**Summary**

- What is the optimal way for a defined benefit plan to de-risk? This is one of the most challenging questions faced by plan sponsors. To answer appropriately, a sponsor must first consider their risk tolerance and the objective factors influencing it – including the plan’s relative size, whether it’s open or closed, and business cyclical.

- We have developed a quantitative framework to help map risk tolerance onto a choice of glide path. At the heart of our analysis is a dynamic glide path—equivalent of standard mean-variance optimization, a mathematical approach that solves for glide paths rather than static allocations.

- Through this framework, we are able to construct what is, in effect, a liability-driven investing (LDI) efficient frontier. The LDI efficient frontier helps plan sponsors to probe the potential impact of different decisions, and understand the precise tradeoffs that they’re making when deciding on a glide path.

**Downside Protection Is Our Guiding Principle for LDI Glide Path Design**

<table>
<thead>
<tr>
<th>Allocation</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreasing total</td>
<td>Return-seeking allocation</td>
</tr>
<tr>
<td>Liability-hedging allocation (long-duration fixed income)</td>
<td></td>
</tr>
<tr>
<td>Increasing correlation with liabilities</td>
<td></td>
</tr>
<tr>
<td>U.S. Treasuries</td>
<td>U.S. Credit</td>
</tr>
<tr>
<td>U.S. Corporates</td>
<td>U.S. A-rated Corporates</td>
</tr>
</tbody>
</table>

- Match duration of fixed-income assets to liabilities
- Increase fixed-income allocation
- Shift long-duration holdings into A-rated corporates
- Reduce allocation to return-seeking assets, identify specific expected volatility/return contributions

Source: Capital Group.

**Multiple Perspectives. One Approach.**

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LDI Can Help Plan Sponsors Meet Their Objectives

In our view, an approach to LDI that seeks to move a plan toward fully funded status along a glide path makes sense, providing a disciplined schedule for asset allocation.

Early on, investments should focus more on seeking returns – bearing investment risk and letting the power of compounding returns do its work. As funded status improves, the emphasis evolves toward security – that is, less volatility in funded status.

As illustrated in the chart on the previous page, we have made downside protection a guiding principle of our approach to LDI glide path design. In essence, the glide path begins with the plan switching all existing fixed-income assets into longer duration bonds. This allocation is then increased as funded status improves (see sidebar below for details).

For LDI Glide Paths, One Size Does Not Fit All

Sponsors often make particular LDI strategy choices for subjective reasons. For example, past market losses may engender risk aversion among trustees. This means that the sponsor may choose to rapidly de-risk as funded status improves – even if this necessitates upping corporate contributions to the plan.

Conversely, another board of trustees at a different pension plan with similar demographics and funded status may have greater tolerance for risk. These fiduciaries may instead opt to move only gradually toward a relatively conservative asset allocation. Alternatively, they may decide to delay embarking on an LDI strategy, preferring to retain higher allocations to return-seeking assets and accept funded status volatility for the time being. In this instance the hope is that funded status improves in time, but the sponsor must then accept that it will bear the cost in the future if this approach fails.

It’s rational for each plan sponsor to react differently to changes in funded status, de-risking at different rates depending on their unique circumstances. But in addition to subjective factors such as the preferences of trustees or other fiduciaries, a plan sponsor’s unique risk tolerance is also determined by objective factors related to its own characteristics and those of the plan.

Implementation of an LDI Glide Path Includes Four Key Phases

The two broad components of the asset mix in an LDI glide path are return-seeking assets (equities and possibly emerging markets debt, non-U.S. bonds, high-yield bonds, alternatives or real estate), and liability-hedging assets – a combination of long-duration U.S. government bonds and U.S. credit. As a pension plan’s funded status improves, the plan seeks more downside protection to funded status:

**Phase 1.** Match the duration of existing fixed-income investments with that of the liabilities (regardless of funded status).

**Phase 2.** Increase the allocation to fixed income as funded status improves, thus:
- Raising fixed-income investments’ hedging role versus liabilities;
- Offering a measure of explicit downside protection.

**Phase 3.** Continue to increase fixed-income investments’ correlation with liabilities by moving from government/credit to A-rated corporates, resulting in:
- Higher plan-level correlation of assets and liabilities.
- Declines in volatility generated by return-seeking assets.

