

A New Risk Metric for Defined Benefit Pension Plans

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Abstract

In order for actuaries to play a valuable role in the realm of Enterprise Risk Management, they must provide value-added advice and quantitative analyses. In this paper, the authors use stochastic simulation technology to present a risk metric for defined benefit pension plans that provides improved measures of the plan's solvency and provides a tool for pension plan managers to determine the value of risk mitigation activities.

The Enterprise Risk Management (ERM) framework presented in this paper was recently developed for the pension plan of a large tax-exempt religious organization in the U.S., so many accounting and ERISA issues were not important considerations. These constraints add substantial complexity to the analysis of pension plans, and consequently, it has been helpful in developing an ERM framework for defined benefit (DB) pension plans to begin in a simplified environment. From this framework, one can then move on to consideration of such issues as ERISA compliance, Generally Accepted Accounting Principles, and the pressure of quarterly corporate reporting.

An ERM process should include two components:

- 1) Identification and management of specific risks
- 2) Risk quantification

There are a number of institutions that have produced lists of specific risks such as the Committee of Sponsoring Organizations of the Treadway Commission ("COSO"). For our framework, we used the American Academy of Actuaries adaptation for Life Insurance Risk Mapping of the US Federal Reserve Risk Categorization.

This paper will focus on a risk quantification methodology that helps pension plan stakeholders in understanding the solvency of a pension plan and provides risk managers with a tool for evaluating risk mitigation activities.

As life insurance consulting actuaries, our initial response when this pension plan asked for assistance in measuring risk was to explain the concept of capital. The more risk there is, the more capital there should be. But capital is an alien concept for a pension plan, and any risk measures submitted on this basis might seem inappropriate. For a pension plan, there is really no difference between capital and funding – it is all fungible within the pension trust. [We will leave aside the legal issue of who owns the surplus of a DB plan]. Moreover, for a church plan, the more funds put into the pension plan, the less is available to do the good works of the sponsoring organization.

The primary risk for a DB pension plan is the question of its ability to meet its payment obligations. To measure this risk, one would have to take into account the future viability of the pension sponsor, but that would make the whole quantitative process too subjective, complicated and unreliable. A more realistic measure of risk would be to calculate the probability of meeting the pension obligations taking into account the plan's existing trusteed assets, and potentially, future contributions from the plan sponsor.

It is interesting to note that calculations of liabilities do not figure prominently in this analysis. That is because the liability value may be useful for accounting purposes, but it is not helpful for risk management purposes. Our view is that the obligation of a pension plan is the stream of contractual payments. Too much noise is added when this obligation is translated into a single number.

This can be demonstrated by use of a simplified example of a lump sum obligation of \$1 million payable in 30 years. Funding will be a single contribution at time zero. There is not a clear consensus as to how to report this obligation as a liability on financial statements. A property and casualty insurance company would record the obligation as \$1 million because that industry doesn't favor discounting to reflect the time value of money. By contrast, a U.S. life insurance company would record the liability as \$200,644, using a discount rate of 5.5% as required by the NAIC for 2005. And a corporate pension plan might report a liability as \$114,221 based on a discount rate of 7.5%.

Taking a different tack, we could ask the plan sponsor's chief investment officer (CIO) how much cash she would want to invest in order to meet this lump sum obligation. Let's assume her answer is \$75,371 because she is calculating that the funds could be invested in a diversified stock portfolio which would earn an average annual return of 9% over the next 30 years. But what if another criterion is added – being 100% certain of having enough funds to pay the obligation in 30 years? Then, she would want \$286,892 to invest – the cost of a 30 year zero coupon government bond.

From a risk management viewpoint the objective isn't getting the liability right -- five different numbers could be presented -- but rather determining the probability of satisfying the obligations given a specified funding amount and a specified investment strategy.

| <u>Initial Contribution</u> | <u>Probability of Success</u> |
|-----------------------------|-------------------------------|
| \$75,371 | 75% (if stocks earn 9.0%) |
| \$286,892 | 99.99% |

The 75% probability is determined through a stochastic simulation that assumes a 9% average annual return over the complete set of simulation results and also assumes that the variability of the stock market, as measured by the Standard & Poors index continues at historical levels. The 99.99% is a guess to demonstrate that there is only a very small chance that the zero coupon government bond would default and that there is no interest rate risk, reinvestment risk, or C3 risk.

To assist pension trustees, CFO's and risk managers make risk adjusted decisions that make sense from both an economic and actuarial stand point, we propose a risk metric that measures the probability of success in satisfying the pension obligations.

While a single probability value has as little value as a single liability value, the proposed risk metric is the cumulative distribution function of the calculated surplus or deficit of the quantum of assets backing the pension liability. The measure of both assets and liabilities will be determined by their respective cash flows and the surplus or deficit would be calculated as follows:

$$\sum_{t=s}^{\infty} (a_t - b_t)v^t$$

where a_t = expected asset cash flow at time t
 b_t = expected benefit cash flow at time t
 v^t = discounted interest rate at the risk free yield curve
 s = start time for the calculation

Further discussion of “expected asset cash flows” is required. For ease of classification, we will define all investment vehicles with contractual payments as the fixed-income investment class and those that don't have contractual payments as the equity investment class. For the equity class, the expected cash flow will be defined as the market value of the investment vehicle at time of sale.

