The Right Way to Use Long-Duration Swaps in LDI

Executive Summary

- Typical LDI practice in the U.S. involves overlaying a long-duration swap onto an existing asset allocation heavily invested in equities. Because the market risks of equities are greater than—and in "a different direction" from—those of bonds, such usage of swaps will not be effective in reducing funded-balance volatility.
- In contrast, some European DB plans are utilizing LD swaps as part of a complete asset re-allocation, with active investments focused on sectors suitable to a LIBOR benchmark.
- Our guess is that as current U.S. LDI swap usage practice proves to be ineffective, it will be scrapped, possibly replaced by usage similar to that seen in Europe.

I. Introduction

It is common Liability Driven Investing (LDI) practice among U.S. defined-benefit pension plans to utilize interest rate swaps to "remove" interest rate sensitivity (duration) from the plan's funded balance. For virtually all these plans, the bulk of assets remain allocated to equities or to other high-volatility sectors. We believe this usage of swaps will prove to be short-lived, because it will not prove successful in significantly reducing the volatility of plans' funded balances (surpluses/deficits).

In a previous report[1], we showed that with equity allocations of 60% or more, the dominant source of funded balance volatility for a plan is the market risk of its equity exposure. Therefore, attempting to eliminate interest-rate risk via allocations to a swap will **at best** effect only a slight reduction in funded-balance volatility. Furthermore, the optimal swap allocation is crucially dependent on the observed duration of the equity allocation, and this is extremely hard to predict. As equities' **realized** duration fluctuates away from the **assumed** value used to determine swap allocations, the slight benefits of the swap quickly disappear and turn to detriments. Funded balance volatility could well prove to be higher with the swap than without it.

A plan cannot significantly reduce funded balance volatility except by reducing exposure to equities and other high-volatility asset classes to the point that such assets no longer dominate the portfolio. At that point, long-duration swaps do become effective in matching the duration of plan liabilities to the total (dollar) duration of plan assets and thence reducing residual funded balance volatility. This latter usage of swaps is quite different from the current U.S. usage of swaps in LDI efforts.

Some European plans are utilizing swaps effectively within LDI strategies. Such plans completely reallocate their portfolio **in addition to** allocating to the long-duration swap. In effect, they use the swap to convert their liabilities from long-duration to LIBOR, and they then construct from scratch an asset portfolio that is designed to perform well against a LIBOR benchmark. In effect, these plans run their pension allocation as a "portable alpha," with the beta sector being plan liabilities, the swap used as a device to replicate that beta, and the asset portfolio chosen as a cohesive set of alpha targets.

In another previous report,[2] we showed that such treatment of the pension allocation (as a portable alpha) can achieve an optimal allocation (minimal funded-balance volatility for a given level of expected return), provided the specifics of the allocation satisfy certain conditions. So these European plans appear to be on the right track, and their usage of long-duration swaps is likely to be the one that will prevail over time.

These "optimal" European plan allocations need not be devoid of exposure to equities. Typically, however, equity exposure would be below 25%, with similar allocations for other risky asset classes. At such exposure levels, the market risks of equities and the like will not dominate plan asset volatility—interest-rate risks will—and swaps can then be helpful in closely matching asset and liability risks.

In sum, swaps can be an effective LDI tool when used as a duration **extender** within a portfolio largely directed to fixed-income assets. They are not an effective LDI tool when used as a duration **provider**: that is, when overlaid onto a portfolio dominated by equities or other high-volatility (non-fixed-income) assets.

This paper elaborates these points in detail. While Western Asset (2006b) detailed the ineffectiveness of LDI swaps in equity-heavy portfolios on a statistical and empirical basis, this result is so counter to mainstream thought and practice that we will work through it one more time: here on a visual, geometric basis. We then elaborate on the more effective usage of swaps as LDI tools, in particular the specifics for both beta and alpha allocations that allow a plan to achieve an optimal pension allocation.

