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LDI and the Persistence of Tracking Error

Executive Summary

- We find that simple LDI strategies provide about the same degree of risk reduction as do more complex strategies that attempt to closely match yield curve and spread sensitivities of DB liability valuations.
- This result holds across a range of hedging exercises involving various discounting methods for DB liabilities.
- This result reflects the fact that basis risk exists between DB plan liabilities and all available asset classes and combinations thereof. DB liabilities are essentially uninvestible.
- In view of this basis risk, we believe a DB plan is typically better served by actively-managed, simple LDI strategies than by more complex strategies, where scope for active management is limited.

Section 1. Introduction and Summary

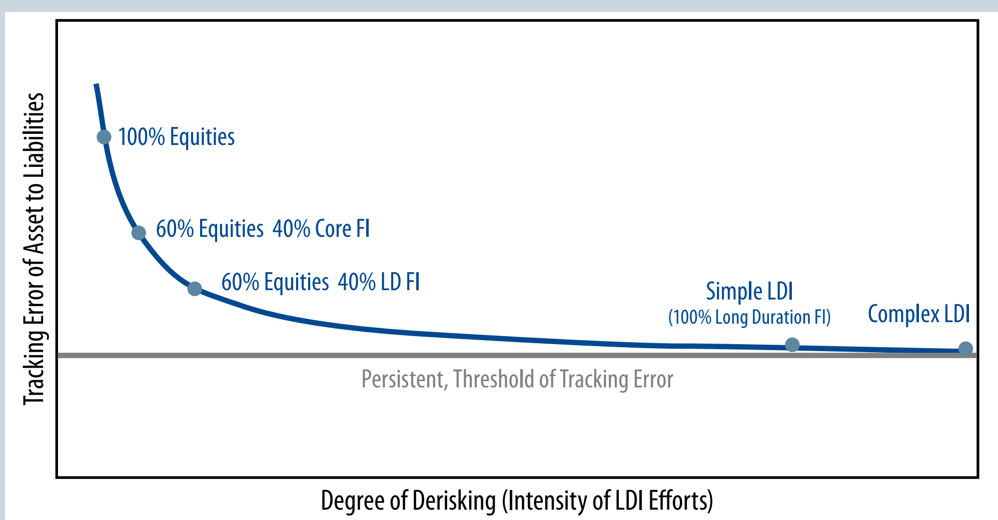
Our defined-benefit (DB) pension clients have recently shown increased interest in pursuing liability driven investing (LDI) strategies to reduce the tracking error between their plan assets and the valuation of their liabilities. Substantial reduction in tracking error can be achieved by increasing a plan's asset allocation to fixed-income and by increasing the duration of fixed-income assets toward that of liabilities.

The issue analyzed here is whether substantial further reductions in tracking error can be achieved by allocations attempting to match not only duration, but also yield curve and spread sensitivities. We refer to these allocations as complex LDI strategies. Our finding is that simple LDI strategies involving standard long duration indices provide essentially all of the available benefits from LDI operations. Once broad duration-matching has been achieved, a residual level of tracking error persists despite a plan's most complex efforts to eliminate it.

DB liabilities are essentially uninvestible. Once a plan chooses to use corporate-bond yields (or yield curves) to discount pension obligations to a present value, some "basis risk" will exist between those liability valuations and all available assets. No combination of available assets will be fully able to hedge the liability returns.

Exhibit 1 presents a stylized view of these findings. Relative to common techniques of liability valuation, 100% allocations to equities would feature annual tracking error in excess of 20% per year. Moving to 60%/40% allocations involving equities and fixed-income could reduce tracking error below 15%. Choosing a 100%

Exhibit 1
Tracking Error Persists Even with Complex LDI Strategies



Source: Western Asset

allocation to long duration fixed-income could reduce tracking error to about 4%. At this point, persistence of tracking error sets in, and further LDI efforts result in only marginal improvement.

A plan is probably better off attempting to outperform liability returns via active management than it is trying to further reduce tracking error via such complex strategies as key-rate-duration or cash-flow-matching. This is so because besides reducing tracking error, a plan must also take some steps to ensure that **average** returns on assets match those on liabilities. This task is more difficult than it sounds. (This topic will be discussed in detail in a follow-up paper.)

Presenting the empirical results supporting the aforementioned assertions in Section 2, we construct various asset allocations that match either the key-rate durations or the cash flows of pension liability valuations across a range of historical data. We then compare the tracking errors arising from these constructs with those arising from simple combinations of long government and long credit indices. In all cases, the simple LDI strategies perform nearly as well as—and in some cases better than—the complex ones.

