AN IN-DEPTH ANALYSIS

Liability Driven Investing

Evaluating a Pension Plan's Assets in the Context of Its Liabilities

Northern Trust

LIABILITY DRIVEN INVESTING:

Evaluating a Pension Plan's Assets

in the Context of Its Liabilities

CONTENTS

FOREWORD

"Defined benefit pension plans are dead!" This was the conclusion of one featured speaker at a recent industry conference. We hope not, because we regard these plans as an extraordinarily valuable employee benefit, and good public policy as well. The concept of elderly retirees outliving their money is sobering indeed.

While corporate defined benefit plans may not be dead, they do appear to be candidates for the endangered species list. Many large companies have chosen to freeze their plans; a soft freeze (plan closed to new entrants) often is followed by a hard freeze (no further benefit accruals). Others have terminated their plans as the expense of maintaining the plan is perceived to be too great, and the risks inherent in the structure unattractive.

These expenses and risks are about to grow. The pension reform bill just passed in Washington addresses pension funding, requiring that funding deficits be amortized over seven years, down from the current 30. The target for full funding will become more volatile as all plans will value liabilities with a changing yield curve and as the bill also shortens the time period over which both assets and liabilities can be smoothed. Meanwhile, the Financial Accounting Standards Board (FASB) will be making changes in how corporations will report on their pension funds. Effective at year-end 2006, companies will report funded status, at current market value, on their balance sheets. With many U.S. corporate plans underfunded, the impact of this will not be positive. For some companies with large plans and large unfunded liabilities, the pension deficit could severely dilute, and in some extreme cases, potentially wipe out shareholder equity. While these figures had been reported previously in a footnote to annual reports, their inclusion on the balance sheet will further highlight this issue.

The purpose of this paper is not to focus on changes in the rules governing pension accounting or funding. Other papers do that in detail. Instead, this paper addresses how we see the investment strategies of pension funds changing in response both to these regulatory changes and to the negative market conditions of recent years. This leads us to Liability Driven Investing, or LDI. It is a popular topic at industry conferences and in trade publications, but what exactly is meant by the term LDI? Why the great interest today? What has changed that makes this such a compelling topic? And how should plan sponsors address the funding issue?

Duane Rocheleau
Managing Director
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WHAT EXACTLY IS LDI?

LDI is not a product. Rather, it is a framework for investing the assets of a defined benefit pension plan. This framework is focused on the plan's liabilities, and the risks and returns of all investment alternatives are measured in the context of their impact on a plan's surplus or deficit.

Pension plans exist for one reason only: to fund pension payments. In the early years, U.S. pension plans were generally not funded. Those that were funded were invested in long bonds or insurance annuities. It wasn't until the 1950s that equities became a popular investment choice. New plans were being started and benefits negotiated. With massive past service obligations to fund, equities appeared to be an attractive investment alternative. (It helped also that equity performance was very strong during the 1950s, while bonds were doing poorly.) Equities have remained a core investment for most pension plans ever since.

The term LDI makes many people think of dedicated bond funds. This was a popular strategy in the 1980s, when interest rates were high. A plan would build a bond portfolio designed to generate payouts that would match in amount and timing of its pension payouts. Major plans embracing this strategy included Chrysler and American Airlines. They took advantage of rates ranging to as high as 16%. At those levels, dedicated portfolios were an attractive option.

Most plan sponsors would probably argue that they have always invested assets with the objective of best positioning their plans to meet their obligations. Those obligations, however, have generally been viewed as long-term in nature. Over a multi-year time horizon, riskier but higher-returning assets such as common stock will appear to be more attractive. This is because returns compound over time, while volatility grows with the square root of time. Most pension plans decided on their strategic asset allocations only after undertaking detailed asset liability analyses. In these studies, a diversified mix with a significant commitment to equities has generally appeared to offer the highest probability of building assets, containing costs and meeting the plan's obligations.