Exhibit 1A

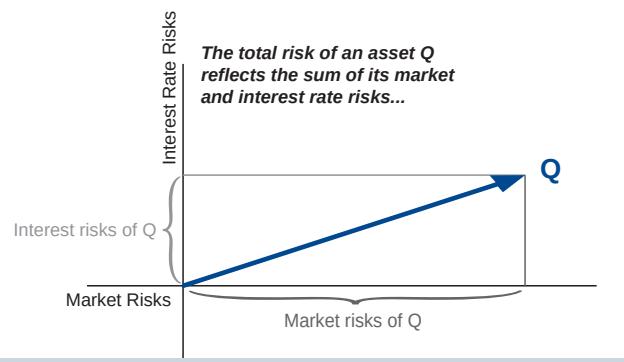


Exhibit 1B

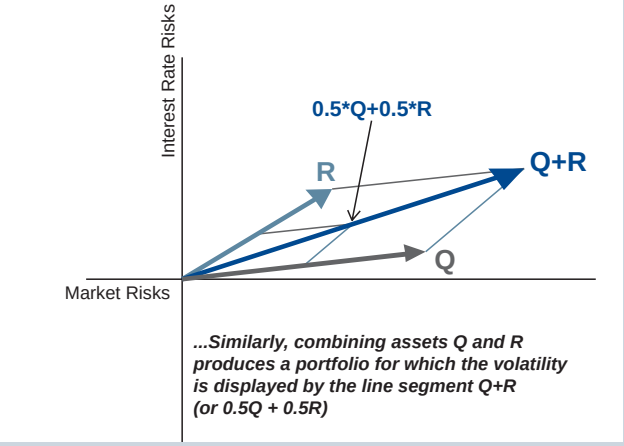
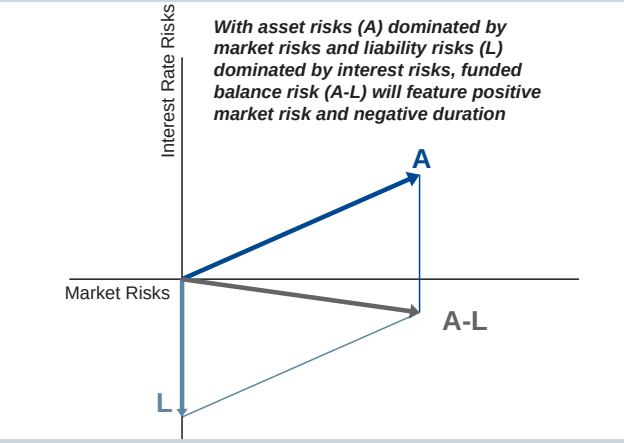


Exhibit 1C



II. The Geometry of Assets, Liabilities, and Long Duration Swaps

Equity market risks are different from and largely unrelated to interest rate risks. In effect, equity investments take their risks "in a different direction" from those of fixed-income investments. This is the true source of "mismatch" between equity assets and either bond assets or DB pension liabilities. A long-duration swap cannot remove this mismatch. It can only reduce the magnitude of one source of the mismatch, and as it turns out, such swaps address the least important element of the mismatch.

This can be seen visually by charting allocations in a series of diagrams displaying equity-market risks and interest-rate risks. In Exhibit 1A, interest-rate risk is shown on the vertical axis, and "market risk" is shown on the horizontal axis. (By "market risk" we mean volatility in equity and other asset returns which is completely unrelated—perpendicular in the charts—to interest-rate volatility.) Any asset might display elements of both market risk and interest-rate risk (duration). The **total** risk or volatility of an asset Q is the "sum" of its market and interest risks, shown by the length of line Q, the diagonal of the parallelogram formed by the market and interest risks.

Now, add another asset, R, to the mix, as in Exhibit 1B. The correlation between assets Q and R is indicated by the extent to which the lines Q and R lie in the same direction. Completely uncorrelated assets will be perpendicular to each other. Perfectly correlated assets will lie in exactly the same direction. The total risk of the combination of Q and R is shown by the line Q+R, formed by the parallelogram in that diagram.[3] Similarly, dividing a portfolio between assets Q and R in equal shares results in total portfolio volatility as displayed by 0.5*Q+0.5*R in Exhibit 1B.

Exhibit 1C introduces liabilities into the mix. Since the DB plan owes its liabilities, it is "short" them, and so the risks of the liabilities extend in a "negative" (downward) direction. Relative to assets A and liabilities L, the risk of the funded balance (A-L) is determined by drawing the parallelogram and diagonal in Exhibit 1C.