**Phase 4.** As funded status increases, continue to reduce the allocation to return-seeking assets and identify specific volatility (and return) contribution expectations. The asset mix is optimized in regard to the growth of the liability. The allocation decision will, therefore, vary depending on whether the plan is open/active or closed.
Key objective measures that should influence the design of the glide path and the pace of de-risking include:

- **Plan size relative to sponsor’s balance sheet.** Economically, the plan is part of the corporate sponsor’s balance sheet; it therefore generates balance sheet volatility in proportion to its size. This implies that larger plans should de-risk relatively quickly.

- **Whether the plan is closed or open.** Closed plans can be de-risked with a high confidence interval – that is, there should be less uncertainty over outcomes as the evolution of the liability profile is reasonably predictable. The relative size of the plan’s retired and active populations is also critical.

- **Correlation between investment returns and the sponsor’s business.** In a downturn, revenues of a cyclical business may fall sharply, possibly at the same time as equities post losses and bond yields fall. The sponsor may have to make a contribution when it can least afford to. Conversely, a plan sponsor whose business is not cyclical can afford to hold more risk through downturns, and may prefer to de-risk more slowly.

As the exhibit below shows, sponsors from cyclical industries should be particularly mindful of the third objective measure – correlation. In 2001 and 2009, industrial companies in the U.S. were potentially vulnerable to a double whammy of plan investment losses and declining financial health at the corporate level. Firms in the consumer staples sector were not similarly vulnerable.

**History Suggests That Sponsors With Cyclical Businesses Should Be Mindful of Correlation**

Free Cash Flow and U.S. Stock Market Returns (12/31/93-12/31/14)

As the exhibit below shows, sponsors from cyclical industries should be particularly mindful of the third objective measure – correlation. In 2001 and 2009, industrial companies in the U.S. were potentially vulnerable to a double whammy of plan investment losses and declining financial health at the corporate level. Firms in the consumer staples sector were not similarly vulnerable.

**How Is the “Optimal” Glide Path Determined?**

What would be particularly useful for plan sponsors is a quantitative framework that enables objective risk tolerance to be mapped to an LDI glide path. Finding the optimal glide path for a given risk tolerance is akin to the static portfolio allocation problem, solved with mean-variance efficient portfolios. We might hope that a similar approach could yield a solution for glide paths, but the problem is both harder to define and to solve.
What Is an LDI Efficient Frontier?
Standard portfolio theory has been a workhorse of investment management. In standard portfolio theory, the efficient frontier defines the optimal investment risk/return tradeoff, where risk is defined as the standard deviation of return. The hypothetical example in the exhibit below shows three optimal portfolios along the efficient frontier. As you would intuitively expect, the greater the risk an investor is willing to take, the more “aggressive” their asset allocation, and the higher the rewards they should expect.

How can we recast the theory’s basic idea – that there’s a tradeoff between “risk” and “reward,” and that there exists a strategy that optimizes reward for a given level of risk – in the context of LDI?

As a first step, risk and reward should be redefined in a way that’s relevant to plan sponsors, taking both assets and liabilities into account. And single limited investment horizons aren’t appropriate; we need to consider extended time periods. Finally, rather than single static allocations, we need to analyze glide paths – strategies with asset allocations that change over time.

These LDI-specific considerations render the problem much more mathematically complicated, and much more challenging to solve. Still, the underlying principle remains simple: if you know how much risk you want to take, does there exist an optimal strategy (the efficient glide path) that gives the most reward for that level of risk? In the context of LDI, an efficient glide path frontier quantitatively defines the optimal strategy.

In the exhibit on the next page, three points are once again highlighted at different locations on a hypothetical frontier. This time, however, there’s an optimal glide path for each level of risk – not just a single optimal static allocation. In this exhibit, “Risk measure” refers to the average volatility of funded status over the next 10 years, and “Funded status measure” specifies the average funded status over the next 10 years. Both these measures evolve over time: typically, funded status improves and tracking error declines over time. These are, therefore, summary measures over the whole 10 years.

The mathematical machinery used to discern the LDI efficient frontier and optimal glide paths is complex. Specifically, the hypothetical portfolio analysis in the glide path setting presented in this paper uses Monte Carlo simulation to calculate the range of outcomes and probabilities (see sidebar on page 5). To learn more about the efficient LDI glide path, see our August 2014 LDI paper on managing pension risk through glide path design, available at thecapitalgroup.com/us.

A Hypothetical Efficient Frontier Defines the Optimal Asset Allocations at Different Risk Levels

Asset Mix:
- U.S. equity
- Global high yield
- Long government
- Long credit
- Long corporate

For illustrative purposes only. This example is hypothetical and does not reflect the results of any particular investment.

