By Michael J. Senoski, FSA, CFA
Vice President and LDI Investment Director
Pyramis Global Advisors

THIRD QUARTER 2008
THIRD IN A SERIES

Liability-Driven Investing: Risk Metrics and Strategy Evaluation

The move to a market-based system for measuring pension financials represents a challenge for defined benefit (DB) plan sponsors. The challenge is to identify a pension investment strategy that is consistent with the fiduciary obligations of the Employee Retirement Income Security Act of 1974 (ERISA), as amended, and supports the top-level financial goals of the plan sponsor. The purpose of this paper is 1) to describe three market-based risk metrics and 2) to illustrate how they can assist plan sponsors in meeting this challenge.

One of the more interesting and challenging aspects of the Liability-Driven Investing (LDI) phenomenon from the perspective of the plan sponsor is identifying the right strategy. The increase in the availability, understanding, and acceptance of financial derivatives has expanded the range of potential investment solutions. And the ongoing rollout of a variety of absolute return strategies can be expected to do the same. A wide array of options confronts plan sponsors considering the implementation of an LDI strategy.

Unfortunately, the absolute best strategy, if such a strategy exists, will not be immediately obvious in most cases. But, in all cases, plan sponsors should strive to reach a well-informed decision. This can be accomplished by following a rational and systematic process that identifies and quantifies the sources of risk and their expected impact on portfolio performance.

Risk Management, Metrics, and Investment Policy

As the science of risk management has evolved, a variety of risk metrics has been developed to facilitate the risk management process. Until now, these risk metrics have not played a significant role in the pension investment process. This has been due in large measure to the regulatory framework within which pension plans have operated—a framework that facilitated, and some might say encouraged, a "smoothing" process that rendered market-based measures of economic risk, and investment strategies designed to manage such risks, largely irrelevant. The rules of the game are changing now.

The move to a market-based system for pension financial measurement and reporting is well underway, thanks to the Pension Protection Act of 2006 and recent initiatives by the Financial Accounting Standards Board, including adoption of Statement of Financial Accounting Standards No. 158 (FAS 158). These developments have fostered a transformation of the pension investment process that we refer to as LDI. This process will be enhanced by a reappraisal of the role of market-based measures of risk as part of the pension investment process. This paper examines three such risk measures and illustrates their potential application within an LDI pension management framework.

These include 1) the hedge ratio, 2) tracking error, and 3) Value at Risk (VaR). While limited options for smoothing of interest rates and asset values still exist in both the financial accounting and funding regulations governing DB pension plans, all of the illustrations that follow are based on the assumption that assets are measured on a market value basis and liabilities are measured based on a full current high-quality spot rate yield curve.

Hedge Ratio

Within the context of pension investment policy, the hedge ratio is typically the result obtained by dividing the dollar duration of plan assets by the dollar duration of plan liabilities, or:

$$\textbf{hedge ratio} = D\$_a / D\$_l$$

where $D\$_a$ represents the dollar duration of assets and $D\$_l$ represents the dollar duration of liabilities.

Closely related to the hedge ratio is the **dollar duration gap**, typically measured as the dollar duration of plan assets minus the dollar duration of plan liabilities, or:

$$\textbf{dollar duration gap} = D\$_a - D\$_l$$

Exhibit 1 illustrates the mathematics of the hedge ratio calculation.

Exhibit 1: Hedge Ratio Illustration*

Duration of assets	Amount	Effective Duration (years)	Dollar Duration
Equity allocation	$600,000,000	0	$0
Fixed income allocation	$400,000,000	5	$20,000,000
Total plan assets	$1,000,000,000	2	$20,000,000
Duration of liabilities			
Total plan liability	$1,000,000,000	16	$160,000,000
Hedge Ratio			**13%** [= $20M/$160M]
Duration Gap			**–$140,000,000** [= $20M – $160M]

***Assumptions:** Market value of plan assets: $1,000,000,000. Plan liability: $1,000,000,000. Asset allocation—Equity: 60%; Fixed Income: 40%. Duration (years)—Equity: 0; Fixed Income: 5; Liability: 16.

