allocation indicates that 100% of plan liabilities are hedged with matching fixed income securities such that there is zero risk. Risk in this case is volatility of the pension fund's surplus return, defined as the difference between the plan's asset return (adjusted for funded ratio) and liability return[3]. Other risk definitions are feasible, but ultimately, the plan sponsors' and participants' concerns key on the amount of surplus or deficit of plan assets relative to plan liabilities[4]. For this 100% hedged portfolio, the fund sponsor expects zero (or nil) volatility with respect to its surplus return, and consequently, the plan's dollar surplus[5].

On the other end of the risk spectrum, a 0 / 100 pension liability allocation indicates an investment policy where selected assets are largely independent of liabilities. This 100% unhedged portfolio is intended to be the maximum-risk policy with respect to surplus return. While this portfolio may be determined by optimization routines based on asset classes under consideration, it may be worthwhile to consider a theoretical maximum risk portfolio when reviewing a particular plan's investment policy. However, when assessing pension risk between different sponsors, setting a fixed level of surplus return volatility may facilitate the comparison.

With both anchors of the risk spectrum specified, alternative investment policies may be evaluated from a surplus-return perspective. For example, an alternative investment policy calculated to have an 80 / 20 liability allocation will have half the surplus return volatility relative to the plan's current 60 / 40 liability allocation (i.e., 20% unhedged liability is half that of the current policy's 40%)[6]. By referring to the calculated pension liability allocation for any investment policy, the plan sponsor can quickly gauge the implied increase or decrease in pension risk relative to current policy.

A convenient feature of the liability allocation definition is that the sum of the hedged and unhedged factors sum up to the plan's funded ratio. While all prior examples of liability allocations have totaled to unity, it will be more common for the factors *not* to add up to one; the factors will sum up to one only when assets exactly equal liabilities. Thus, a 30 / 60 liability allocation denotes an investment policy resulting in 30% of the plan's liabilities being hedged, 60% unhedged and 10% unfunded. In cases of an overfunded position, the surplus is added to the unhedged factor by definition, as the excess assets do not have any matching liabilities[7].

Asset Allocation, Funded Position and Liability Allocation

A plan's asset allocation has long been used as an intuitive starting point for estimating the plan's level of risk. For example, the Pension Protection Fund (the UK equivalent of the US Pension Benefit Guarantee Corporation) explicitly points

out the need to factor asset allocation risk in assessing risk-based levies on covered pension schemes. Its July 2005 Pension Protection Levy Document explicitly points out the historical and future impact of asset allocation (Pension Protection Fund, 2005). The document notes "the effects of historic risks that have led to the current environment include … the effect of the asset allocation strategies adopted by schemes and the percentage of investments that do not match income streams to future liability profiles". It adds "the future risks faced by the Board include … the effect of the asset allocation strategies adopted by schemes and the percentage of non-matching investments". Finally, "the Board acknowledges that asset allocation is an important leading indicator of future scheme funding levels".

The decision of the Pension Protection Fund to defer the inclusion of asset allocation in its risk-based levies points to possible shortcomings of using asset allocation by itself and the complexity of having to integrate other metrics to complete the risk framework. For example, given that two plans have the same 60 / 40 asset allocation, it is not possible to make any conclusions regarding the level of pension risk inherent within the two plan sponsors. From an asset perspective, there are an infinite number of ways to implement 60% in equities and 40% in fixed income. Equity implementation may vary between styles (value, growth), size (large, mid, small), geography (domestic, developed international, emerging markets), levels of active (versus passive) management and other equity overlays, all of which will ultimately impact asset volatility. Additional complexity is likely with the use of non-traditional equity classes such as private equity, hedge funds and real estate when included in the equity factor of the asset allocation. The various potential implementations of the fixed income allocation will likely have a more significant, wider range of impact on pension risk, primarily relating to how closely the implemented bond portfolio's cash flows match and correlate with the plan's liability cash flows (see Section 2 on duration mismatch risk).

However, even if the two plans held the same exact securities, one still cannot conclude that pension risk between the two plans are equal. This should be expected since asset allocation only deals with half of the pension equation, and disregards differences in: (1) the starting pension surplus or deficit, and (2) the nature of the pension liability in terms of future, variable cash flows.

