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The Salomon Brothers Pension Discount Curve[SM] and the Salomon Brothers Pension Liability Index[SM]

1995 Update

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FIGURES

Pension discount rates have been a pressing issue for plan sponsors during the past two years, as interest rates plunged to historic lows in 1993 before surging in 1994. To help plan sponsors comply with the 1993 guidelines of the Securities and Exchange Commission (SEC), we developed the Salomon Brothers Pension Discount Curve and Pension Liability Index.[1] In this report, we review the construction of these two measures, as of December 1994.

We also examine how the markets of the past few years have affected pension funds. The 1993 bond market rally, combined with the SEC guidelines, forced plan sponsors to lower their discount rates by about 100 basis points at year-end 1993. The result was that liability increases substantially exceeded the excellent investment returns enjoyed by most funds, markedly weakening their funded status. The process reversed in 1994, as the discount rate underlying the Pension Liability Index soared from 7.36% to 8.65% and liabilities plummeted. Even the anemic investment returns of most pension funds generated large gains *relative to their falling liabilities*, strengthening their funding ratios. The consequence, which appears paradoxical to investors who focus only on their asset returns, is that the funding ratio (assets divided by liabilities) of a typical pension plan fell by 10.4% during 1993 and rose by 9.1% during 1994.

CONSTRUCTION OF THE SALOMON BROTHERS PENSION DISCOUNT CURVE

The Pension Discount Curve enables corporate plan sponsors to determine their discount rates. Our previous report explained the construction of this curve; we now review and update the explanation as of year-end 1994. We begin with a U.S. Treasury par curve that reflects the entire Treasury coupon and STRIPS market.[2] We use this approach, rather than proceeding directly to the corporate market, because we can develop a smoother and more reliable yield curve in the Treasury market. The Treasury market permits such a curve because of its homogeneity in terms of credit and the general absence of call provisions. In addition, the STRIPS market allows reasonable precision along the entire Treasury curve, including maturities beyond ten years, which would be difficult to specify precisely and completely with only coupon bonds. From the Treasury curve, we produce a double-A corporate par curve by adding option-adjusted spreads (OAS) that are drawn from the double-A corporate sector of the Salomon Brothers Broad Investment-Grade (BIG) Bond Index. Finally, from the double-A corporate par curve, we derive the spot rates that constitute the Pension Discount Curve.

Some Caveats

In using broad averages and making several judgments about methodology, we have not designed the Pension Discount Curve to produce the highest discount rate that would comply with the SEC standards: we simply present a market average. By focusing on particular sectors of the double-A market, one could attain somewhat higher yields than the overall double-A market

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[1] See *Introducing the Salomon Brothers Pension Discount Curve and the Salomon Brothers Pension Liability Index,* Salomon Brothers Inc, March 1994. The SEC requires that discount rates reflect the yield at the measurement date of a cash-matched portfolio of securities "that receive one of the two highest ratings given by a recognized ratings agency ... (for example ... Aa or higher from Moody's)."

[2] A par curve specifies the yields of coupon bonds; a spot curve measures the yields that would apply to zero-coupon bonds. Either type of curve can be derived from the other.

average. Selective approaches should, however, be used cautiously. Because of the thinness of the market in many corporate bonds and the infrequency with which they trade, pricing the entire market on the basis of reliable current transaction prices is not possible. Selecting a small number of the highest-yielding double-A securities could easily produce a portfolio that is overweighted with securities whose pricing may be unrepresentative of the market. Even dropping all the way to the single-A universe — which, of course, would not meet the SEC guidelines — would add only 25 basis points to the Pension Liability Index discount rate at year-end 1994.

Because we are developing hypothetical zero-coupon securities, there is no certainty that a plan sponsor could actually purchase a portfolio with the indicated yield. An actual defeasance may have a higher or lower yield, depending on plan size, specified portfolio constraints, market liquidity, bid-asked spreads, and other considerations at the time of purchase.

The Treasury Par Curve

The Salomon Brothers Treasury Model statistically develops a spot curve that best fits the market prices of all "off-the-run" Treasury securities.[3] From this curve, we derive the year-end 1994 Treasury par curve shown in Figure 1.

Selection of Corporate Bonds

We begin with the universe of securities that constitute the BIG Index. The BIG Index covers all institutionally traded U.S. Treasury, agency, mortgage, and investment-grade corporate fixed-rate bonds with maturities of one year or more — 4,211 issues on December 31, 1994.[4] We then select the 689 issues that are either rated AA+, AA or AA− by Standard & Poor's *or* Aa1, Aa2 or Aa3 by Moody's.