Exhibit 1D

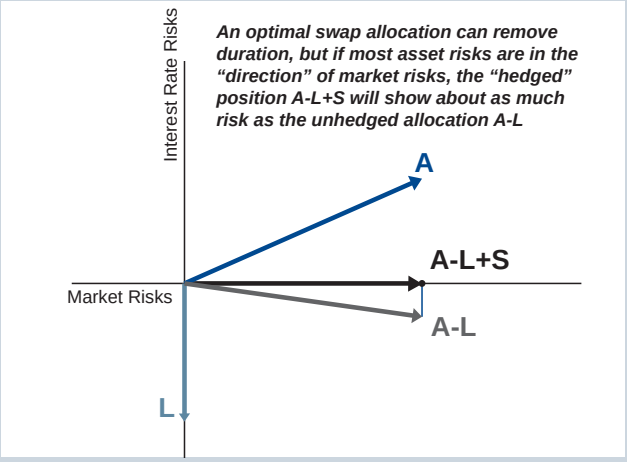


Exhibit 1E

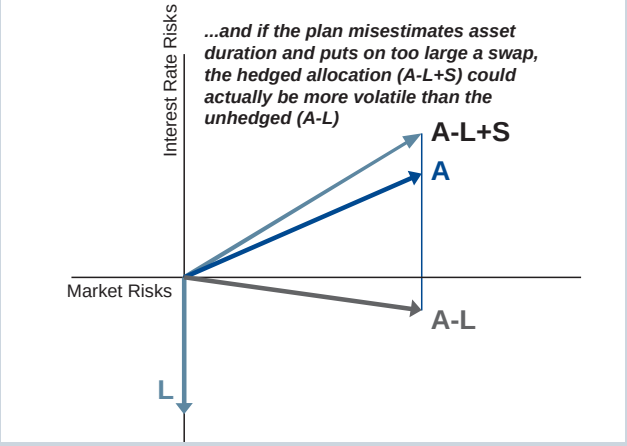
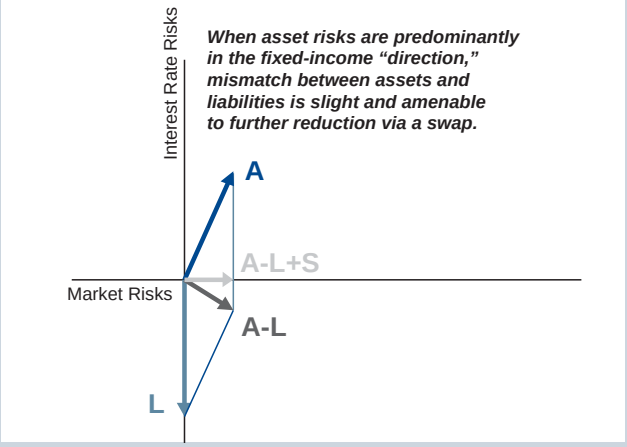


Exhibit 1F



We have drawn Exhibit 1C so that the total risk of plan assets is much greater than the (negative) risk of the liabilities. As detailed below, this in fact has been the historical experience for equity-dominated portfolios. It is also the case that liability and asset risks occur in quite different directions, as in the chart. At least they do when assets are predominantly equities and the like. As can be seen in Exhibit 1C, the length of the line A-L is dominated by the length of line A. Substantial reductions in the magnitude of liability risk—in the length of L—effect only slight reductions in total funded balance risk (A-L), so long as line A is much longer than line L.