Source: Pyramis Global Advisors

Observations

The hedge ratio is 13% and the dollar duration gap is a negative $140 million in Exhibit 1. The hedge ratio is a measure of the impact of a parallel shift in interest rates across the yield curve on plan assets relative to its impact on plan liabilities. The plan portfolio in our example is obviously much less sensitive to a move in interest rates than the plan's liability.

As far as this plan's funding level is concerned, there is a significant amount of interest-rate risk embedded in this plan's portfolio. A 1% decrease in interest rates across the yield curve would take this plan from its fully funded position to a deficit of $140 million apart from any impact that such a change in interest rates would have on the value of this plan's equity portfolio. Interestingly, such a high-risk profile is not at all unusual among DB plans. Considering that the average equity allocation is somewhat north of 60%, and most fixed income mandates are core (or core plus) mandates benchmarked against the Lehman Brothers Aggregate Index with a duration of roughly five years, this plan's hedge ratio is roughly in line with the typical DB plan, but indicative of an investment policy that is inconsistent with the liability risk profile.

Within the context of pension fund investment management and LDI, the utility of the hedge ratio derives from the fact that the interest-rate risk that it measures is in many cases the major source of risk to a plan's funding level. It is also easy to calculate relative to other risk metrics whose determination may require more extensive data and computer modeling. However, its utility as a strategy development tool within an LDI context is limited since it does not address the risks arising from equities and other non-fixed income assets. As we have noted, these asset classes often represent the majority of a pension fund's asset allocation.

Our illustrative example attributes a duration of zero to the equity component of the portfolio. A review of the available literature on LDI indicates that this is a relatively common expedient. Yet experience has shown that it is difficult to predict the impact of a change in interest rates on equities with the same level of accuracy that applies in the case of fixed income assets. The relationship between interest rates and equity prices is a complex one, and historical equity durations have been notoriously unstable. Consequently, the hedge ratio is not a particularly robust measure of risk in multi asset-class portfolios. Thus it has limited value as an indicator of total funding-level risk for plans with a moderate to high level of equity exposure. Exhibit 2 illustrates this point.

Observations

Asset allocation A is the 60% equity and 40% core fixed income in sample plan shown in Exhibit 1. Asset allocation B is a 100% long-duration strategy benchmarked against the Lehman Long Government/Credit Index. With a portfolio duration of 11 years, the result is a hedge ratio of approximately 69%. The increase in hedge ratio as we move from strategy A to strategy B results from the 60% increase in the fixed income allocation (from 40% to 100%) and the extension of the duration of the fixed income portfolio from 5 to 11 years.

Asset allocation C is an overlay strategy combined with the 60% equity and 40% core fixed income strategy. The notional value of the overlay is approximately 78% of the value of the cash portfolio, and is equally distributed across 10-, 20-, and 30-year bellwether swaps. This particular overlay structure was designed to achieve a 69% hedge ratio as in strategy B. Although not apparent from the hedge ratio risk metric, these clearly are very different strategies. When we evaluate these strategies based on more comprehensive risk measures, it will become apparent that the risk to this plan's funding level represented by strategy C is significantly greater than the risk represented by strategy B, primarily as a consequence of strategy C's much higher (60%) equity allocation.

Like strategy C, strategy D is an overlay strategy designed to achieve a 69% hedge ratio. The difference is that strategy C employs zero coupon swaps rather than bellwether swaps. The notional value of the overlay is approximately 48% of the value of the cash portfolio, and is equally distributed across 10-, 20-, and 30-year zero coupon swaps. Both strategy C and strategy D consist of identical cash portfolios (60% equity and 40% fixed income) and have 69% hedge ratios. The difference lies in exposure across the yield curve. Strategy C's exposure is distributed across the yield curve, while strategy D's exposure is bulleted at 10-, 20-, and 30-years. While differences in yield curve exposure do not typically represent a significant risk to a plan's funding level, it is a dimension of risk beyond the scope of the hedge ratio metric whose impact must be captured by more comprehensive risk metrics.