Figure 1. Construction of the Salomon Brothers Pension Discount Curve, 31 Dec 94
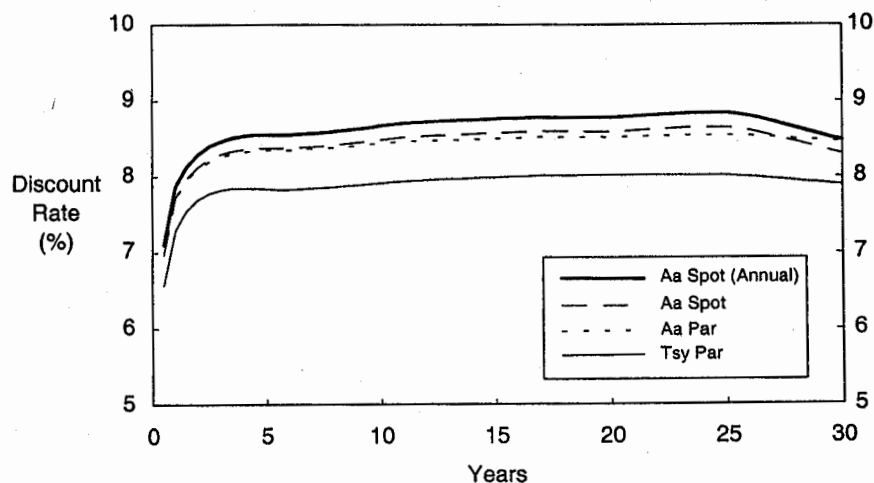
Tsy Treasury.

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[3] "On-the-run" securities are the most recently issued securities of their maturity. Because they are the most actively traded, they tend to trade at slightly lower yields than the less-liquid, off-the-run securities. To avoid creating irregularities in the yield curve, we include only the more numerous off-the-run securities in the Treasury model. If we used an on-the-run curve instead, the resulting Treasury curve would be slightly lower and the corporate-to-Treasury option-adjusted spreads would be slightly higher. The resulting corporate curve would be essentially unaffected.

[4] As of December 31, 1994, issues with at least $100 million outstanding ($1 billion for mortgages) are included in the BIG Index, and they remain until their outstanding amount falls below $75 million.

Adjusting for Call Provisions

Corporate-to-Treasury spreads are generally quoted in nominal (yield-to-maturity) terms; the average nominal spread of the 689 double-A issues is 66 basis points. A portion of the spread on a callable bond, however, represents a yield increment that compensates the holder for the issuer's right to call the bond. This increment must be removed in pricing a fixed cash flow, such as a pension obligation, which is not callable.

Valuing the call provision requires a yield curve model and long-term estimates of interest rate volatilities, which can introduce significant uncertainty. To reduce dependence on this valuation, we consider only those bonds that do not have "excessive" call exposure. Specifically, we include a callable bond if it has *either* of the following characteristics:

(1) At least three years of call protection; or

(2) A spread of at least ten points between its earliest call price and its market price.

These tests eliminate 67 issues, leaving 622. For each of the remaining issues, we compute an option-adjusted spread. The option-adjusted spread is the spread that the bond provides over a comparable Treasury bond, reflecting the potential call dates on a probabilistic basis. The option-adjusted spread effectively removes the yield increment related to the call provision.[5]

Corporate Par Curve

We use the option-adjusted spreads to develop a corporate double-A par curve. First, we group these spreads by maturity. Within each group, we determine the market-weighted average spread, eliminating securities whose option-adjusted spreads are more than two standard deviations away from the preliminary average. This test eliminates 21 issues. Figure 2 shows the statistics for the remaining 601 securities.[6] Overall, the average option-adjusted spread of our "call-protected" sample is 51 basis points, compared with the 66-basis-point average nominal spread of the entire double-A corporate sector of the BIG Index.

Figure 2. Option-Adjusted Spreads versus Maturity, 31 Dec 94

Maturity (Years)	1-3	3-7	7-15	15-25	25+	Total
Number of Issues	80	150	184	51	136	601
Average OAS (Basis Points)	41	52	53	50	57	51
Standard Deviation of OAS (Basis Points)[a]	7	8	11	11	19	11

[a] This standard deviation represents the distribution of spreads *within* the maturity sectors, not the volatility of spread *changes* over time. OAS Option-adjusted spread.