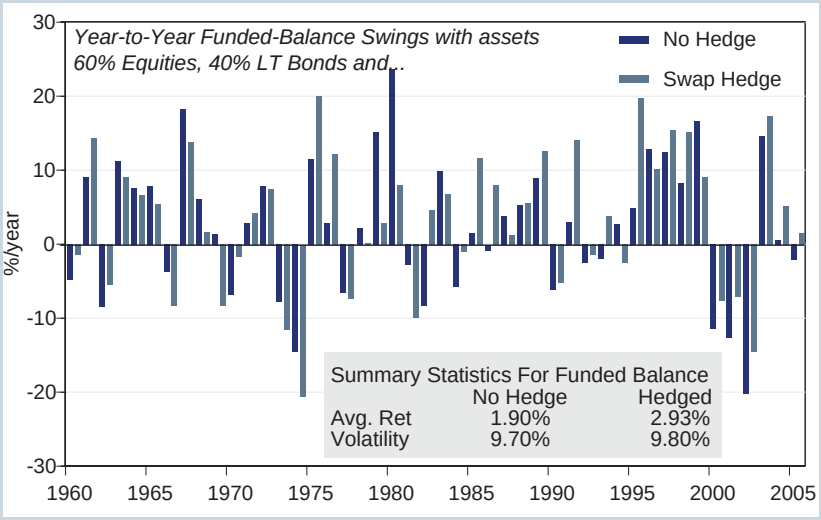
The effect of long-duration swaps is shown in Exhibit 1D. An "optimal" allocation to a swap would remove all interest-rate risk from the funded balance, as in A-L+S. However, the total risk of this "hedged" position is only slightly smaller than that of the unhedged position, A-L. Because the risks of assets and liabilities lie in different "directions," the swap cannot address this mismatch. The risks of the assets dominate funded balance risks, and they continue to do so even after the swap is in place.

The optimal allocation to the swap is that which sets the dollar duration of the funded-balance to zero, NOT necessarily that which offsets all the interest risks of the liabilities. In order to determine the optimal allocation to the swap within an equity-heavy portfolio, the plan must make some estimate of the expected duration of equities. As equities' **actual** duration fluctuates from the **expected** value—and equities' historical duration has fluctuated wildly over time—the actual, experienced funded-balance duration for the plan will fluctuate wildly as well. Exhibit 1E illustrates the situation with a swap calibrated on an assumption of zero duration for equities, but with an actual equity duration equal to their long-term historical average, more than half that of long bonds. The hedged allocation A-L+S features **positive** funded-balance duration that is larger in magnitude than the **negative** funded-balance duration of the unhedged allocation, and so the total risk of the hedged allocation A-L+S is actually larger than that of the unhedged allocation A-L.

This result replicates the actual experience of the last forty-five years. Exhibit 2 illustrates how the funded balance of a DB plan would have behaved year-to-year had it maintained a 60% Equities/40% Long Bonds asset allocation with no "liability hedge" and also how the funded balance would have behaved with the same asset allocation but also with an LDI swap hedge equal in notional size to the equity allocation, so as to "offset the mismatch" between equities and liabilities. Across the whole period, funded-balance volatility would have been higher with the swap than without it. While the plan's asset allocation would have had too little duration without the swap, it would have had too much duration with the swap in place.

As detailed in Western Asset (2006b), the observed duration of equities has fluctuated wildly from decade to decade, and those fluctuations affect the efficacy of swaps. For example, over 1996-

Exhibit 2
Funded-Balance Volatility Simulated Over 1960-2005 Experience



Source: Western Asset

2005, equities exhibited substantially negative duration, and so that period would have been a "garden spot" for a swap. Even then, however, the swap would have reduced funded-balance volatility only modestly, from 14.27% per year to 11.56% per year, because equities' volatility was still the dominant contributor to funded-balance volatility. Meanwhile, over 1986-1995, equities' duration was equal to that of bonds, and an LDI swap would have resulted in a noticeable **increase** in funded-balance volatility, from 4.54% per year to 7.81% per year. Again, the issue of accurately predicting equities' duration sorely complicates the task of utilizing swaps to reduce funded-balance volatility. In order to eke out even the slight benefits a swap can provide in this context, a plan has to predict equities' duration quite accurately, and this is no small task.

In contrast, consider Exhibit 1F, which emulates the "European model" discussed earlier. When asset risks are predominantly interest-rate risks, as in Exhibit 1F, the risks of assets and liabilities largely "cancel" each other out, and any duration mismatch between assets and liabilities can be addressed via a swap. Thus, line A-L in Exhibit 1F is much shorter than A or L separately, and A-L+S there is shorter still. Furthermore, since the portfolio is dominated by fixed-income assets, its duration is not as variable as that of an equity portfolio, and so determination of the optimal swap allocation is much less tenuous.