One of the most appealing features of the hedge ratio is its simplicity. The computation of the hedge ratio is relatively straightforward compared to other risk metrics. The implications of the hedge ratio are clear. And it is especially well suited to fixed income portfolios where interest-rate risk represents the predominant source of risk. At the same time it should be noted that the hedge ratio is a snapshot of a risk profile at a point in time. Because it is highly sensitive to plan funding level and the composition of assets, it can change very quickly. And, as noted above, its utility is limited in the case of multi asset-class portfolios with significant exposure to non-fixed income assets.

Exhibit 2: Hedge Ratios

Liability	
Amount	$1,000,000,000
Duration	16
Funding Ratio	1.0

Asset Allocation	A	B	C	D
Equity	60%		60%	60%
Core fixed income	40%		40%	40%
Long-duration fixed income		100%		
Swap bellwether				
10-year			26%	
20-year			26%	
30-year			26%	
Swap zero coupon				
10-year				16%
20-year				16%
30-year				16%
Hedge ratio	**13%**	**69%**	**69%**	**69%**

Source: Pyramis Global Advisors

Tracking Error

Tracking error is a risk metric that is most often used to measure 1) the performance of an index fund relative to its benchmark, or 2) the performance of an active fund manager relative to the manager's assigned benchmark, or active manager risk. Within the context of LDI tracking error is typically measured as the annualized standard deviation of portfolio alpha relative to liability return, or portfolio return (%) minus liability return (%), or:

tracking error = annualized standard deviation ($R_a - R_l$)

where R_a represents portfolio return and R_l represents liability return.

Tracking error is perhaps the most widely recognized of a family of related LDI risk metrics that also includes **funding ratio risk** and **surplus risk**[1]. As it turns out, there is generally very little difference between tracking error and funding ratio risk. Unlike these two measures of risk, surplus risk depends on the plan's relative funding level. For plans with a funding ratio close to 100%, there will be little difference between any of these risk metrics.

Relative to the hedge ratio, tracking error is a more comprehensive measure of risk. It captures all the factors within a portfolio that contribute to variability between portfolio returns and liability returns, including market (beta) risk as well as interest-rate risk. Exhibit 3 illustrates this issue for strategies A, B, C, and D.

Observations

As shown in Exhibit 3, the tracking error embedded in strategy B is significantly lower than strategy A's tracking error. This is consistent with the much higher hedge ratio and consequent reduction in interest-rate risk embedded in strategy B. But, it is also due in large measure to the much lower equity market (beta) risk embedded in strategy B. In fact, the decrease in equity exposure accounted for roughly half of the reduction in tracking error. Without this change, strategy B's tracking error would have been 9.8%.

The difference in tracking error between strategy B and strategy C is interesting. While each of these strategies has the same hedge ratio, the tracking error embedded in strategy C is almost twice as great as the tracking error of strategy B. While some of this is attributable to differences in the risk factors embedded in the core and long-duration strategies and the overlay, most of the difference is attributable to the difference in equity exposure. Excluding the effect of the 60% allocation to equity reduces the strategy C tracking error to 5.7%, while adding a 60% allocation to equity raises the strategy B tracking error to 9.8%.