Source: Capital Group.
A Hypothetical LDI Efficient Frontier Defines the Optimal Glide Paths at Different Risk Levels to Liabilities
Efficient Frontier: Starting Funded Status of 78%, Rebalance Every 0.1%

Asset Mix:
- **U.S. equity**
- **Non-U.S. equity**
- **Long government**
- **Long credit**

For illustrative purposes only. This example is hypothetical and does not reflect the results of any particular investment. Analysis performed using Monte Carlo simulation of assets and liabilities (see note on Monte Carlo simulation, below).

Source: Capital Group.

**Monte Carlo Simulation**

Monte Carlo simulation is a statistical technique that, through a large number of random scenarios, calculates a range of outcomes that are based on certain assumptions.

For a single path of simulated monthly asset and liability returns, the path-specific risk is defined as the realized volatility of the funding ratio over the full simulation period (assuming no additional contributions by the plan sponsor), and the path-specific return is defined as the average funding ratio over the full period. In the full Monte Carlo analysis, we define risk and return by averaging the path-specific risk and return measures over all simulated paths.

In several charts and related discussions, “risk measure” refers to the average, over all simulation paths, of the tracking error of asset returns versus liability, measured over the 10-year simulation horizon. Likewise, “funded status measure” refers to the average, over all simulation paths, of the plan’s funded status averaged over the 10-year simulation horizon.

The hypothetical LDI-related examples presented in this paper are simulation-based results, and are provided for informational purposes only; they are not intended to provide any assurance of actual results. The simulation will not capture low-probability, high-impact outcomes. While we believe the calculations to be reliable, we cannot guarantee their accuracy.
The LDI Efficient Frontier Remapped Into More Familiar Terms

Though the risk and funded status measures produce an efficient frontier that is reminiscent of those in standard portfolio theory, they are a little abstract. Fortunately, it’s possible to present an LDI efficient frontier in a form that is more tangible for plan sponsors: in terms of a tradeoff between the speed at which funded status improves and the risk of a severe negative shock to funded status.

The hypothetical example presented in the chart below shows a plan with an initial funded status of 95%, and highlights four different risk scenarios in which funded status volatility equals 450 basis points per year, 550 basis points per year, 650 basis points per year or 750 basis points per year – recall that each figure specifies the amount of risk that a sponsor is willing to see its plan take.

The blue line illustrates the efficient frontier for a plan where funded status drawdown risk is in reference to a threshold of 70% funded status. The green line shows the same plan, but with an 85% threshold instead.

Both lines trace the tradeoff between average time to achieving fully funded status (assuming no pension contributions from the corporate sponsor) and drawdown risk (that is, the likelihood that drawdown will breach the threshold at some point). Note once more that this is the result of a simulation and we’re talking about an average time; the actual time this may take remains random and unpredictable.

As can be seen from this hypothetical analysis, selecting a riskier glide path toward the right of the blue line suggests a tendency to become fully funded more quickly, which is what would be expected with slower de-risking. But adopting a glide path that retains a relatively high equity allocation means that the risk of becoming severely underfunded (that is, breaching the 70% threshold) at some point is quite high. Conversely, choosing a conservative glide path on the left part of the blue line (de-risk sooner and more completely), entails a lower probability of becoming severely underfunded, but it’s likely to be considerably longer before fully funded status is achieved.

With a drawdown threshold set closer to the initial funded status (85% rather than 70%), the probabilities of drawdown associated with various risk levels vary over a wider range.

The Risk/Return Tradeoff Between Pace of Funded Status Improvement And Drawdown Risk Varies Significantly for Different Thresholds of Drawdown Risk

Average time to 100% funded (years); 95% initial funded status

| Drawdown risk: probability of funded status falling below specified threshold |
|---|---|---|---|---|---|---|---|
| 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
| Threshold of 70% funded status | 2.4 | 3.0 | 3.4 | 3.6 | 3.8 | 4.0 |
| Threshold of 85% funded status | 450 bps/year | 550 bps/year | 650 bps/year | 750 bps/year |

For illustrative purposes only. This example is hypothetical and does not reflect the results of any particular investment. Analysis performed using Monte Carlo simulation of assets and liabilities (see note on Monte Carlo simulation on page 5).

Source: Capital Group.
**How Significant Is the Influence of Initial Funded Status?**

So far, our hypothetical examples have assumed a starting point of 95% funded status. Our research suggests this healthy starting point means that — for most levels of risk tolerance — the optimal glide path is going to dictate an asset allocation that is heavily weighted toward longer duration bonds. And, on average, it doesn’t take too long to get to fully funded status.