To recap, the diagrams here are intended to visually illustrate the following facts:

1) for a plan allocated mostly to equities and the like, the bulk of funded-balance volatility comes from those assets;
2) the risks of equities and the like occur "in a different direction" from those of DB plan liabilities, and a long-duration swap has no ability to bridge this directional mismatch;
3) therefore, a long-duration swap cannot materially reduce funded-balance volatility of such plans;
4) however, swaps can effectively reduce funded-balance volatility for plans that are heavily allocated to fixed-income or to LIBOR-benchmarked assets (those featuring little "market risk").

III. LDI And Portable Alpha: Structuring The Beta, Appropriate Alpha Sources

As discussed in Western Asset (2006a), any allocation on the efficient frontier for funded-balance (surplus) optimization can be decomposed into a full hedge of the plan's liabilities and a suitable level of exposure in that overlay (zero net investment portfolio) with maximum expected return relative to risk, or maximum Sharpe ratio.[4] The more aggressive (risk tolerant) a plan is, the larger its allocation to this overlay. In effect, the liability hedge converts the plan's liabilities from long-duration to LIBOR, and the maximum Sharpe ratio overlay is that which

performs best relative to a LIBOR benchmark. This construction is equivalent to running the pension allocation as a portable alpha, with plan liabilities comprising the beta component, and the maximum Sharpe ratio overlay comprising the alpha sources the plan chooses.

As with a portable alpha, the plan can replicate its beta position—that is, it can hedge its liabilities—with either a cash portfolio or an overlay, swaps or futures, or a combination of these. If it replicates its liability hedge via a cash portfolio, then the alpha sources must be achieved via an overlay. If it achieves the liability hedge via an overlay—say a custom-tailored long-duration swap—then the alpha sources can be pursued via cash investments. This is not a crucial difference, and which of these paths a plan embarks upon will likely depend on where it chooses to seek active allocations (on the alpha or beta side or both).

In Europe, the paucity of long-duration securities has driven many plans to achieve their liability hedge via long-duration swaps. Still, European plans are more likely to pursue LDI via a complete re-allocation of assets. Again, U.S. plans almost uniformly overlay LDI swaps onto existing portfolios heavily invested in equities and other risky asset classes.

However, the fact is that equities are not an effective alpha source for such portable alpha constructions. While their average relative returns are favorable, equities show too much volatility relative to LIBOR. Therefore, optimal pension allocations—which, again, consist of a liability hedge plus exposure in that overlay with optimum risk/return characteristics—inevitably feature low equity allocations, on the order of 25% of assets or less, no matter how aggressive the plan allocation. ***On a risk-adjusted basis, aggressive asset allocations can be better achieved via leveraged allocations to fixed income than by "cash" allocations to equities. This result holds over the range of historical experience.***

Exhibit 3 shows the observed volatilities of large- and small-cap equities and commodities[5] measured against both long-duration and LIBOR benchmarks. These metrics illustrate the observed volatility of equities and commodities in unhedged and hedged DB allocations, since, again, a DB plan is long its assets and short its liabilities. An unhedged DB allocation heavily allocated to equities is identical to financing an equity purchase with a long-duration bond. Overlaying a custom-tailored long-duration swap provides a position identical to financing equities with broker loans (cash equivalents).

Exhibit 3
Observed Volatility (Tracking Error) Against Benchmarks

Assets \ Episode	Long-Run, 1926-2005	Inflation Round Trip, 1960-2005	Rising Inflation, 1960-1980	Falling Inflation, 1981-2005	Stocks' Golden Age, 1950-1965	Bonds' Golden Age, 1996-2005
Long Lg.Cap./Short Long-Dur	19.4%	15.5%	15.9%	15.3%	14.9%	22.6%
Long Lg.Cap./ Short Cash	19.5%	15.6%	16.6%	14.8%	12.5%	18.4%
Long Sm.Cap./Short Long-Dur	30.0%	23.0%	27.4%	18.5%	21.6%	22.4%
Long Sm.Cap./ Short Cash	30.1%	22.2%	27.0%	17.7%	18.4%	18.7%
Long Comm./Short Long-Dur.		19.3%	19.3%	17.3%		15.8%
Long Comm./Short Cash		14.4%	14.3%	13.9%		13.3%

Source: Ibbotson & Associates, AIG Financial Products, Western Asset

As Exhibit 3 details, there is little difference in the volatilities of these two positions, either across historical experience or within particular episodes. Both large- and small-cap equities are as high-volatility relative to a cash benchmark as they are relative to long duration. Only for commodity allocations does the shift to a cash benchmark make even a slight difference in volatility. The failure of these volatilities to decline substantially moving from