Adding these corporate spreads to the Treasury par rates develops the corporate par curve shown in Figure 1.

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[5] The method used to determine the OAS is described in *Effective Duration of Callable Bonds: The Salomon Brothers Term Structure-Based Option Pricing Model*, William Boyce, Salomon Brothers Inc, April 1987. The assumed interest rate volatility was 10% at December 31, 1994.

[6] This spread curve is quite flat relative to what any individual company would face. The flatness arises from the different financing patterns of different types of companies. Financial companies, which tend to have higher spreads, concentrate at the short end of the curve. Utilities, which have lower spreads, generally borrow at the long end. These tendencies raise the average short-term spread and lower the average long-term spread, flattening the curve overall.

Double-A Spot Curve

From the double-A corporate par curve, we calculate the spot rates that compose the Pension Discount Curve.[7] We convert from semiannually compounded rates, the convention used in the U.S. fixed-income markets and in the previous figures in this report, to annual rates, the convention used to specify actuarial discount rates for employee benefit plan liabilities. At current rate levels, this conversion adds about 20 basis points at the longer maturities.

Figure 3 tabulates the annual rates at half-year intervals from 0.5 to 30 years. These are the yields that would apply to "average" double-A zero-coupon bonds of the indicated maturities.

Figure 3. Tabulation of Salomon Brothers Pension Discount Curve, 31 Dec 94

Years	Discount Rate	Years	Discount Rate	Years	Discount Rate
0.5	7.09%	10.5	8.68%	20.5	8.78%
1.0	7.85	11.0	8.69	21.0	8.79
1.5	8.13	11.5	8.71	21.5	8.80
2.0	8.29	12.0	8.71	22.0	8.81
2.5	8.40	12.5	8.72	22.5	8.81
3.0	8.46	13.0	8.73	23.0	8.82
3.5	8.51	13.5	8.73	23.5	8.83
4.0	8.53	14.0	8.74	24.0	8.83
4.5	8.55	14.5	8.75	24.5	8.83
5.0	8.55	15.0	8.75	25.0	8.83
5.5	8.55	15.5	8.76	25.5	8.81
6.0	8.55	16.0	8.77	26.0	8.79
6.5	8.56	16.5	8.77	26.5	8.75
7.0	8.57	17.0	8.77	27.0	8.72
7.5	8.58	17.5	8.77	27.5	8.67
8.0	8.59	18.0	8.77	28.0	8.63
8.5	8.61	18.5	8.77	28.5	8.59
9.0	8.62	19.0	8.77	29.0	8.55
9.5	8.64	19.5	8.77	29.5	8.51
10.0	8.66	20.0	8.77	30.0	8.47

Spot Rates Beyond 30 Years

Determining the discount rates for cash flows beyond 30 years presents special difficulties. Treasuries do not exist beyond 30 years; there is a scattering of corporates in the 30-40 year range and a few with longer maturities, but not enough to establish a reliable curve. Simple extrapolation from the below-30-year rates may be uncomfortable for many plan sponsors, because of the downturn in rates that currently (and frequently) exists from 25 to 30 years.

In considering the possible patterns of rates beyond 30 years, we find conflicting arguments. On the one hand, the convexity of very long bonds is an attractive feature for which investors have shown a willingness to sacrifice yield; thus, we might find a continuing decline in the yield curve beyond 30 years. On the other hand, the downturn in rates as maturities approach 30 years may result from technical factors that relate to the 30-year bond being the longest available Treasury bond; perhaps if the Treasury issued a full

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[7] As Figure 1 shows, the spot rates exceed the par rates over most of the 0-30 year range. This relationship holds for a positively sloped yield curve, because the spot rate (the yield on a zero-coupon bond) is not diluted by the lower yields on the short-term coupons that drag down the par rate.

supply of bonds out to 40 years, the downturn would be shifted ten years further out on the curve. Because of the uncertainties, we confine the Pension Discount Curve to the below-30-year range, where we can report the market conditions with a minimum of assumptions.

Rates beyond 30 years can, however, be significant for discounting pension liabilities, especially in low-rate environments or for young populations. For the Pension Liability Index at year-end 1994, however, the 30-year-plus rate is relatively unimportant. Applying the 30-year spot rate to all cash flows beyond 30 years, we arrive at an overall discount rate of 8.65%. On this basis, the 30-year-plus cash flows account for 8.7% of the total liability. By way of illustration, a 10-basis-point decrease in the 30-plus rate would reduce the overall discount rate by 2.4 basis points and boost the liability by 3%.