Exhibit 3: Tracking Error

Liability	
Amount	$1,000,000,000
Duration	16
Funding Ratio	1.0

Asset Allocation	A	B	C	D
Equity	60%		60%	60%
Core fixed income	40%		40%	40%
Long-duration fixed income		100%		
Swap bellwether				
10-year			26%	
20-year			26%	
30-year			26%	
Swap zero coupon				
10-year				16%
20-year				16%
30-year				16%
Hedge ratio	13%	69%	69%	69%
Tracking error	**14.0%**	**5.3%**	**9.6%**	**9.6%**

Source: Pyramis Global Advisors

As noted previously, we attributed a duration of zero to the equity component when calculating strategy C's hedge ratio. The hedge ratio of strategy C would have been greater than strategy B if we had attributed a positive duration to the equity component of strategy C. The irony is that this result implies that strategy C is less risky than strategy B, when the tracking error of strategy C is nearly double that of strategy B, as we have noted. A comparison of strategy D with strategy C indicates that the differences in yield curve exposure arising from the overlay strategies has practically no impact on their tracking error.

Within the context of LDI, tracking error as a measure of risk does have its limitations. Not all sources of risk are equal. Some generate excess returns (alpha) while others do not. Tracking error in the strictest sense does not distinguish between those sources of risk that generate alpha and those that do not. As a consequence, the impact that a change in portfolio strategy designed to reduce tracking error will have on a portfolio's efficiency (information ratio) may not be obvious.

Additionally, developing a risk budget for tracking error may be as much art as it is science. The extent to which tracking error will be a concern to a plan sponsor will depend largely on the impact of tracking error on pension financials such as contribution volatility.

As a general observation based on our experience, the tracking error for many, if not the majority of, plans falls within the 12% to 15% range, because equity exposure typically represents more than 60% of plan assets. But the range of contribution volatility among these plans as a consequence of the funding provisions of the Pension Protection Act of 2006 is likely to be much wider, unless plan sponsors implement strategies designed to reduce tracking error. In addition to tracking error, contribution volatility also depends to a large extent on the size relationship between plan assets, plan liabilities, and current service cost. There is a wide variation in these relationships across the DB plan universe.

And then, of course, there is the issue of the plan sponsor's risk tolerance for contribution volatility. This further broadens the scope of the analysis to a consideration of the plan sponsor's top-level financial performance objectives, and the impact of pension financials on top-level financial performance. (See: "Pension-Liability Analysis: An Application of Fixed Income Analytics," by Michael J. Senoski, FSA, CFA, Third Quarter 2007, at www.pyramis.com.) Clearly, setting a risk budget for tracking error involves a host of complex and interrelated investment and financial issues. A collaborative effort that includes the plan sponsor's finance staff, the actuary for the plan, and an investment consultant is the best way to address this issue.

Tracking error is already an established and widely applied risk metric among investment professionals. Traditionally applied within a Capital Asset Pricing Model (CAPM) framework, its extension to liability-based performance benchmarks is straightforward. It is a more comprehensive measure of risk than the hedge ratio, capturing the impact of other sources of risk, such as beta risk, in addition to interest-rate risk. And it is a good proxy for other risk metrics such as funding ratio risk and, in some cases, surplus risk. On the other hand, the impact of tracking error on pension financials such as contribution volatility will not be immediately obvious, and can vary significantly. Additionally, differences in the methods and assumptions for computing tracking error can lead to different results. And by its nature, it is not a particularly useful measure of short-term volatility, an issue of growing concern among plan sponsors.

Value at Risk (VaR)

VaR is a risk metric that has important applications within the banking and insurance industries. Within the context of LDI we define VaR as the increase in a plan's unfunded liability over a one-year time frame at a 95% confidence level. For example, a VaR of $100 million means that there is a 95% probability that the unfunded pension liability will increase (or surplus will decrease) by less than $100 million over the next year. Thus, VaR measures the combined impact of pension fund investment returns and pension liability returns on the plan's funding level. The following example illustrates VaR for strategies A, B, C, and D.