And for many years this strategy worked. As recently as 1999, companies in the S&P500 with DB plans had an average funded status of 128%[1]. Estimates place the average U.S. DB plan's allocation to equities at 61% at this time. Many plans had gone years without making contributions. That situation changed abruptly in 2000.

WHAT HAPPENED TO U.S. PENSION PLANS AND WHAT DO THEY DO NOW?

During the three-year period from 2000 to 2002, U.S. pension plans suffered a dramatic decline in fortune. In the grasp of a horrific bear market in equities, the S&P 500 declined by almost 40% over this time span. If we assume that a plan's equity exposure was the S&P 500, this translated into a negative hit of 20% or more to the asset value of the average DB plan. Fortunately, other assets were doing well over this period, which helped somewhat to offset the equity losses.

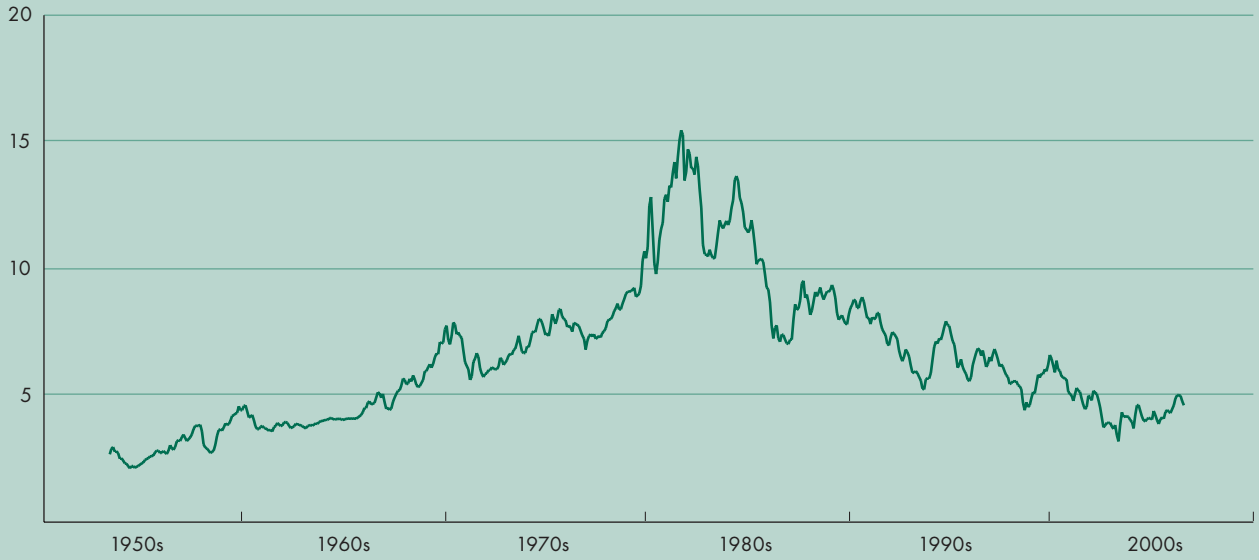
More painful for pension plans, was the concurrent decline in U.S. interest rates, which had a huge impact on liabilities. Since the liability figure is the present value of future benefit payments, the interest rate used in the calculation is critical. As interest rates fell, the liabilities ballooned, and this exposed a major disconnect between the investment policies of most plans and the risk inherent in the liability.

For most pension plans, the duration of the liabilities is quite long. Durations of 12 to 15 years are common, and durations in excess of 20 years are not unknown. The duration provides an estimate of how the liability will change as a result of a 1% parallel shift in the yield curve. A plan with a liability duration of 15 years could expect to see liabilities grow by approximately 15% if interest rates dropped by 1%.