The plan's initial funded ratio is a direct input in the calculation of expected surplus return, and consequently its volatility. Contrary to common intuition, a less funded plan would generally demonstrate lower surplus volatility relative to a more funded plan, for a given liability and a high-equity asset allocation[8]. The sheer greater volume of more volatile equity assets of an overfunded plan makes for a more volatile surplus position relative to an underfunded plan for the same set of liabilities and asset allocation.

The second factor to consider is the specific liability structure of the pension plan. Given the same set of asset securities and an equal starting funded position, two such plans will still have varying levels of surplus risk, depending on the differences in their liability characteristics (specifically on how liability cash flows match up with asset cash flows). The longer the liability durations, the lower surplus volatility will be with equity strategies (to the extent that equities are assumed to have higher correlations with longer liability flows).

While asset allocation disregards the above two risk factors, the pension liability allocation algorithm takes both as direct inputs and are consequently reflected concisely in the calculated liability allocation ratio. As a pension risk measure, a plan's liability allocation clearly provides more information than the asset allocation by itself, or even combined with the plan's initial funded position. Pension liability allocation may well suffice as a starting point in the UK Pension Protection Fund's search for an appropriate framework to factor a scheme's investment policy into its risk-based levy calculations.

Other interested parties such as credit-rating agencies and investment analysts can take advantage of pension liability allocation in assessing pension risk, particularly in enterprises where the unfunded pension liability is significant relative to the enterprise net worth. While rating agencies such as Standard and Poor's and Moody's will have their proprietary algorithms for pension-risk valuation (Standard and Poor's, 2002; Moody's, 2003), it appears that the analysis generally involves expected-scenario approaches; it is not clear how volatility is treated. Moreover, there appears no mention of the pension plans' investment policy and their integration (or non-integration) with liabilities.

Such agencies can utilize pension liability allocation to extend their analysis to worst-case or at-risk scenarios. The liability allocation can provide both intuitive as well as analytic inputs when evaluating pension risk using appropriate poor percentile events. While these agencies' pension rating methodologies evolve (Moody's, 2006), the pension liability allocation provides a promising enhancement to achieve more effective pension ratings.

2. USING PENSION LIABILITY ALLOCATION TO CALCULATE FIXED INCOME DURATION MISMATCH RISK

Pension liability allocation is a convenient framework for estimating asset / liability mismatch risk arising from implemented fixed income allocations that are not consistent with the duration of the liabilities. The bond portion of pension portfolios have traditionally been benchmarked against the low-duration Lehman Brothers' Aggregate Index; that index has a much shorter duration than the typical pension plan's liability double-digit duration (10 to 20 years). While strong arguments favoring longer bond exposures for pension plans' fixed income portfolios have become more common, there have been no effective means of quantifying the risk reduction benefits of doing so. The discussion in this section illustrates how pension liability allocation can effectively quantify this asset / liability matching benefit.

The pension plan used in the example is a defined benefit plan, with future benefit accruals discontinued[9]. The frozen plan has $500 million in accrued pension liabilities, with 60% of the liabilities coming from still working participants. The liabilities are valued on a marked-to-market basis, using a full corporate AA spot yield curve, with the 30-year spot rate used to discount liability cash flows expected in year 30 and beyond. The (modified) liability duration is 15.8 years. The plan is currently underfunded, with assets only equaling $400 million or 80% of total liabilities. This underfunded plan was intentionally selected to illustrate key points derived in the pension liability allocation process of minimizing surplus risk with less than sufficient funds to hedge the entire liability.

To illustrate the full impact of the asset / liability duration mismatch, Table 1 shows the surplus impact of 100% bond portfolios with varying durations. It is not the paper's intent to espouse full liability-hedging in all situations; the use of pension liability allocation to validate or revise current investment policy (including equities) is further discussed in the second part of the paper. Since typical pension portfolios have fixed income allocations around 30-40%, the potential for risk reduction from the appropriate bond implementation is less than show in Table 1, but still meaningful.