Section 3 analyzes the conceptual sources of mismatch between plan assets and liabilities, in order to better understand the empirical findings of Section 2. Finally, Section 4 introduces the prospect of active management within a simple LDI strategy as an alternative to complex LDI (de-risking) strategies.

Section 2. Empirical Results of Hedging Exercises

Once again, complex LDI strategies go beyond simple duration-matching of assets and liabilities to matching yield curve sensitivities (key-rate durations). Such strategies have the best chance of performing well when liability valuations are based on yield **curves** rather than on a single long-bond yield. That is, if a single yield is used to discount plan cash flows, then that valuation will not exhibit any yield **curve** sensitivities. Cash flows of different maturities will merely be affected to different degrees by the **same** yield. In contrast, when a yield curve is used, different points along that curve discount cash flows, and the resulting valuation indeed exhibits different sensitivities to different points on the curve.

In the hedging simulations discussed here, we constructed two sets of yield curves for generating liability returns. The first set was based on the yield curve promulgated by the US Treasury for corporate plans' reporting under the Pension Protection Act of 2006 (hereafter known as "PPA yield curve"). The Treasury uses market data on bonds rated A through AAA to generate its yield curves. Such valuations would not be usable for corporations' financial reporting, since GAAP protocols are generally interpreted as specifying AA or better bond yields for use in discounting liabilities. To produce GAAP compliant liability returns, we also constructed a yield curve using only AA bonds but otherwise following the same procedures as for the PPA curve. (This GAAP-compliant curve is hereafter referred to as the "AA curve.")

For both of these methods, end-of-year yield curves were generated back to 1988, as far back as Barclays POINT data allow. Successive curves were then applied to a standard set of DB cash flows to generate a sample of liability returns extending over 1989 to 2012. The details of these yield-curve estimation processes, the features of the resulting liability valuations, and the specific details of all our hedging exercises are presented in detail in a technical Appendix supporting this paper.[1]

For the complex LDI strategies, allocations to specific-maturity Treasury STRIPS (separate trading of registered interest and principal securities) were utilized to match the yield curve sensitivities of the liability returns.

1 See LDI Persistence Tracking Error Appendix 2013 available online at http://www.westernasset.com/us/en/commentary/commentaryRedirect.cfm?cmpid=LDIPersistenceTrackingErrorAppendix2013&srcid=WA_Commentary

Of course, assets so allocated to STRIPS are then not available for hedging the spread sensitivities of the liabilities. And while allocations to credit feature both interest-rate and spread sensitivity, zero-coupon corporate bonds are not generally available, so that corporate bonds are of limited usefulness (by themselves) in complex hedging operations. In other words, plans face a trade-off between hedging interest-rate risks and hedging-spread risks.

Plans can attempt to address both risks via leverage, and we tried two forms of leverage in our hedging exercises. In one form, allocations to STRIPS were combined with allocations to an overlay (long/short portfolio) that delivered the historical excess returns on Barclays Credit. While this overlay was not available to real-world investors, its introduction allows STRIPS allocations maximum rein in hedging interest-rate sensitivities. By its construction, such an overlay exhibits spread duration, but no duration.[2]

In another form, allocations to both STRIPS and credit were allowed to be as large as necessary, and the overage of these assets above 100% was funded via borrowing at LIBOR (overt leverage). As many plans do not allow leverage, we also constructed hedges using only non-leveraged allocations to STRIPS and credit.

For both the simple and complex LDI strategies, optimal hedges across the 1989 to 2012 sample were determined by regressing liability returns on returns of various sets of assets, with optimal portfolio weights determined by the regression. We performed such regressions involving complex LDI strategies with no leverage, with leverage via the credit overlay, and with overt leverage. We performed analogous regressions involving simple LDI strategies, that is, combinations of long governments and long credit, with portfolio weights determined by the regressions.