Between 2000 and 2003, interest rates dropped by far more than that. One year rates fell by almost 500 basis points while 10-year rates fell by almost 300 basis points. Had the duration of the assets been equally as long, the results would have been very different. The average pension plan, however, had assets with a far shorter duration. Many benchmarked fixed income to the Lehman Aggregate Bond Index. With a duration of approximately 4.5 years, it is far shorter than the liabilities. Over this three-year period, the Lehman Aggregate actually appreciated by about 33%, which was not sufficient to offset the growth in liabilities. (While an argument can be made that equities have a long duration, the relationship between equity returns and interest-rate changes is far less stable, as can be seen from this three-year period.)

By 2002, S&P 500 companies with DB plans had an average funded status of 82%, versus 128% three years earlier. Of the companies offering plans, only 35 were overfunded that year, while 335 were underfunded.[2] Even today, after a bounce in equity returns and interest rates, the average DB plan finds itself in a deficit position. The funded status has improved, but not back to 100%. Plan sponsors realize that the mismatch in duration is a problem. But to rectify the situation by moving assets into long fixed-income instruments is unappealing. As can be seen in Exhibit 1, interest rates continue to languish at levels not seen since the 1960s. While Chrysler and American Airlines, among others, were able to lock in interest rates close to their peak levels, the rates obtainable today are lower than the actuarial expected return for the typical plan. On the other hand, can companies afford to take the risk of not significantly lengthening duration? They have now experienced a "worst-case" scenario in terms of what can happen with interest rates, and can see what another one would do to their balance sheets and pension expenses.

EXHIBIT 1: 10-YEAR TREASURY CONSTANT MATURITY RATE



Source: Federal Reserve Bank of St. Louis

Each company with a defined benefit pension plan needs to think about how best to address these risk/return issues. No two companies are identical, and neither are their pension plans. Keep in mind that LDI is a framework, not an off-the-shelf product.

In the next section of this paper, we have modeled several alternative plans and used them to illustrate the impact of various investment strategies. These are simple models developed to stimulate the thought process. They are not intended as substitutes for the much more robust analyses that companies will undertake as they consider their options for managing their funds.

MODELING EXERCISES

In thinking about possible investment approaches, we have reverted to the framework of a traditional asset allocation model, but one that also incorporates liabilities. We use a quadratic optimizer and model liabilities as short positions. We have modeled two hypothetical pension plans:

- A mature plan with a freeze on benefit accruals
- An ongoing plan with younger employee participants

The goal of this exercise is to answer some of the following questions:

- What are the risks of the traditional mix in the asset-only space and in the asset-liability space?
- How do the risks change as duration is lengthened?

- Does a dedicated fixed-income strategy make sense? When might a plan want to put all of its assets into such a strategy?
- Should Treasury Inflation-Protected Securities (TIPS) be a part of the allocation?
- How does the initial funded status impact the results?
- How do the results change if one allows leverage and includes derivatives?

This analysis views a pension plan as a stand-alone entity. Extraordinarily important considerations, such as the financial strength of the company, the size of the pension plan, the ability for volatility within the plan to negatively impact a company's financials, the importance of the DB plan within the company culture, etc., are beyond the scope of this work.

The liability models are simplified; they are not detailed actuarial projections. We have made no attempt to model pension expense (contributions). The sole focus here is on funded status: what happens to liabilities given various interest rate changes, and what investment strategies a plan might consider in response.

The list of assets considered for investment is also streamlined. We have included the traditional vehicles: equities, a bond index and cash. We have also included a dedicated bond fund, designed to defease a given liability stream. The exact composition of this fund will differ, depending on the characteristics of the liabilities. Finally, we have included an "alpha" strategy, the characteristics of which could come from a diversified basket of hedge funds.

THE TRADITIONAL ASSET MIX

As a base case, we looked at a fairly traditional asset mix of 60% equities, 35% bond index, and 5% cash. We used fairly standard assumptions for expected return, standard deviation and correlations, as shown in Exhibit 2. The expected nominal return for this mix was 8.3%, with a standard deviation of 9.5%.