Table 1 shows five different implementations of a 100% bond portfolio. The first portfolio is the typical US Core Fixed Income implementation using the Lehman Brothers Aggregate Index as a benchmark, with duration of under 5 years, significantly lower than the 15.8 year liability duration. The second portfolio implements a longer bond portfolio, using the Lehman Brothers Long Government Corporate Index as its benchmark, with duration of around 11 years, closer but still shorter than the liability duration. The next three allocations (see Figure 1) delve into customized portfolios that match selected liability cash flows; each of the customized portfolios account for 80% of the liability value. The short cash-matched portfolio hedges the liability flows that come nearest, while the long cash-matched portfolio hedges flows that are farthest out. Finally, the equal

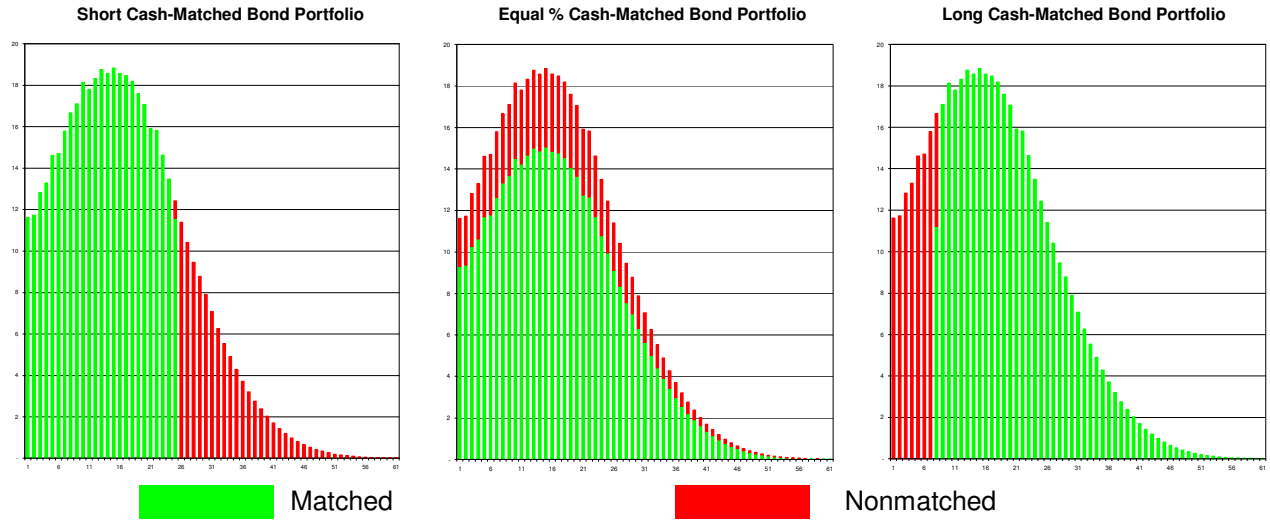
percentage cash-matched portfolio hedges 80% of the liability cash flow in every year.

Table 1

Portfolio	100% US Core Fixed	100% Long GovCorp	Short Cash-Matched	Equal % Cash-Matched	Long Cash-Matched
Asset Alllocation %	0 / 100	0 / 100	0 / 100	0 / 100	0 / 100
Liability Allocation %	50 / 30	59 / 21	68 / 12	75 / 5	80 / 0
Portfolio Modified Duration (years)	~5	~11	12.2	15.8	18.9
BOY Surplus (Deficit) ($M)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Expected EOY Surplus ($M)	(106.5)	(105.2)	(105.6)	(105.5)	(105.2)
Change from 100% US Core Fixed ($M)	NA	1.3	0.9	1.0	1.3
Surplus-at-Risk ($M) (5th Percentile EOY Surplus)	(179.3)	(158.5)	(138.9)	(123.8)	(112.1)
Change from 100% US Core Fixed ($M)	NA	20.8	40.4	55.5	67.2

All five portfolios in Table 1 would have 100% bond allocations. Yet, the widely varying range of pension risk for five portfolios with the same asset allocation exposes the severe deficiency of using asset allocation as a pension risk measure. Due to the "coarseness" of the weights, the generic bond allocation is unable to differentiate between the varied liability-hedging properties of the different portfolios. On the other hand, the liability allocation measure succinctly accomplishes this. Interestingly, only 50% out of a maximum 80% of liabilities are hedged when investing the assets in a Lehman Aggregate implementation. Shifting assets to a Lehman Long Government / Corporate portfolio extends hedged liabilities to nearly 60%.