Exhibit 4
Optimal Overlay Portfolio* Over Various Historical Episodes

Episode / Assets	Long-Run, 1926-2005**	Inflation Round Trip, 1960-2005	Rising Inflation, 1960-1980	Falling Inflation, 1981-2005	Stocks' Golden Age, 1950-1965**	Bonds' Golden Age, 1996-2005
Cash Equivalents	-38.1%	-30.0%	-23.0%	-30.4%	-25.0%	-24.7%
Intermediate Notes	56.4%	37.6%	30.1%	34.3%	33.8%	16.3%
Long-Term Corporates	-24.6%	-17.1%	-14.8%	-13.2%	-15.2%	0.7%
Large-Cap Stocks	3.7%	1.6%	1.0%	2.4%	6.5%	2.4%
Small-Cap Stocks	2.5%	2.9%	2.4%	3.1%	-0.1%	2.0%
Commodities		5.0%	4.3%	3.9%		3.3%

**Amount of overlay necessary to produce target return of 1%, expressed as percent of total assets.*

***As commodity returns data begins in 1959, overlays for these periods are calculated without commodities*

Source: Ibbotson & Associates, AIG Financial Products, Western Asset

long-duration to cash benchmarks is a restatement of the fact that long-duration swaps will be ineffective in such portfolios. The size of these volatilities relative to cash indicates that these assets will not be major components of a portfolio designed to optimize risk/return characteristics.

Exhibit 4 illustrates how maximum Sharpe ratio overlays would look for various periods, based on an asset universe of cash, intermediate notes, long bonds, large- and small-cap stocks, and commodities. These portfolios are shown in overlay form, to be used in conjunction with a ***cash-portfolio*** liability hedge. Opposite a liability hedge achieved ***via a swap***, simply add 100% cash to these to convert them to a cash-portfolio "alpha set."[6]

Note from Exhibit 4 that even relative to this six-asset universe, the "risky" equity and commodity investments still comprise only trace elements of an optimal (maximum risk/return) overlay. In all of these episodes, a plan would have to seek a very aggressive, four-times allocation to the respective overlay before the **total** allocation to risky (non-fixed-income) assets even approaches 30%. (A four-times allocation to the overlay would seek a return on assets 4 percent per year higher than that provided by the liability hedge.)

Even in such very aggressive allocations, total exposure to equities would peak at 25.6%, in the "stocks' golden age," 1950-65 episode. That is, ***even in the historical market environment most beneficial to equities, a very aggressive but risk-efficient DB allocation would feature equity exposure far lower than is currently normal among U.S. DB plans.*** Again, equities and commodities are not efficient enough alpha sources to be used as anything more than trace elements of an optimized (LDI) pension allocation. Unless coming historical experience proves to be completely different from the past, an equity-heavy allocation would not be a suitable LDI allocation… with or without a long-duration swap.

Again, the European plans that use an LDI swap in concert with a complete portfolio re-allocation to LIBOR-benchmarked asset classes appear to have a better take on LDI techniques. Even for these plans, the allocations must adhere to a couple of fine points in order to prove to be optimal or efficient.

First, the plan's hedge must address all systematic risks of the liabilities, not just the interest risks. If liabilities have inflation exposure and/or if beneficiaries' earnings levels can be shown to be systematically related to returns on real assets (i.e., assets other than cash or fixed-income), then the plan's liability hedge should also address these risks. Hedging interest risks alone is not enough. Otherwise, the custom interest rate swap alone will not be sufficient to "convert" liabilities to purely LIBOR, and so the aggregate allocations need not be risk-efficient.

Second, the "alpha sources" the plan chooses for its opportunistic allocations should mesh well. To achieve an efficient allocation, it is crucial that the ***combined portfolio*** of the alpha sources have maximum risk/return characteristics. Even if the individual alpha sources feature favorable Sharpe or Information ratios, if these assets are highly correlated with each other, the aggregate (overlay) portfolio may feature excessive risk. In setting its opportunistic (alpha) allocations, the plan should choose a set of assets which feature favorable risk/return characteristics in combination rather than merely individually.[7]

IV. LDI and Leverage

Upon inspecting the overlay portfolios in Exhibit 4, it should be clear that virtually any optimized pension allocation will involve financial leverage in the portfolio. As cash is unlikely to be an element of the liability hedge and as all the overlays shown feature short positions in cash, adding any of these overlays to a liability hedge will necessarily involve short cash positions, thus some degree of leverage. Meanwhile, the long-duration LDI swap itself is a source of leverage.