We also constructed hedges where STRIPS were key-rate-duration matched or cash-flow-matched to the liabilities, with portfolio weights changing each year as key-rate-durations changed.[3] Since STRIP yields are invariably lower than the corresponding corporate yields used to discount liabilities, the present values of those STRIP allocations invariably exceed those of the cash flows, so that the total value of the STRIP portfolio exceeds the liability valuation. In other words, some financing (borrowing or leverage) is necessary for any plan to defease its liabilities via STRIPS. The amount of leverage in our hedging constructs varied as yield levels fluctuated from year-to-year.[4]

2 Excess returns for a fixed-income index are calculated as the total return on an index less the total returns on a portfolio of duration-matched UST. Typically, a suite of Treasury instruments is utilized and key-rate-duration-matched to the index, and, again, the excess returns are the differences between the two corresponding total returns. These excess returns can be thought of as the return on an overlay that is long the fixed-income index and short the corresponding duration-matched UST, hence our characterization in the text. Since the index and its corresponding UST are duration-matched, the overly will not have any duration, but it will have all the spread duration of the index.

3 As is discussed in more detail in the Appendix, the regression results involving STRIPS provide optimal key-rate-duration matches so long as there is no trend (bias) in our data. This is so since the cash flows underlying liability valuations are static over time, with only the yield curves varying, and since the STRIPS instruments utilized feature constant-maturities over time. The fact is, however, that interest-rate levels declined secularly over the historical sample, leading to rising liability durations. The durations of standard fixed-income indices rose in concert with this, but the durations of the (constant-maturity) STRIPS did not. To counteract any possible bias against the STRIPS allocations from this fact, we constructed the KRD- and CF-matched allocations that are optimized for each year separately. As will be seen in the text, these year-by-year optimized allocations generally do not perform so well as pan-sample optimizations provided by regression analysis. This appears to be the case because the year-by-year optimized allocations involve sufficient exposure to the credit overlay to produce spread duration-matching, and that exposure to credit appears to be excessive. The issue of matching spread duration is discussed in the text below.

4 Generally, a DB plan's cash flows obligations stretch 70 to 100 years into the future. However, Treasury STRIPS are available only out to 30 years maturity. So how were we able to defease plan cash flows more than 30 years out? We used the same structure as was followed for the PPA curve to generate STRIPS yield curves extending out to 100 years maturity. Successive versions of that curve were then used to generate total returns on hypothetical STRIPS at each maturity point along the estimated curve. We then used these hypothetical STRIPS to defease the cash flows in the CFM-matching allocations discussed in the text. Since the yield curve generating the hypothetical STRIPS valuations followed exactly the same shape specifications as the curves used to discount liability cash flows, this process can be seen to be as "friendly" as possible to the issue of CFM-matching allocations. Also, this process is comparable with that utilized for cash-flow-matching swaps used by real-world plans. However, with the CFM swaps, there is no presumption that the swaps yield curve used to evaluate these is of similar shape to—or moves in concert with—the yield curves utilized here.

Exhibit 2
Results of Hedging Exercises Over 1989–2012 Sample Period

With Liability Returns Generated by PPA Curve

Run #	Assets Included in Hedge	Compound Track. Err.	STRIPS 6 Yr	STRIPS 23 Yr	Long Govt.	Long G/C	Lg. Cred Overlay	Lg. Cred. Cash Sec.	Leverage
	Unhedged Volatilty of Liabilities	8.89%			Portfolio Weights				
	Results For Standard Long Duration Indices								
	Long Governments	8.92%			1.000				
	Long Credit	2.81%						1.000	
	Long G/C	4.28%				1.000			
	Results With Hedges Optimized Via Regression Analysis								
A1	STRIPS & Credit Overlay	2.36%	0.722	0.278			0.817		
A2	STRIPS & Lg Credit	2.20%	-0.063	0.112				0.951	
A3	STRIPS, Credit, & Leverage	1.77%	0.331	0.026				0.909	-0.266
A4	Long Governments & Credit Overlay	2.49%			1.000		0.904		
A5	Long Governments & Long Credit	2.40%			0.157			0.843	
A6	Long Governments, Credit, & Leverage	1.99%			0.204			0.984	-0.188
	Results With Hedges Based on Key-Rate-Duration- Or Cash-Flow-Matching STRIPS								
A7	KRD-Matched STRIPS	8.81%	KRD-match, avg. total = 1.020						-0.020 avg.
A8	KRD-Matched STRIPS & Credit Overlay	2.57%	KRD-match, avg. total = 1.020				1.099 avg.		-0.020 avg.
A9	CF-Matched STRIPS	15.27%	Cashflow match, avg. total = 1.176						-0.176 avg.
A10	CF-Matched STRIPS & Credit Overlay	5.93%	Cashflow match, avg. total = 1.176				1.099 avg.		-0.176 avg.