Figure 1: Customized Cash-Matched Bond Portfolios



Using customized bond portfolios permits higher levels of matched liabilities with the same market value of assets. However, with funds sufficient to hedge only a portion of total liabilities, the question of which cash flows to match requires a comparison of the resulting liability allocations of the three alternatives. All three customized implementations have seemingly valid arguments that justify the particular strategy:

1) Under the short cash-matched implementation, the rationale common in individual personal financial planning is used. Under this implementation, liability cash flows that are coming up earliest are supported by funded bond cash flows. The modified duration of this bond portfolio is 12.2 years; as expected, the duration is shorter than the liability duration.

2) Under the equal percentage cash-matched strategy, a fraction (equal to the funded ratio) of the liability cash flows in each year is matched with available assets. This straightforward strategy treats the cash flows over all years evenly, resulting in a bond duration exactly equal to the liability duration of 15.8 years.

3) Under the long cash-matched implementation, liability cash flows that are farthest away are matched with long-dated bonds. The rationale for the strategy is that the longest liabilities generate the largest surplus volatility which can be effectively reduced to zero or nil, using appropriate zeroes, synthetic long bonds and / or interest rate derivatives. The resulting modified bond duration is 18.9 years, higher than the total liability duration.

From Table 1, it is clear that the long cash-matched strategy provides the minimum pension risk portfolio[10]. By construction and definition, this policy generates the maximum amount of hedged liabilities at 80%, with 0% unhedged and 20% unfunded. Matching the shorter end of the liabilities only effectively

covers 68% of liabilities, leaving 12% unhedged. Not surprisingly, the equal percentage cash-matched policy falls in-between the short and long strategies, hedging 75% of liabilities.

The argument for hedging the longest, most volatile (from a surplus perspective) liability flows is validated using pension liability allocation. The recommendation is consistent with recommendations in a recent editorial in the Financial Analysts Journal (Arnott, 2004). Arnott comments on the varied risk perspectives investors need to consider; specifically, he discusses pension plans and the "biggest risk – asset / liability mismatch". In his case study "more than 40% of the interest rate sensitivity of the entire pension fund is tied to long-tail obligations of at least 25 years, even though these obligations comprise only about 10 percent of the overall fund liability". Consequently, Arnott recommends that "by having only 10% of a fund's assets invested in ultra-long strips and synthetic strips, the fund can typically eliminate 30 percent of the interest rate sensitivity of the funding ratio and 40-50 percent of the asset / liability mismatch"[11].

The optimal reduction of pension risk using the long-cash matched approach gives credence to the often-suggested strategy of over-leveraging (relative to total liability duration) fixed income investments when actual assets or policy allocations to bonds are less than 100% of liabilities. In this case where there are assets sufficient to fund only 80% of liabilities, the minimum pension risk portfolio has duration of 18.9 years, longer than the plan liabilities' overall duration of 15.8 years. Should a plan be even more underfunded and / or the investment policy is less than 100% fixed income, the plan sponsor desiring to minimize pension risk should seriously consider even longer duration portfolios (i.e., hedge the longest liability flows with the available funds budgeted to fixed income allocations).

While the discussion has dealt primarily on the risk perspective, Table 1 also provides measures on the cost of risk reduction, with respect to expectations of year-end projected surplus / deficit. Generally, it is expected that lowering surplus volatility comes at a cost of lower expected surplus (as will be seen in the following section on equity mismatch). However, in the case of fixed income duration extension, there is no expected cost penalty; typically, there is even an expected cost reduction based on assumptions of a positively sloping yield curve (higher yields and returns at longer durations) and level future yields. While the volatility and correlation assumptions used in Table 1 are based largely on actual experience over the last 10 years, return assumptions are based on the yield curve as of the valuation date. As such, the expected surpluses at year-end are insignificantly different between all five policies, due to the flat valuation yield curve in place at the measurement date. Expected surpluses between the five portfolios are within $1.3M of each other. If a steeper yield curve were to be used, the win-win result in terms of lower-volatility, lower-cost advantage for bond duration extension strategies would be clearer.

It should also be noted that in the absence of additional inflows other than investment returns (i.e. employer contributions), the deficit would continue to increase. Even for the long cash-matched portfolio where 80% of liabilities are matched (so that the funded position for that liability subset is fixed), the expected total deficit still increases due to changes in the unmatched liabilities.