In asset-only space, this is an attractive mix, and it looks even more attractive if one looks out five or 10 years. The return compounds over time, but the standard deviation grows with the square root of time. Exhibit 3 shows the range of expected returns for each of these time horizons, within one standard deviation.

EXHIBIT 2: ASSUMPTIONS FOR EXPECTED RETURN, STANDARD DEVIATION AND CORRELATION

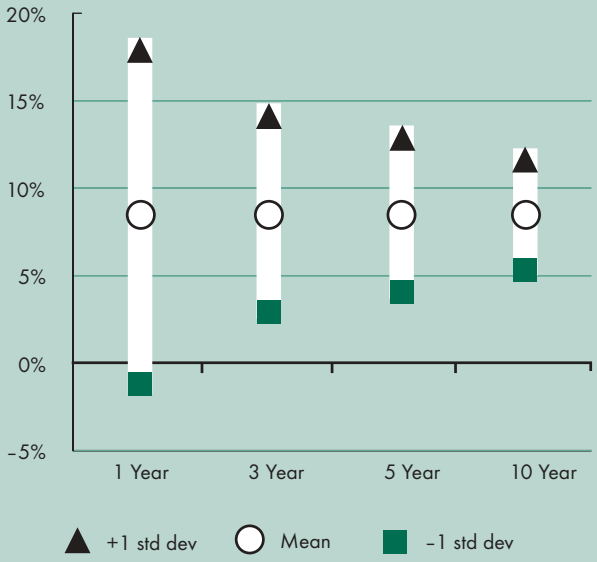
	RETURN	STD. DEVIATION	STOCKS	BONDS	CASH
Stocks	10.0%	15.00%	1.00		
Bonds	6.0%	3.70%	0.30	1.00	
Cash	4.5%	1.00%	0.02	0.16	1.00

Source: Northern Trust

We next looked at this traditional mix to see how it would fare in the asset-liability framework. We derived the liabilities from our first case study: a mature plan with liabilities frozen. This, in many ways, is the simplest of the models. There will be no further benefit accruals. There are some young employees, however, so payments are assumed to continue for 62 years. The duration of the liability, discounted at 5.5%, is 12.5 years.

EXHIBIT 3: ANNUALIZED RETURNS OF TRADITIONAL 60/35/5 ASSET ALLOCATION

Annualized Returns through Time



Source: Northern Trust

EXHIBIT 4: INTRODUCTION OF A DEDICATED BOND PORTFOLIO

NET LIABILITIES	DEDICATED BONDS	BOND INDEX
Expected Return	2.65%	2.83%
Std. Deviation	11.21%	13.74%
ASSETS ONLY		
Expected Return	8.15%	8.33%
Std. Deviation	10.62%	9.47%

Source: Northern Trust

We integrated the liabilities as a short exposure to an asset growing at 5.5% per year, with a standard deviation of 12.5%. As the starting point, we assumed that assets were equal to liabilities. With an 8.3% return on assets, we would expect the fund to move into a surplus position and it does, although within a fairly wide range. The net return for this mix was 2.8%, but the tracking error of the assets to the liability was 13.7%. (This level of tracking error has been very common among pension funds, and we do not want to imply that it is inappropriate. We will, however, look at ways to lower tracking error as we progress through this analysis.)

ALTERNATIVE MIXES

We next looked at how this risk would change if we were to hold a dedicated bond portfolio, cash flow matched, pro rata, to the liabilities. We assumed a somewhat lower return on this dedicated portfolio than we had for the bond index: 5.5% vs. 6%. The 35% of assets previously held in a shorter bond index strategy were put into this portfolio. The results were what we would expect. In an asset-only framework, the longer duration bonds increase volatility, as shown in Exhibit 4. Considered versus liabilities, however, they lower the tracking error.