Observations

As shown in Exhibit 4, VaR embedded in strategy A is $338 million. This indicates that there is roughly a 5% chance that this plan could move from a fully funded position to a shortfall of $338 million over the next year based on this strategy. Although one might view a 1-in-20 chance occurrence to be a small risk, a potential loss of this size should attract some attention. Apart from the economic loss itself, other consequences of such an event would be a $338 million pretax charge against shareholders' equity, a substantial increase in premiums paid by the plan to the Pension Benefit Guaranty Corporation, a designation as an "At Risk" plan subject to additional minimum funding requirements under the Pension Protection Act of 2006, notification to participants of the "At Risk" status, restrictions on lump-sum payouts from the plan, and possible restrictions on nonqualified plan funding.

Consistent with the improvement in the other risk metrics, there is a dramatic decrease in VaR as we move from strategy A to strategy B. The potential economic loss has been reduced from $338 million to $95 million, along with a reduction in the collateral damage that could result from a larger loss.

The change in VaR as we move from strategy B to strategy C is interesting. The VaR has moved from $95 million back up to $324 million, although the hedge ratio is unchanged. This is a further demonstration of the limited value of the hedge ratio as a measure of total funding level risk for plans with moderate-to-high equity exposure. In addition, it demonstrates the dominating effect that equity exposure has on VaR relative to the effect of interest-rate exposure on VaR.

This is particularly evident from a comparison of strategy A and strategy C. Despite the fact that strategy C's hedge ratio is more than five times that of strategy A (69% versus 13%), they have roughly the same VaR. The common exposure between them is the 60% equity exposure. A comparison of strategy C and strategy D indicates that, just as with tracking error, the change in yield curve exposure had a negligible impact on VaR.

Exhibit 4: Value at Risk

Liability	
Amount	$1,000,000,000
Duration	16
Funding Ratio	1.0

Asset Allocation	A	B	C	D
Equity	60%		60%	60%
Core fixed income	40%		40%	40%
Long-duration fixed income		100%		
Swap bellwether				
10-year			26%	
20-year			26%	
30-year			26%	
Swap zero coupon				
10-year				16%
20-year				16%
30-year				16%
Hedge ratio	13%	69%	69%	69%
Tracking error	14.0%	5.3%	9.6%	9.6%
Value at Risk	**$338,000,000**	**$95,000,000**	**$324,000,000**	**$324,000,000**

Source: Pyramis Global Advisors

Relative to the hedge ratio and tracking error, VaR is an attention getter. This should not be surprising, since it is designed to capture the effect of extreme events such as a two standard deviation event, and results are expressed in dollars—something we all understand—rather than ratios or percentages. Like tracking error, VaR is a more comprehensive measure of funding-level risk and captures the effect of all the risk factors within a portfolio that contribute to changes in a plan's funding level, including market (beta) risk and interest-rate risk.

As a result of FAS 158, any change in plan funding level flows onto the plan sponsor's balance sheet. As a direct measure of risk to a plan's funding level, VaR has become a more relevant and useful pension risk metric. VaR analysis should be of particular interest to plan sponsors with a relatively thin or highly leveraged balance sheet.

VaR is a well-established measure of surplus risk within the banking and insurance industries. Methods of computation of VaR have become fairly standardized. Its extension to market-based measures of pension surplus (under-funding) is straightforward. The implications of VaR are clear. It is especially relevant to the pension investment process as a consequence of FAS 158. On the other hand, the results of a VaR computation will be highly sensitive to parameters that are part of the calculation process. And, as with tracking error, the impact of VaR on contribution volatility may not be immediately obvious, and can vary significantly.