Most importantly, it is imperative to note the significant improvement in surplus-at-risk, or the 5th percentile value of year-end surplus / (deficit), in going from the Lehman Aggregate-implemented portfolio to the customized long cash-matched strategy. Under a 100% Lehman Aggregate portfolio, the worst 5th percentile deficit is nearly $180 million (from a starting deficit of $100 million). When the long cash-matched bond strategy is used, surplus-at-risk is only at $112 million, where the additional $12 million in downside risk comes from the unfunded, unmatched liability. The improvement of nearly $70 million in surplus-at-risk gives notice to plan sponsors to carefully plan their fixed income implementations. With the growing interest in customized bond solutions espoused in liability driven investing or LDI (Pension & Investments, 2006), pension liability allocation provides a natural liability-focused investment framework.

3. USING PENSION LIABILITY ALLOCATION TO CALCULATE EQUITY MISMATCH RISK

In this section, a similar analysis is performed on quantifying asset / liability mismatch risk, this time focusing on the mismatch arising from using equity investments to defease pension obligations.

The magnitude of the equity / liability mismatch risk will depend on which bond class assets are being allocated to or away from equities. Based on the findings in the prior section, the change in mismatch risk would be smallest when the plan is reallocating away from a Lehman Brothers Aggregate bond portfolio (relative to the other bond portfolios considered in Section 2); the mismatch risk would be largest for the long cash-matched strategy. In the following discussion, a Lehman Brothers Aggregate Long Government / Credit will be assumed as a starting point, as an intermediate choice between Aggregate and the cash-matched strategies (and also a relatively common implementation in practice). The same pension plan with the 80% funded ratio in Section 2 is used.

Table 2 below shows the risk impact of allocating to/away from equities in 20% increments. Equities are invested 60% US Large Cap, 20% US Small Cap and 20% International Developed. The first portfolio is 100% invested in a Long Government / Corporate bond benchmark mix and the subsequent portfolios have equity investments incrementing by 20% each step. The portfolio in the last column is 100% equities.

The liability allocation row in Table 2 reveals the changes to the plan's liability allocation as equities are introduced. Recall from Section 2 that the hedged factor for the 100% Long Government / Corporate portfolio was nearly 60%. Going across the table, each 20% equity increment increases the unhedged factor by 10 to 12%. Interestingly, the (excess) surplus volatility has doubled at 40% equity relative to that of the 100% long bond portfolio (i.e., unhedged factor of 42% in the liability allocation of the 40% equity portfolio is twice that of the 100% long bond portfolio). The traditional 60 / 40 portfolio has two-and-a-half times the surplus volatility of the bond portfolio. At 80% equity, the volatility has tripled, with the unhedged factor at 66%. The 100% equity portfolio is very close to the maximum surplus risk portfolio, as evidenced by the 78% unhedged factor being only slightly less than maximum-possible 80% unhedged factor; this is not surprising, as the equity portfolio is only slightly different asset-allocation-wise from the maximum risk portfolio defined for this example.

Table 2

Portfolio	100% US Long Gov/Credit	20% Equity	40% Equity	60% Equity	80% Equity	100% Equity
Asset Alllocation %	0 / 100	20 / 80	40 / 60	60 / 40	80 / 20	100 / 0
Liability Allocation %	59 / 21	49 / 31	38 / 42	26 / 54	14 / 66	2 / 78
BOY Surplus (Deficit) ($M)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Expected EOY Surplus ($M)	(105.2)	(103.2)	(101.3)	(99.3)	(97.3)	(95.3)
Change from 100% US Long G/C ($M)	NA	2.0	4.0	6.0	8.0	10.0
Surplus-at-Risk ($M) (5th Percentile EOY Surplus)	(158.5)	(177.5)	(199.6)	(222.8)	(246.7)	(271.0)
Change from 100% US Long G/C ($M)	NA	(19.1)	(41.1)	(64.4)	(88.3)	(112.5)

The row showing the expected deficit after one year provides some flavor on the cost / benefit analysis that is essential when reviewing or revising the equity allocation in the plan. The expected year-end deficit is smaller by $2 million for each 20% equity increment. The $2 million is consistent with the forward-looking assumption of a 2.5% equity premium (over long government / corporate bonds). Ultimately, the plan sponsor needs to translate the annual differentials to longer-term estimates that take into account compounding, and clarifies the trade-off between long-term cost and short-term risk reduction. The second half of this two-part paper further discusses investment-policy setting using the pension liability allocation methodology.