For a frozen plan, this is still quite a risky mix. Since we assumed this plan to be fully funded, we could probably defease the entire liability by moving all of the assets into a dedicated bond strategy. In this situation, this is the minimum-risk portfolio.

EXHIBIT 5: EFFICIENT FRONTIER WITH CONSTRAINTS

TARGET EXCESS RETURN	NA	0.00%	1.00%	1.40%	2.00%	3.00%	4.00%	
FRONTIER WEIGHTS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**60/35/5**
Stocks	0.00%	13.44%	35.67%	44.56%	57.89%	80.11%	100.00%	60.00%
Bond Index	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	35.00%
Dedicated Bond	100.00%	86.56%	64.33%	55.44%	42.11%	19.89%	0.00%	0.00%
Cash	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.00%
ASSETS & LIABILITIES								
Expected Return	–0.61%	0.00%	1.00%	1.40%	2.00%	3.00%	3.90%	2.22%
Std. Deviation	2.97%	4.18%	7.56%	9.05%	11.34%	15.22%	18.73%	14.79%
ASSETS ONLY								
Expected Return	5.50%	6.11%	7.11%	7.50%	8.11%	9.11%	10.00%	8.33%
Std. Deviation	12.50%	11.32%	10.35%	10.37%	10.85%	12.65%	15.00%	9.47%

Source: Northern Trust

Assume, however, that the plan is underfunded and has assets equal to 90% of the forecasted liability. There are only three ways to make up this deficit: (1) put more money into the fund; (2) benefit from a higher discount rate; (3) earn a higher return on the assets. We will focus exclusively on the third option. Putting 100% into a dedicated bond strategy at 5.5% will no longer deliver the required return. A return of 6.1% will only prevent further erosion of the funded status, so an even higher return is essential if the deficit is to be pared back. In fact, a return of 7.5% a year would be required for the fund to get back to a fully funded status within seven years. (We selected seven years since this is the period over which deficits are to be funded under the new pension-reform legislation.)

The first efficient frontier (Exhibit 5) shows an array of portfolios that would be optimal given certain constraints. We did not allow hedge funds and we did not allow leverage. The optimal portfolios were mixes of equities and the dedicated bond fund. (Neither the bond index nor cash came into any of the portfolios.)

The minimal risk portfolio with a high enough expected return is #4. Note that in an asset-only analysis, this would not be optimal. As can be seen, it is significantly less attractive than the traditional 60/35/5 mix.

We reran the optimizer, making two changes. We introduced an "alpha" asset designed to look like a diversified basket of low-volatility hedge funds. While hedge fund managers would say that our return assumptions are too modest (cash plus 3%), the model, nonetheless, liked the asset and included it in all of the solution portfolios, with the exception of the lowest-risk portfolio. We also introduced leverage. We first ran the analysis allowing a maximum of 20% leverage. We then increased the leverage in 10% increments up to a maximum of 50%. The results appear in Exhibit 6. The first series are the optimal mixes, given an excess return target of 1.4%, and the asset-only return of 7.5%.

EXHIBIT 6: INTRODUCTION OF HEDGE FUNDS AND LEVERAGE

TARGET EXCESS RETURN = 1.4%					
MAXIMUM LEVERAGE	**0%**	**20%**	**30%**	**40%**	**50%**
FRONTIER WEIGHTS					
Stocks	44.56%	33.56%	29.00%	26.78%	23.90%
Bond Index	0.00%	0.00%	0.00%	0.00%	5.93%
Dedicated Bond Fund	55.44%	71.70%	81.00%	93.22%	100.17%
Alpha	0.00%	14.74%	20.00%	20.00%	20.00%
Cash	0.00%	–20.00%	–30.00%	–40.00%	–50.00%
ASSETS & LIABILITIES					
Std. Deviation	9.05%	6.86%	5.84%	5.04%	4.58%
ASSETS ONLY					
Std. Deviation	10.37%	10.96%	11.64%	12.90%	13.69%

Source: Northern Trust

As can readily be seen, as leverage increases, the bulk of the exposure increase goes to the dedicated bond fund. With 50% leverage, the optimal strategy would be to have 100% of the notional value exposed to a dedicated strategy, with another 50% seeking higher returns mostly from equities and hedge funds. These exposures could be taken in a variety of ways, using a mix of physical instruments, futures, swaps, etc. Interest rate swaps are one vehicle currently being touted in the market. However it is achieved, this mix would seem to have a significantly lower tracking error than is achievable without the use of leverage.