With Liability Returns Generated by AA-Only Curve

Run #	Hedging Selection Method	Compound Track. Err.	STRIPS 6 Yr	STRIPS 23 Yr	Long Govt.	Long G/C	Lg. Cred Overlay	Lg. Cred. Allocation	Leverage
	Unhedged Volatilty of Liabilities	9.85%			Portfolio Weights				
	Results For Standard Long Duration Indices								
	Long Governments	5.94%			1.000				
	Long Credit	6.70%						1.000	
	Long G/C	3.85%				1.000			
	Results With Hedges Optimized Via Regression Analysis								
B1	STRIPS & Credit Overlay	3.49%	0.698	0.302			0.416		
B2	STRIPS & Lg Credit	3.48%	0.307	0.217				0.476	
B3	STRIPS, Credit, & Leverage	3.20%	0.719	0.126				0.433	-0.278
B4	Long Governments & Credit Overlay	3.92%			1.000		0.475		
B5	Long Governments & Long Credit	3.82%			0.554			0.446	
B6	Long Governments, Credit, & Leverage	3.69%			0.598			0.567	-0.165
	Results With Hedges Based on Key-Rate-Duration- Or Cash-Flow-Matching STRIPS								
B7	KRD-Matched STRIPS	5.98%	KRD-match, avg. total = 1.024						-0.024 avg.
B8	KRD-Matched STRIPS & Credit Overlay	7.01%	KRD-match, avg. total = 1.024				1.13 avg.		-0.024 avg.
B9	CF-Matched STRIPS	10.90%	Cashflow match, avg. total = 1.139						-0.139 avg.
B10	CF-Matched STRIPS & Credit Overlay	3.93%	Cashflow match, avg. total = 1.139				1.13 avg.		-0.139 avg.

Source: Western Asset, Barclays, US Treasury

Exhibit 2 Summary of Results. *The table shows results from hedging exercises applied to two curve-based measures of liability valuation. For regressions, optimal portfolio weights are fixed across the sample. For other exercises, average portfolio weights across the sample are listed. The left column shows the tracking error associated with each exercise. The green-shaded lines show the best results for complex and simple LDI strategies employing* ***leverage*** *(asset weights sum to more than one). The yellow-shaded lines show the best results with no leverage. The red-shaded lines show results for key-rate-duration- and cash-flow-matching allocations. The "Long Credit Overlay" is a hypothetical long/short portfolio delivering the excess return on Long Credit.*

For the regression results, a "suite" of constant-maturity STRIPS was tried initially, one matching STRIP each of five segments of the yield curve.[5] However, only STRIPS in the five-year and 22-year maturity "buckets" were found to have significant effects on liability returns, so only these STRIPS survived to the final results. Similarly, allocations to both intermediate and long credit (and overlays for these) were tried, but only long credit was found to have significant effects.

Exhibit 2 lists the tracking errors and portfolio weights for LDI hedging exercises for both PPA curve-based liability returns and AA curve-based returns. First the unhedged volatility of each return measure is shown, followed by tracking errors versus standard long-duration indices. Following are the regression results for complex LDI strategies (leveraged and otherwise) and corresponding results for simple LDI strategies. Finally, results for the key-rate-duration and cash-low-matching strategies are shown.

Thus, for the PPA curve liability returns, Run A1 is a regression involving STRIPS and the credit overlay resulting in an optimal hedge with 72.2% and 27.8% of assets in five-year and 22-year STRIPS, respectively, with an allocation to the long credit overlay having notional value of 81.7% of assets. That allocation delivered a 2.36% tracking error across the sample. With overt leverage (Run A3), the tracking error falls to 1.77%, while the unleveraged allocation (Run A2) delivered a tracking error of 2.20%. Results for the other hedging exercises are shown similarly.

Simple Strategies Hold Up Well. Notice first that for the PPA curve returns, the simple LDI strategies (Runs A4 through A6) deliver tracking errors nearly as low as for the comparable complex strategy. (Compare A4 to A1, A5 to A2, and A6 to A3.) Notice also that for the allocation with the lowest tracking error, A3, the dominant component of this allocation is a 90.9% "cash" allocation to long credit. STRIPS amount to merely "trace" exposure here. Again, a similarly leveraged combination of long government and long credit, run A6, provides nearly the same level of tracking error.