Application of the Salomon Brothers Pension Discount Curve

A pension plan sponsor who wishes to use this curve to determine the pension (or retiree medical) liability would discount each year's projected cash flow at the yield specified for that year. For example, the second-year cash flow would be divided by $1.0813^{1.5}$, because 8.13% is the 1.5-year spot rate. (We assume that benefits are paid at midyear, on average.) The total discounted value is the pension liability. The discount rate reported in the financial statements would be the *single* rate that, if applied to all years' payments, would result in the same discounted value as the array of rates that make up the Pension Discount Curve.[8]

THE SALOMON BROTHERS PENSION LIABILITY INDEX

The Salomon Brothers Pension Liability Index, which is based on the pricing each month of a typical pension plan liability profile, serves the following purposes:

• To express the level of the Pension Discount Curve as a single number that would represent the discount rate appropriate for a "typical" pension plan; and

• To provide an investment performance benchmark for asset/liability management.

Figure 4 illustrates the cash flows on which the Liability Index is based.

**Figure 4. Salomon Brothers Pension Liability Index Cash Flows**
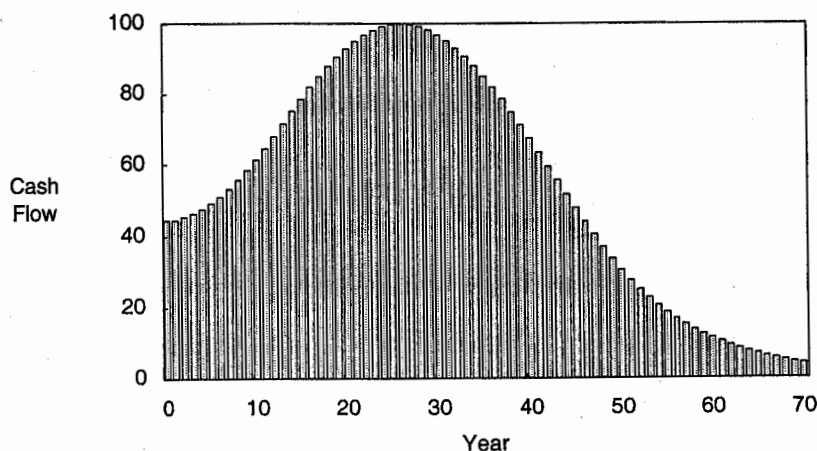
[8] This rate is equivalent to the internal rate of return of the cash-flow matching portfolio of double-A zero-coupon bonds.

Discount Rate

At December 31, 1994, the Liability Index reflected a discount rate of 8.65%. (As noted earlier, we apply the 30-year spot rate to all cash flows beyond 30 years.) Its duration was 12.5 years, meaning that a 1% decrease in the discount rate would have raised the liability by approximately 12.5%.

Figure 5 depicts the history of the discount rate reflected in the Liability Index during the past six years. The annual volatility of the rate changes was 9.5% during that time period.[9] Figure 7 also shows the duration of the Liability Index, which has ranged from 11.2 to 14.3 years. The duration moves inversely with changes in the discount rate, increasing by about one year for every 1% drop in the discount rate.

Figure 5. Discount Rate and Duration of Salomon Brothers Pension Liability Index, 1989-94
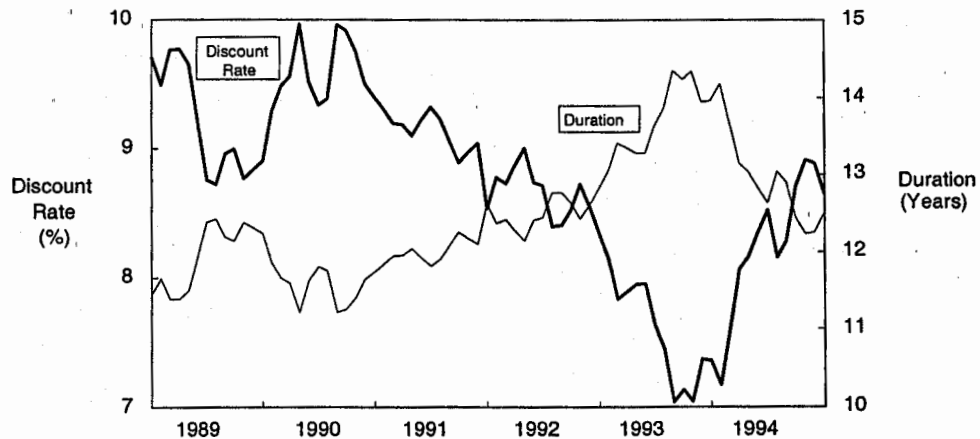