We then repeated the exercise, but this time with a target excess return of 3%. As can be seen in Exhibit 7, the higher return makes it far more difficult to find a low-risk solution. This is because, by necessity, more of the assets have to be positioned in those asset types expected to generate higher returns. This just underscores the difficulty that many funds face. Since they are underfunded, they need to generate higher returns. With interest rates at current levels, long duration fixed income, by itself, is not adequate. Leverage is an important component of the solution, but leverage, as we all know, introduces other complexities and other risks.

EXHIBIT 7: INTRODUCTION OF HIGHER EXCESS RETURN TARGET

TARGET EXCESS RETURN = 3.00%					
Maximum Leverage	0%	20%	30%	40%	50%
FRONTIER WEIGHTS					
Stocks	80.11%	66.98%	64.56%	62.33%	60.11%
Bond Index	0.00%	0.00%	0.00%	0.00%	0.00%
Dedicated Bond Fund	19.89%	33.48%	45.44%	57.67%	69.89%
Alpha	0.00%	19.54%	20.00%	20.00%	20.00%
Cash	0.00%	–20.00%	–30.00%	–40.00%	–50.00%
ASSETS & LIABILITIES					
Std. Deviation	15.22%	12.92%	11.82%	10.82%	9.95%
ASSETS ONLY					
Std. Deviation	12.65%	11.50%	12.00%	12.69%	13.51%