Long G/C Allocations Require Some Fine-Tuning Versus PPA Curve. The "standard" long G/C index provides a tracking error (4.28%) substantially above those for the optimized strategies. The long G/C's historical allocations to credit (averaging 40% across the sample) are simply too low for liability returns based largely on A bonds.[6] When credit and government allocations are optimized, an 84.3% allocation to long credit is chosen, and the resulting tracking error (2.40%) is only slightly above that for the comparable, complex LDI strategies. Similarly, when the AA curve is used to discount liabilities, optimal allocations to long credit are uniformly lower, and the straight long G/C index fares much better there. So, even plans choosing simple LDI strategies might do well to choose government and credit allocations different from those embedded in the standard long G/C index.

Notice that the best-performing allocations with high STRIPS exposure involve the (hypothetical) credit overlay. Even then, optimized (non-leveraged) simple strategies come within 4 basis points (bps) of matching this tracking error (2.36% for A1 versus 2.40% for A5). Notice also that the year-by-year key-rate-duration and cash-flow matching exercises are not very fruitful, even when an allocation to the credit overlay is included.

Use of AA Curve Results in Lower Optimal Allocations to Credit. Much the same findings occur with respect to the AA curve liability returns. Optimal allocations to credit are uniformly lower for this set, but here too,

5 STRIPS maturities were chosen to match the segments of the yield curve specified by the Treasury in its estimation of the cubic spline structure that generated its yield curve. (See Appendix.) Each of the STRIPS has maturities equal to the midpoints of the corresponding segments of the yield curve designated by Treasury. A 22-year, five-month STRIP was chosen as the longest-maturity STRIP because this is the longest maturity for which STRIPS were in existence across the sample period. Because the Treasury reduced then stopped issuance of 30-year bonds over 1999-2006, maturities of available STRIPS declined over that period.

6 While the PPA curve is based on bonds rated A through AAA, the fact is that A rated bonds comprise 80% to 90% of the par values and market values of these universes across the historical sample.

the simple LDI strategies produce nearly the same levels of tracking errors as did the complex strategies.

It is important to note that optimal allocations to credit are lower for the AA curve liability returns than for the PPA curve returns despite the fact that the AA curve liabilities feature higher duration and, therefore, higher spread duration. The lesson here is that spread sensitivity is a multi-dimensional phenomenon, varying with credit quality as well as maturity. Thus, it is often the case that prices of **intermediate** BBB or high-yield bonds prices fluctuate more sharply than prices of **long** AA bonds, despite the higher spread duration of the latter. Looking at spread duration alone can give a misleading indication of spread sensitivity and how best to hedge it.

Plans Need To Choose Which Liability Valuation To Target. These results also indicate that hedging funded balance volatility (tracking error) for financial reporting purposes (AA curve relevant) can be a very different matter from hedging funded balance volatility for funding purposes (with the PBGC, PPA curve relevant). Notice first the very different relative performance of long governments, long credit, and long G/C versus the PPA curve as versus the AA curve. Long credit fares best versus the PPA curve returns and worst versus the AA curve returns. Similarly, optimal portfolio weights for hedging the PPA curve returns are very different from those for hedging AA curve returns. Plans must choose which of these valuations to target most closely.

We find our client base typically to be more interested in reducing tracking error for funding purposes. That is, they are more likely to choose the PPA curve liabilities as a hedging target in their LDI operations. As it turns out, this preference goes hand in hand with clients' recent interest in Credit-heavy allocations, given the much higher optimal allocations to Credit for the PPA curve results than for the AA curve results.

Still, the most impressive element of our findings in Exhibit 2 is how well simple long-duration allocations stack up versus the more complex strategies. True, some complex strategies can be seen to produce lower levels of tracking error, but these gains are not dramatic, even when they take advantage of hypothetical asset classes not available to real-world investors. Also, those benefits are somewhat scattered across the range of complex strategies. Some apparently promising strategies fail to deliver any benefit.

Section 3. Why Does Tracking Error Persist?

Notice in Exhibit 2 the very large tracking errors for key-rate-duration and cash-flow-matching allocations with no credit exposure. Treasury instruments are unable to hedge movements in credit spreads, and spread risk is obviously an important source of empirical volatility in liability returns.

Allocations to credit can be used to address spread risks, but this then introduces credit-risk mismatch into the mix. That is, corporate bonds exhibit credit risk, losing value when individual securities are subjected to downgrades or defaults, but DB liability valuations are not affected by these events. Spread risk mismatch between assets and liabilities can be reduced only at the expense of increasing credit risk mismatch. Meanwhile, credit allocations are unable to hedge curve sensitivities as precisely as STRIPS, since zero-coupon corporate bonds are generally unavailable. And as we saw in the previous section, spread risk (sensitivity) depends on both credit quality and asset maturity (duration), so that zero-coupon corporates would not perfectly hedge liability returns even if they were widely available.