Conclusion

The move to a mark-to-market basis for measuring pension financials is well underway. This process will enhance the usefulness of traditional market-based measures of risk within the pension investment policy development process. Three such risk measures are the hedge ratio, tracking error, and Value at Risk (VaR). Each of these risk metrics considers a different dimension of risk. Their utility will vary depending on a variety of factors such as plan funding levels and the plan sponsor's top-level financial performance goals. The hedge ratio is a relatively straightforward calculation. And because of similar data requirements, the effort required to calculate both tracking error and VaR is not much greater than the effort required to calculate either one. For all these reasons, Pyramis Global Advisors typically employs all these metrics as part of its internal LDI strategy development. We believe that plan sponsors would benefit from such a comprehensive approach as well. ◻

Michael J. Senoski, FSA, CFA, is vice president and LDI investment director at Pyramis Global Advisors. In this role, he contributes to the product development, analytical support, and overall marketing for Liability-Driven Investing (LDI) strategies. Mike has more than 30 years of experience as a pension actuary advising defined benefit plan sponsors on pension funding strategy and investment policy.

[1] If we let R_a represent the periodic portfolio return and R_l represent the periodic liability return, then tracking error is the annualized standard deviation of the series $(R_a - R_l)$.

Funding ratio return, as developed by Leibowitz, Kogelman, and Bader ("Funding Ratio Return," Martin L. Leibowitz, Stanley Kogelman, and Lawrence N. Bader, *The Journal of Portfolio Management*, Fall 1994), can be described as the percentage change in a plan's funded ratio. For example, if a plan's funded ratio increases from 80% to 84%, the funded ratio return for the period is 5%.

Funding ratio risk (volatility) is the annualized standard deviation of the funding ratio return series. It can be shown that this is equal to the standard deviation of the series $(R_a - R_l)/(1 + R_l)$. Since the term $1 + R_l$ will typically be close to 1, there will generally be relatively little difference between tracking error and funding ratio risk.

Surplus return is not particularly useful when it is defined as the percentage change in surplus, i.e., change in surplus divided by initial surplus. Such a definition produces results that are difficult to interpret when initial surplus is low, or when a plan moves from a negative surplus (under-funded) position to a positive surplus position.

Surplus return is more commonly defined as the change in surplus expressed as a percentage of the initial portfolio value. Using this definition, it can be shown that surplus risk (volatility) is the annualized standard deviation of the return series $R_a - (L/A)*R_l$ where L is the initial liability value and strategy A is the initial portfolio value. When a plan is roughly fully funded and the expression L/A is close to 1, there will be relatively little difference between tracking error, funding ratio risk, and surplus risk.

Note: You can access additional papers issued in the Pyramis series of white papers on contemporary investment topics including "Liability-Driven Investing: Setting the Benchmark" and "Pension-Liability Analysis: An Application of Fixed Income Analytics," which both focus on Liability-Driven Investing, at www.pyramis.com.

About Pyramis Global Advisors
Pyramis Global Advisors, a Fidelity Investments company, is an investment management firm focused on serving corporate and public retirement funds, endowments, foundations, other institutions, and non-U.S. investors. Pyramis offers active and risk-controlled domestic equity, international equity, fixed income, real estate, and alternative disciplines.

Pyramis Global Advisors, LLC, is a registered investment advisor, and Pyramis Global Advisors Trust Company is a New Hampshire–chartered trust company and an investment manager. Both are Fidelity Investments companies. Pyramis products and services are presented by Fidelity Investments Institutional Services Company, Inc., a nonexclusive financial intermediary that is an affiliate of Pyramis.

For more information about Pyramis and the custom LDI solutions being developed for defined benefit plans, please contact Mike Senoski, vice president and LDI investment director, Pyramis Global Advisors, at 401-292-4753, or Chris Pariseault, vice president and fixed income investment director, Pyramis Global Advisors, at 401-292-4744.

Information presented herein is for discussion and illustrative purposes only and is not a recommendation or an offer or solicitation to buy or sell any securities. Past performance is no guarantee of future results.

Certain data and other information in this research paper were supplied by outside sources and are believed to be reliable as of the date presented. However, Pyramis has not verified and cannot verify the accuracy of such information. The information contained herein is subject to change without notice.

Pyramis does not provide legal or tax advice, and you are encouraged to consult your own lawyer, accountant, or other advisor before making any financial decision.