Source: Northern Trust

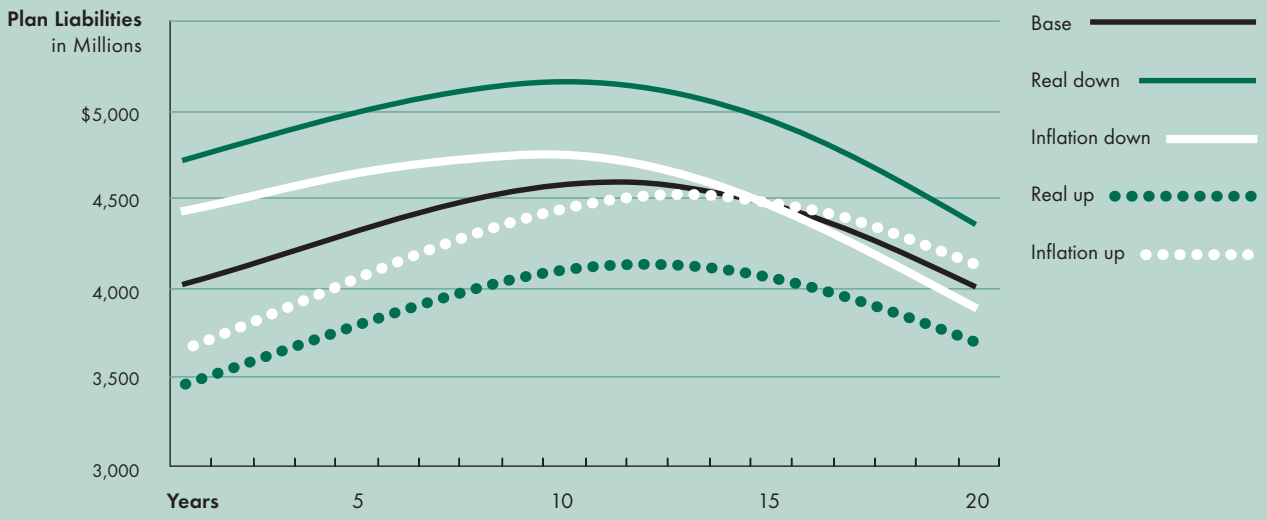
AN ONGOING PLAN

So far, the analysis has focused on a mature, frozen plan. Our next question was how the results might change for a non-frozen plan with more and younger active employees. We created a hypothetical plan with three active employees for every retiree. The duration of the liability was about 16 years, significantly longer than in the previous case. We made it a final pay plan with salaries assumed to grow in line with inflation.

A couple of things are immediately clear. The longer duration of the liability means more of a mismatch probably exists with the assets. Also, it is reasonable to assume that the pressure for performance will be even greater, since the liability will be growing as employees accrue additional years of service.

The discount rates used in actuarial calculations are nominal interest rates. Nominal interest rates have two components: a real interest rate and an inflation premium. It can be argued (see Siegel and Waring[3]) that pension liabilities respond differently to changes in each of these. A change in inflation impacts salaries, and hence the future benefits, of existing employees. For corporate plans, most of which do not have cost of living adjustments, a change in inflation does not affect the benefits of existing retirees. Also, the impact is somewhat muted. If the discount rate increases, the present value of the liability will drop. But, if the increase in the discount rate is coming from an increase in inflation, it can reasonably be expected to result in higher benefit payments for future retirees and thus a higher liability longer term.

EXHIBIT 8: IMPACT OF ONE PERCENT CHANGE IN DISCOUNT RATE ON LIABILITIES



Source: Northern Trust

A change in real rates impacts the entire liability stream, and an increase will lower the present value of the liability. Changes in real rates have a greater impact. We show this in Exhibit 8. The white lines show how the liability changes with a change of 1% in the discount rate, with that 1% coming from a change in the inflation premium. The green lines reflect a change in real interest rates.

EXHIBIT 9: ASSET MIX IMPLICATIONS

TARGET EXCESS RETURN = 1.40% WITH 50% LEVERAGE ALLOWED	FROZEN PLAN	YOUNGER PLAN
FRONTIER WEIGHTS		
Stocks	23.9%	61.6%
Dedicated Bond Fund	100.2%	68.4%
Alpha	20.0%	20.0%
ASSETS & LIABILITIES		
Std. Deviation	4.6%	11.0%
ASSETS ONLY		
Std. Deviation	13.7%	15.4%

Source: Northern Trust

In our case study, the duration of the liability for a change in inflation is 10 years; the duration to a change in real rates is 16 years. Given these different durations, TIPS present an interesting investment opportunity. TIPS, unlike nominal bonds, have different durations to changes in real rates and changes in inflation. By incorporating them into the mix of instruments considered for a dedicated strategy, one can achieve a better hedge of the liabilities.

We ran the optimizer for the ongoing plan, and found that the results were quite different. The changes made to the input data were few, but they proved critical. First, we increased the duration for both the liability and the dedicated portfolio to 16

years, up from 12.5 years. for the frozen plan. Second, we increased the "return" for the liability to 7%, up from 5.5%, to reflect future growth. The return on the dedicated portfolio did not change.

In Exhibit 9, we show the optimal mix for each of the plans (major asset classes only). The target excess return for each was 1.4%, and we allowed 50% leverage. Each had an initial funded status of 90%. The younger plan needed to keep more in equities, the asset class with the highest return. The tracking error for this mix was far higher than what was achievable for the mature plan. (Had we not increased the growth rate for the liability, the results for the two models would have been quite similar.)

Another issue that we would like to explore is: if a dedicated portfolio is used to defease a portion of the liability, should it focus on the longer- or shorter-duration portion?