The resulting pension liability allocation for each of the portfolios foretells the resulting impact in surplus-at-risk. Each equity increment worsens surplus-at-risk from $20 to $25 million, with magnitudes increasing for each additional 20% increment. The 100% bond portfolio has a surplus-at-risk metric of $160 million deficit; adding five 20% equity increments results in the metric worsening to over $270 million, a cumulative change for the worse of over $110 million**.**

While surplus-at-risk may be a valid pension risk metric, it needs to be complemented with other measures such as beginning surplus and / or additional surplus-at-risk values to get an effective grasp of the pension risk. Using the example above, one cannot conclude that an investment policy with a deficit-at-risk of over $270 million is very aggressive; the conclusion can only be arrived at if one is provided the additional information that the initial deficit was only $100 million and / or an alternative, more conservative investment policy has a deficit-at-risk of only $160 million.

Liability allocation does not suffer from this requirement; it has the advantage of being able to convey pension risk even as a stand-alone measure. Knowing that a plan has a pension liability allocation from 100 / 0 to 80 / 20 indicates a conservative investment policy that has little to nil pension surplus volatility. Conversely, a plan with a pension liability allocation of 20 / 80 to 0 / 100 indicates an investment policy that is aggressive and structurally similar to the maximum pension risk portfolio[12].

Conclusion

The first portion of this two-part paper discussed the quantification of asset-liability mismatch risk in pension funds. The concept of pension liability allocation was first introduced in Section 1. A pension plan's liability allocation was defined as the ratio of hedged assets to unhedged assets, expressed as a percentage of liabilities, where hedged / unhedged is calculated relative to the particular liabilities of the plan. Pension liability allocations may be determined for a variety of investment policies and / or strategies to provide plan sponsors and other interested parties a quick and concise measure of the impact on pension risk (volatility of surplus return). Moreover, by definition, pension liability allocation has the useful feature of its hedged and unhedged factors summing up to the plan's funded ratio, another common risk metric for pension plans.

While a plan's asset allocation only deals with the asset-side of the pension plan, the pension liability allocation encapsulates (1) the plan's strategic asset allocation, (2) any investment overlays including derivatives, futures and swaps, (3) the plan's funded ratio and (4) the plan's specific liabilities. As such, the pension liability allocation is a far-more comprehensive risk measure than asset allocation, and arguably any other currently used in the field. In addition to plan sponsors and consultants, other interested parties such as stock or credit

analysts and pension regulators will find value in estimating plans' pension liability allocations.

With respect to bond duration-mismatch risk, the case study demonstrated a wide range in pension liability allocations between five implementations of 100% bond portfolios. In the case study of an 80% funded plan ($400 million in assets, $500 million in liabilities), a typical 100% US Core Fixed Income–implemented portfolio was calculated to have a 50 / 30 liability allocation (i.e. 50% hedged, 30% unhedged, 20% unfunded), while the minimum-risk, (long) cash-matched bond portfolio by definition had a 80 / 0 liability allocation. End-of-year deficit-at-risk (95^{th} percentile dollar deficit) differential between the two implementations was a significant 68% of starting deficit million ($180 versus $112 million with beginning deficit of $100 million). The significant variances in risk between the bond portfolios highlight the need for detailed attention required in setting a plan's fixed income implementation.

The more-familiar equity-liability mismatch risk was addressed in Section 3. Using the same case study, the analysis showed that each 10% equity allocation decreased (increased) the hedged (unhedged) factor of the pension liability by 5 to 6% (absolute percentage-wise), assuming a long-bond index implementation for the fixed income allocations. Liability allocations ranged from 60 / 20 for the 100% long bond index to 2 / 78 for a diversified 100% equity portfolio. End-of-year deficit-at-risk (95^{th} percentile dollar deficit) differential between the two portfolios was a staggering 110% of starting deficit ($160 versus $270 million with beginning deficit of $100 million).