Spread of Pension Liability Index Discount Rate to Other Indicators

Figure 6 compares the discount rate underlying the Pension Liability Index with the on-the-run 30-year Treasury yield and Moody's Corporate Bond Yield, Aa Seasoned Issues. (All rates are annualized). The Pension Liability Index discount rate has exceeded the 30-year Treasury yield by 40 to 100 basis points, mostly in the upper portion of the range during recent years, primarily because of credit spreads and, also, its longer duration. The longer duration of the Pension Liability Index relative to Moody's tends to increase its discount rate; compensating for this factor is the use of option-adjusted spreads in the Pension Liability Index, while Moody's uses nominal spreads. Most of the time, these factors have roughly offset each other.

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[9] We compute volatility as the annualized standard deviation of the monthly changes in rate, expressed as a percentage of the initial rate. For example, if the discount rate at the start of a year is 8%, the standard deviation of the one-year rate change is 7.6% (9.5% volatility ‡ 8% initial rate).

**Figure 6. Spread of Pension Liability Index Discount Rate to Other Indicators, 1989-94**
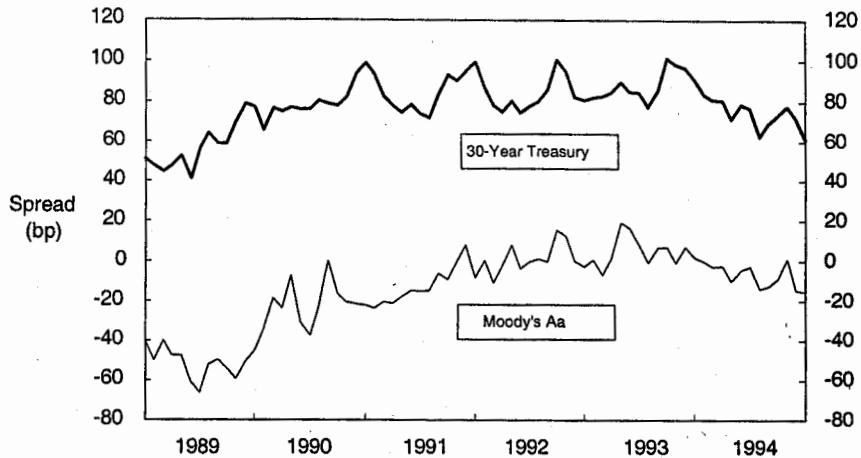
bp Basis points.

Index Returns versus Investment Returns

Figure 7 illustrates the returns of the Pension Liability Index during 1989-94. The strong bond market of 1989-93, combined with the long duration of the index, produced a cumulative return of 106%, a 15.5% annual average. The rate surge in 1994 brought about a −2.8% return, reducing the 6-year average return to 11.1%.

Figure 7 also displays the performance of a portfolio that is 60% invested in S&P 500 Index and 40% in the BIG Index. This portfolio performed quite well during 1989-93, earning 88% cumulatively, equivalent to 13.4% annually. Nevertheless it trailed the Liability Index by the substantial margin of 18% (106% − 88%). Only during 1994's severe market weakness did this "typical" pension portfolio reestablish its 1989 position vis-à-vis the liability.[10]