Oftentimes when only a portion of the liabilities are to be defeased, it is the nearer-term portion: those associated with retirees, for example. These are the liabilities that are better defined and less subject to change. The liabilities associated with the younger workers are not as clearly defined. They will grow as a function of years of service; benefits may change, etc. Nonetheless, it is these longer liabilities that exacerbate the duration mismatch that we have seen in most pension funds.

Exhibit 10 illustrates that point. We looked at the ongoing plan, segregating first the portion of the liability attributable to retirees, and then the portion attributable to those age 45 and younger.

EXHIBIT 10: LIABILITIES SEGREGATED BY TYPE OF PLAN PARTICIPANT

	NPV LIABILITIES (IN MILLIONS)	PERCENTAGE OF TOTAL	DURATION (IN YEARS)
Total Fund	$ 4,016	100%	16
Retirees	$ 1,418	35%	7
All Others	$ 2,598	65%	20
Age 45 and Younger	$ 416	10%	32
All Others	$ 3,600	90%	14

Source: Northern Trust

Retiree benefits account for 35% of the total liability, but have a duration of only seven years. The projected benefits for younger employees are a small part of the total net present value (NPV) of the plan's liabilities, but with a duration of 32 years, have a big impact on volatility. Defeasing this small portion of the liability can have a significant impact on the duration and volatility of the remaining liability.

CONCLUSIONS

The most important conclusion first: each pension plan is unique and there is no one solution that will be optimal for all. LDI is a framework, not a turn-key solution. Having said that, we note the following:

- Duration of the liabilities is key. It appears that in almost all instances, a fund can lower its risk by aligning the duration of its bond holdings with the duration of its liabilities. Alternatively, a commitment to longer bonds (not an immunized or dedicated fund) could be held as a hedge against the liabilities.
- With some exceptions, placing all of the assets into a dedicated bond strategy does not appear optimal. While minimizing the duration mismatch, it does not provide an adequate return.
- In building a dedicated bond fund, TIPS offer a unique opportunity. Their dual duration can add precision when matching the dual duration of the pension liability.
- Equities are increasingly important as funds search for higher returns. Holding equities does increase the tracking error of the assets vs. the liabilities.
- Derivatives can be extremely useful. For a fund with the twin goals of minimizing surplus risk while earning higher returns, incorporating overlay strategies can improve the portfolio characteristics. The return per unit of risk is higher. Of course, other risks are introduced by leverage: counterparty risks, collateral management issues, complexity issues. Those should not be minimized.

Finally, a few thoughts on time horizons, which we think is an important issue. Pension funds have always been regarded as long term in nature. The liabilities are long term and the assets were to be invested so as to maximize return (asset-only or surplus) over the long term, within acceptable risk limits. One of the biggest impacts of the recent legislative and accounting changes is to make pension funds focus on the short term. The current market value of the investment assets and the current level of interest rates take on much greater importance than previously. We question whether this is a positive development. To the extent that companies are discouraged from taking risks in their funds and, instead, encouraged to settle for lower returns, their ability to maintain this important employee benefit is called into question.

We've demonstrated that the key to implementing an LDI framework is to start with the premise that each plan's status is unique. From this critical point, plan sponsors must then work with their actuaries and investment managers to develop a portfolio that addresses their plan's unique characteristics, within the context of their firm's overall goals and risk tolerance.

ENDNOTES

1. Credit Suisse First Boston Equity Research. "The Magic of Pension Accounting, Part III," Zion, David, CFA, CPA, and Carcache, Bill, CPA, February 7, 2005.

2. Ibid.

3. Siegel, Laurence B., and Waring, M. Barton, "TIPS, the Dual Duration, and the Pension Plan," *Financial Analysts Journal,* September/October 2004, Vol. 60, No. 5.

4. Acknowledgements: The Global Investment Solutions Team would like to thank Kathy Condon for her efforts in researching and drafting this paper. We also would like to acknowledge Alex Ryer, who was instrumental in the development of the modeling exercises and formulation of this report.

NOTES

NORTHERN TRUST LOCATIONS

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