The situation changes if you start at a lower funded status, as illustrated below. The curve shows how long, on average, it takes a hypothetical plan to reach 100% funded status with an optimal glide path, for a range of starting points (initial funded status). Risk tolerance is assumed to be 450 basis points per year in all cases.

As might be expected, the lower the initial funded status, the longer it will tend to take to reach fully funded status. Still, it’s instructive to see the shape of the curve. The precise shape of the curve is influenced by capital markets assumptions used in the simulations; while the level of the curve is influenced by the assumed risk premia. Notably, the higher the assumed equity premium, the more rapidly 100% funded status will be achieved, on average.

The left side of the blue line is flatter. This actually has positive implications for plans that are severely underfunded. Even if a plan that starts out with a funded status below 80% experiences further declines in this percentage, its average time to fully funded status shouldn’t be expected to extend that much.

That is, a plan with a lower initial funded status that implements a de-risking policy with the optimal glide path may very well become fully funded in nearly as short a time as a plan with similar characteristics, but a moderately better starting point. Why is this? In essence, it’s because for a lower initial funded status, it is optimal to have a higher allocation to return-seeking assets early on in the glide path, which should help to make up any “lost ground” at the outset.

**With an Optimal Glide Path, Expected Time to Fully Funded Status Declines More Rapidly With a Higher Initial Funded Status**

**Expected time to fully funded status (years)**

<table>
<thead>
<tr>
<th>Initial funded status</th>
<th>Expected time to fully funded status (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.95</td>
<td>2</td>
</tr>
<tr>
<td>0.90</td>
<td>3</td>
</tr>
<tr>
<td>0.85</td>
<td>4</td>
</tr>
<tr>
<td>0.80</td>
<td>5</td>
</tr>
<tr>
<td>0.75</td>
<td>6</td>
</tr>
<tr>
<td>0.70</td>
<td>7</td>
</tr>
</tbody>
</table>

For illustrative purposes only. This example is hypothetical and does not reflect the results of any particular investment. Analysis performed using Monte Carlo simulation of assets and liabilities (see note on Monte Carlo simulation on page 5).

Source: Capital Group.
Key Takeaways

- Plans should, we believe, use a glide path to de-risk. It’s rational for different plan sponsors to choose different glide paths – one size does not fit all.

- Subjective judgments play a role in glide path choice. Think of objective factors – such as plan size relative to sponsor’s balance sheet, whether a plan is closed or active, correlation between investment returns and a sponsor’s business – as determining risk tolerance.

- A simulation-based approach can help plan sponsors to understand the LDI efficient frontier, enabling them to map risk tolerance to an optimal glide path.

Conclusion

Careful investing always involves implementing an efficient balance between risk and reward. In this paper, we have shown that plan sponsors can pursue such a balance by picking a point on an LDI efficient frontier, shown in the exhibit below. Each point on the line corresponds to a different optimal glide path. The choices involving greater potential volatility around funded status are on the right, while those glide paths that – on average – tend to result in less volatility are on the left.

Our experience suggests that sponsors often think of themselves as having a moderate risk tolerance (that is toward the indicated point on the LDI efficient frontier below).

However, if a plan is very big relative to the rest of the corporate balance sheet, the plan sponsor should select a strategy (glide path) further to the left, with an earlier and higher allocation to liability-hedging assets. If the plan is closed and frozen, the sponsor should probably remain focused on the left side. On the other hand, if the sponsor’s business is not cyclical – for example, it’s a utility with a cash flow that tends to be more stable through a recession – the sponsor would have a higher risk tolerance and should perhaps consider glide paths positioned further along the efficient frontier, to the right.

Whatever a sponsor ultimately decides to do, we believe that the quantitative framework we have developed should help sponsors better understand the tradeoffs that different decisions may entail in terms of drawdown risk and time to fully funded status.

The LDI Efficient Frontier Can Lead to More Informed Glide Path Design

Efficient Frontier: Starting Funded Status of 78%, Rebalance Every 0.1%

<table>
<thead>
<tr>
<th>Funded status measure</th>
<th>Plan Characteristics</th>
<th>Objective Risk Tolerance</th>
<th>Glide Path Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.90</td>
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<tr>
<td>0.88</td>
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<tr>
<td>0.86</td>
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<td></td>
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<tr>
<td>0.84</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0.82</td>
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</tbody>
</table>

Risk measure (bps/year)

For illustrative purposes only. This example is hypothetical and does not reflect the results of any particular investment. Analysis performed using Monte Carlo simulation of assets and liabilities (see note on Monte Carlo simulation on page 5).

Source: Capital Group.