**Figure 7. Pension Liability Index Returns versus 60/40 Returns, 1989-94**
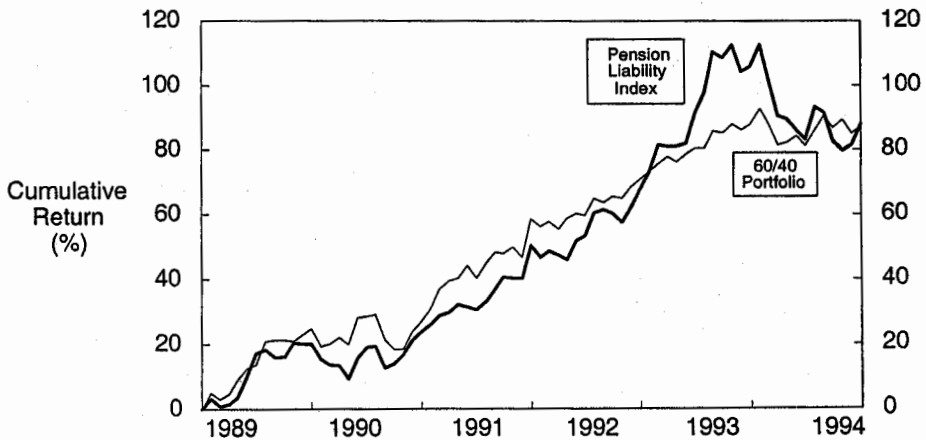
[10] For a more detailed discussion on why weak asset performance tends to be associated with an improvement in pension funding status, see *Bad Is Good: The Weak Bond Market Strengthens Pension Funds During 1994*, Salomon Brothers Inc, July 1994.

The relationship between the asset and liability returns determines the change in the funded position of a pension plan. To measure this change, we use the concept of a *funding ratio return* (FRR).[11] The FRR is the percentage change in the funding ratio and is identical for all plans that have the same asset and liability returns, regardless of their initial funding status. For example, during 1994, a plan whose asset performance tracked our 60/40 portfolio and whose liability pattern matched the Pension Liability Index would have experienced an FRR of 9.1%.[12] Figure 8 depicts the annual and cumulative FRRs for such plans during 1989-94.

The bars in Figure 8 show that the annual FRRs were fairly stable during 1989-92. The strong bond market of 1993 devastated funding ratios, and the weak market during 1994 bolstered them. The annualized FRR volatility during 1989-94 (based on monthly returns) was 7.4%.

Over the entire time period, the cumulative FRR, indicated by the line in Figure 8, has followed a tortuous path to nowhere. The cumulative return was up by as much as 10% through the early 1990s, down by more than that in 1993, and recovered to a level of −0.4% at year-end 1994. Thus, a plan whose contributions, benefit payments, demographic changes, and other factors roughly balanced over this period will have experienced virtually no net change in its funded status.

Figure 8. Annual and Cumulative FRRs for a 60/40 Portfolio versus the Pension Liability Index, 1989-94
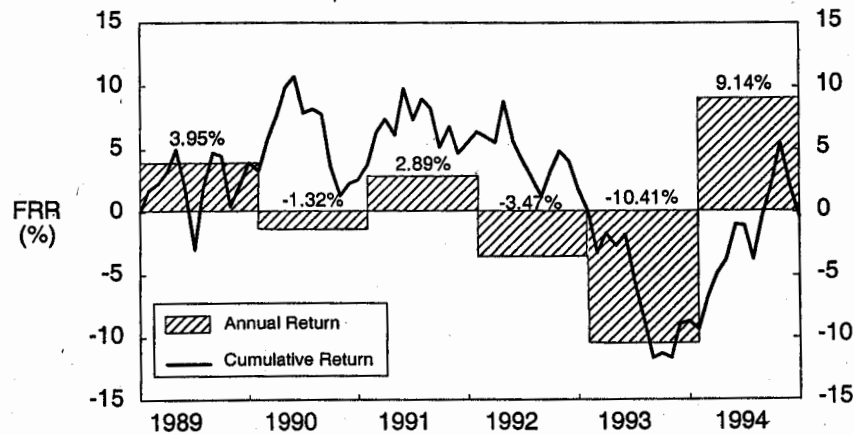
FRR Funding ratio return.

CONCLUSION

The past two years have witnessed extraordinary movements in interest rates and, consequently, in pension discount rates, liabilities and funding ratios. We observed that a typical plan that entered 1993 fully funded would have finished that year with a funding ratio of 89.6%, and would now be back up to 97.8%. Opinions on the significance of these fluctuations differ widely. Many

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[11] See *Funding Ratio Return: A More "Universal" Measure for Asset/Liability Management*, Salomon Brothers Inc, June 1994.
[12] The precise calculation, based on an asset return of −0.32% and a liability return of −8.67%, is
$$FRR = (1 - 0.0032)/(1 - 0.0867) - 1 = 9.1\%.$$

sponsors feel vindicated in their view that patience is an adequate antidote for market cycles. More cautious sponsors regard reliance on the supposed inevitability of "market cycles" as wishful thinking about how markets work; they may focus on the 1993-94 volatility and consider a greater emphasis on long-duration bonds that would track more closely the swings of their liabilities.