In other words, basis risk exists between liability returns and both government and credit instruments, causing substantial amounts of tracking error to persist despite the best efforts to hedge that risk. If a plan used Treasury yields to discount its liabilities, then those valuations would exhibit only interest-rate risk, and they could be exactly defeased via an allocation to cash-flow-matching STRIPS.[7] However, such a discount method is too costly for most real-world plans to follow. And once a corporate yield or yield curve is chosen as the discount instrument for liabilities, the resulting liability valuation becomes uninvestible. It will return the yield of corporate bonds, but without the credit risk of corporate bonds.

Unless spreads are rising steadily and substantially over time, passive US Treasuries (UST) will be unable to match the **average** return on liabilities, and as we have seen here, they will not fluctuate in sync with liability valuations.[8] Passive allocations to similar-quality and maturity corporate bonds will also most likely be unable to match the average return on liabilities, because credit events (downgrades and defaults) will diminish realized returns on corporate bonds without taking any toll on liability returns. Moreover, because zero-coupon corporates are not generally available, credit exposure will not be able to exactly match the spread sensitivities of liabilities. Even a cash-flow-matching swap will exhibit substantial short-term tracking error relative to plan liabilities, because the yield curve underlying swap valuations typically moves differently from that yield curve (or yield) used to discount liabilities.

The results of Section 2 constitute merely an empirical confirmation of this reasoning. Once again, simple steps to match assets and liabilities can prove very fruitful. However, by the time a plan has moved 100% of its assets to simple long duration, it has achieved most of the available benefits from LDI operations.

Section 4. How About Actively Managed, Simple LDI?

Meanwhile, because the complex LDI strategies are so highly engineered, they leave little scope for active management. Our experience is that active asset allocation decisions are vital if a plan is to keep up with its liabilities over time. As discussed just above, liability returns can be expected to exceed those on passive indices of equal-duration UST or corporates. (Over the last 24 years, long credit and long governments have experienced almost exactly the same average total return, even upon adjusting for duration differences, and this return falls short of the "promised" yield on corporates, thus on liabilities.)

We believe active management can be used to bridge this gap. Active management can seek to reduce exposure to the credit risks that cause passive corporates to fall behind liability returns. It can also seek to steer allocations to those sectors that have indeed enjoyed positive historical excess returns. A follow-up paper will expand on this point, dealing more extensively with the issue of realized returns versus yield and analyzing the performance of "barbell" strategies that focus credit exposure in sectors that have actually produced positive excess returns historically.

For now, it should be acknowledged that positive alpha from active management is not guaranteed and that many are skeptical that it can be reliably obtained. However, in various studies, we have reported a decent incidence of positive alpha among long-duration managers.[9] Meanwhile, compared with the opposite

7 Even then, the plan would still experience actuarial risk, as estimates of beneficiaries' work-life, life expectancy, and rate of wage growth varied over time, causing changes in cash-flow estimates. In the present paper, we deal only with the interest-rate risks of liability valuations, abstracting from their actuarial risks, and even under these specialized circumstances, we find substantial levels of tracking error to persist. The occurrence of actuarial risk raises persistence levels for tracking error yet higher. Our research analyzing financial reports by real-world corporate plans suggests that actuarial risk contributes an additional 300 to 500 bps per year to a plan's tracking error.

8 Remember that tracking error as we have calculated it here is the standard deviation in the "misses" of asset returns versus liability returns. The standard deviation is calculated as the variation in these misses relative to the average miss, with no presumption that the average miss is zero. An asset allocation that constantly underperformed liabilities by 100 bps per year would feature zero tracking error, but it would be quite unacceptable because of the persistent underperformance. The results in the present paper focus on reducing this tracking error. In a follow-up paper, we will focus on matching average returns.

9 See "Active Equity and Passive Bonds?" Western Asset, May 2009 and "Active Equity and Passive Bonds? Revisited," Western Asset, February 2010, both available on our website.

extremes of 100% equities or highly-engineered LDI strategies, actively-managed, simple LDI strategies offer a practical alternative. They feature dramatically smaller tracking error than equities and only slightly higher tracking error than the complex strategies, with a better chance than complex strategies of matching liability returns over time.