The plain fact is that ANY DB plan is already leveraged. It is long its assets and short its liabilities. Under-funded plans are even further leveraged. The leverage portrayed in the examples above is leverage intended to reduce risk, not to provide speculative returns.

Certainly, a plan should be cautious and judicious in its use of leverage. However, it shouldn't be myopic about the topic. It is folly to eschew a risk-reducing, leveraged fixed-income allocation in favor of an allocation to equities simply because one wants to avoid leverage. The year-to-year risks that a plan undergoes in maintaining the latter, "cash" allocation dwarf the risks from a leveraged fixed-income allocation.

V. Conclusions

It is well known that allocating to a long-duration swap in effect converts a DB plan's liabilities from long duration to LIBOR. The standard response by a U.S. plan is that it can easily beat LIBOR in the stock market, and so it implements the swap while leaving its equity-heavy asset allocation in place. Though equities can beat LIBOR handily over the long run, they do so only at the cost of very high short-run risk/volatility. As shown here, equities are no better a match against LIBOR than they are against long duration. Equities are not an effective investment against a LIBOR benchmark. The common U.S. usage of LDI swaps alongside equity-heavy allocations will not prove to be effective in materially reducing plans' funded-balance volatility.

Some European plans are more circumspect. Once the swap converts their liabilities to LIBOR, they re-allocate their portfolio to specific LIBOR-targeted asset classes, in effect constructing their pension allocations as portable alphas. The equity allocations in such plans would typically be no more than 25%, low enough that they don't dominate the allocation.

In order to achieve optimal or efficient allocations via these methods, the European plans must be careful to ensure that they hedge all the risks of their liabilities, not just the interest risks. Also, they must ensure that the LIBOR-benchmarked "alpha" targets they choose mesh well as an aggregate portfolio, that they not be highly, positively correlated with each other. Such provisos also hold for U.S. plans, but their equity-heavy allocations already disqualify them from being effective LDI allocations.

Over time, U.S. DB plan practice is likely to split into two groups. Plans that can tolerate erratic short-term swings in their funded balance may maintain risky asset portfolios and eschew LDI practice altogether. Those plans that require a more stable funded balance will reduce exposure to equities and other risky assets and possibly maintain allocations to swaps as a final LDI tactic. However, the equity-heavy allocations cum LDI swaps that we see now will not be sustained, because they won't be effective.

References

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Fama, Eugene and Kenneth R. French (1993) *"Common Risk Factors In The Returns On Stocks And Bonds,"* **Journal Of Financial Economics**, vol. 33, pp. 3-56.

Western Asset (2006a), *"The Impact of Active LDI On Portfolio Selection,"* May 2006, available on our website.

Western Asset (2006b), *"Effective LDI: When Do Bond Swaps Help,"* October 2006, available on our website.

Footnotes

[1] See Western Asset (2006b).

[2] See Western Asset (2006a).

[3] The depictions in the Exhibit 1 diagrams are exact replications of the mathematics of asset/liability volatility. A demonstration of this will be provided on request.

[4] This result is presented formally in Bazdarich (2006).

[5] Commodity returns are represented by the Gorton-Rouwenhorst fixed-weight index of collateralized commodity futures. As that index extends from 1959 to the present, commodity volatilities are not shown for periods extending prior to 1959 and similarly in Exhibit 4 below.

[6] However, for more aggressive allocations, seeking expected returns **more than** 1% per year above that of the liability hedge, those further allocations to the alpha set would have to be achieved via the overlay versions shown in Exhibit 4.

[7] Once some estimate is made of the expected returns and covariances among the prospective assets, it is a simple matter algebraically to calculate the optimal combination of these assets. Still, the plan must be careful to pay some attention to how the alpha sources combine, how they interact with each other, rather than merely picking each in isolation.