This first half of the paper emphasized the use of liability allocation as a risk measure for pension fund management. The example showed how the concept can improve on the current difficult situation for plan sponsors and other interested parties wishing to gauge, let alone measure pension risk. Typical pension risk analyses involve the simultaneous consideration of multiple asset, liability and surplus measures scattered within voluminous pages of an asset / liability management report. Consistent with the old business adage of being able to manage what you can measure, liability allocation promises to be a compact, calculable metric that improves on the traditional asset allocation measure by integrating other critical factors such as current funding position, plan-specific liability structure as well as investment overlays that may reduce (or increase) pension risk. While each sponsor is intimately familiar with their plan's asset allocation, they can benefit significantly from knowing and understanding their respective pension liability allocations.

While the prior discussion has concentrated on pension liability allocation as a risk metric, the concept can be naturally extended as an investment-policy setting framework for liability-driven investing. By calculating expected asset and surplus returns, as well as cash-flow (funding) and accounting measures over the short and long-term, reward metrics may be integrated with the pension liability

allocations to perform the risk / reward tradeoff analyses essential in setting investment policy. The second part of this paper presents such a framework.

NOTES:

[1] Arnott and Bernstein (2002) argue for a modest "normal" equity premium of 2.4%

[2] Pension liabilities throughout this paper are assumed to be accrued, and exclude future benefit accruals. Liability and surplus growth and return calculations do not include benefits expected to be earned over the next year for plans providing ongoing accruals.

[3] Liability return is the period-ending change of the starting liability value, exclusive of new benefit accruals from service within the period.

[4] Funded ratio is an alternative metric often used for asset / liability management. While in most cases funded ratio and dollar surplus will move in the same direction, it cannot be concluded that an improved funded ratio guarantees an improved surplus or deficit. For example, at the beginning of the year, a plan might have a funded ratio of 90%, a deficit of $10 million with assets of $90 million and liabilities of $100 million. Say liabilities increased 20% to $120 million from new benefit accruals as well as lower discount rates. Fortunately, assets increased 21.33% to $109.2 million from returns and employer contributions. However, while the resulting ending funded ratio is improved at 91% relative to the beginning-of-year 90%, the deficit has worsened from the beginning $10 million to an ending $10.8 million.

[5] Drivers of liability and surplus volatility addressed here pertain to capital markets (e.g. bond yields and inflation). It should be remembered that some volatility will arise from demographic factors such as mortality, turnover and retirement rates. Waring (2004) refers to such non-market uncertainties as the alpha component of liability return, with liability beta being reserved to market-driven factors.

[6] More accurately, the excess of the 80 / 20 liability allocation's surplus volatility relative to the minimum risk portfolio is half that of a 60 / 40 liability allocation)

[7] Technically, the excess assets can contribute to the hedged factor to the extent that they are correlated with liabilities; however, the maximum hedged factor remains capped at unity.

[8] While lower surplus volatility may appear to be a silver lining for underfunded plans, it should be remembered that volatility works in both directions. Being stuck in such an underfunded position is not exactly desirable.

[9] With the plan frozen, inflation risk is no longer a concern for this plan (typical in the US) without mandated cost-of-living adjustments, leaving interest rate risk as the sole capital market volatility factor. Due to the recent benign inflation experience, US plan sponsors at present generally do not view unexpected higher inflation as a major risk consideration. For plans with ongoing benefit accruals with inflation risk concerns, Waring (2004) discusses extensively the simultaneous treatment of inflation and interest rate risk in setting investment strategy.

[10] The calculations use volatility and correlation assumptions from the recent history (past 10 years), while bond return assumptions are adjusted for current yield curves. An equity premium of 2.5% is assumed.

[11] Arnott alludes to another risk complication when managing pension assets and liabilities. Pension liabilities are highly convex; that is, the increase in liabilities from a decrease in yields is significantly greater than the decrease in liabilities from an equal increase in yields. Referring back to Arnott's example, "if long-bond yields were to rise 150 bps next year, the NPV of these long-tail liabilities (averaging 35 years in duration) would fall by 37 percent. If interest rates were to fall 150 bps … the NPV would then soar by 62 percent, not the 37 percent that a change in rates of the 150 bps in the other direction would cause".

[12] Also, recall that the pension liability allocation conveniently provides the funded status of the plan by summing up the hedged and unhedged factors.

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