For the fixed income investment asset class projected asset cash flows are well understood. Most asset management systems will produce such cash flows (even taking into account defaults) for even the most esoteric debt instruments such as Collateralized Mortgage Obligations or interest rate swaps.

For the equity investment class, obviously common stocks easily fit into this category but so do real estate, private equity, and hedge funds. The difficulty for the actuary is deriving realistic future simulations of market values for these investment vehicles.

For the equity investment class, the algorithm will assume a sale at time t when $a_t^{FI} < b_t$, for the number of units of the equity class such that the market of those units equals $b_t - a_t^{FI}$ where a_t^{FI} = fixed income expected cash flow at time t .

To illustrate the surplus/deficit risk metric, we will continue to use the 30 year lump sum example:

Table 1
Surplus/Deficit Risk Metric

| Percentile | Year 0 | Year 10 | Year 20 | Year 30 |
|------------|-----------|-----------|-----------|-----------|
| 10.0% | 858,636 | 1,318,608 | 2,128,347 | 3,777,817 |
| 25.0% | 448,038 | 648,514 | 1,087,550 | 1,971,275 |
| 50.0% | 171,292 | 228,667 | 396,096 | 753,650 |
| 75.0% | 7,585 | 9,116 | 17,109 | 33,374 |
| 90.0% | (83,270) | (114,591) | (194,198) | (366,370) |
| 95.0% | (120,979) | (181,862) | (289,916) | (532,284) |
| 99.0% | (167,232) | (285,817) | (442,732) | (735,784) |
| 99.5% | (176,563) | (320,368) | (478,432) | (776,841) |
| 99.9% | (201,720) | (398,896) | (550,977) | (887,524) |

Cumulative Distribution Function (“CDF”)

Looking at the formula for the surplus/deficit risk metric, one sees that the risk metric is a function of the investment strategy. The CDF is created using stochastic simulation. This CDF was created using the American Academy of Actuaries published scenarios and running a simulation of all 10,000 scenarios of the S&P 500 investment class with a 1.5% parallel shift to get an average annual return of 9.0%/annum. The risk free yield curves are also simulated using the AAA scenarios.

The CDF is presented at different times in the future in order to provide an understanding of how both assets and liabilities could change in value yet the pension obligations are still satisfied. A positive value in the chart represents excess funds after all pension obligations are met, discounted to the specific point in time. A negative number represents the additional funds that would have to be contributed at that time in order to satisfy the pension obligations.

In this simulation, since we started with equities worth \$75,371, there is a 75% chance that in year 30, when the lump sum payment is required to be paid, we will have sufficient assets to make that payment. According to the simulation, there is a 25% chance that the pension sponsor will have earned at least another \$1,971,275, but there is also a 5% chance the sponsor will have to make an additional payment of at least \$532,284 to satisfy the obligation and a 1% chance that the additional payment will be at least \$735,784.

We believe there needs to be subsidiary metrics to better understand this primary risk metric. These subsidiary risk metrics are:

1. Market value of assets used in the surplus/deficit risk metric
2. A measure of the liabilities used in the surplus/deficit risk metric
3. CDF of ratio of asset/liabilities

Assets

For the presentation of assets, we use the market value of assets at the specified time.

Table 2

| Assets | | | | |
|------------|--------|---------|-----------|-----------|
| Percentile | Year 0 | Year 10 | Year 20 | Year 30 |
| 10.0% | 75,371 | 466,652 | 1,787,668 | 4,777,817 |
| 25.0% | 75,371 | 319,015 | 1,311,918 | 2,971,275 |
| 50.0% | 75,371 | 199,418 | 772,540 | 1,753,650 |
| 75.0% | 75,371 | 169,615 | 509,175 | 1,033,374 |
| 90.0% | 75,371 | 146,410 | 238,328 | 633,630 |
| 95.0% | 75,371 | 148,931 | 204,294 | 467,716 |
| 99.0% | 75,371 | 87,976 | 97,537 | 264,216 |
| 99.5% | 75,371 | 76,076 | 110,967 | 223,159 |
| 99.9% | 75,371 | 57,007 | 88,672 | 112,476 |

These values represent the market value of assets underlying the surplus/deficit risk metric from Table 1. In this example, the plan was funded with a contribution of \$75,371. This table shows there is 10% chance that after 30 years, these assets could grow to at least \$4,777,817 leaving a surplus of \$3,777,817. There is also a 5% chance that the starting assets will grow to no more than \$467,716, leaving a deficit of at least \$532,284.

Remember that the asset values listed in the table are not a CDF of possible asset values, but rather the market value of assets underlying the surplus/deficit CDF. That is why in year 10, for example, the asset value referenced at the 90% percentile (\$146,410) is less than the asset value referenced at the 95% percentile (\$148,931). What will have caused this seeming inconsistency is the changing value of the liabilities caused by changing yield curves.

Liabilities

For the presentation of liabilities, we use the present value of all future pension payments calculated at the then current risk-free yield curve according to the specific scenario (i.e. the fair value).

Table 3

| Liabilities | | | | |
|-------------|---------|---------|---------|-----------|
| Percentile | Year 0 | Year 10 | Year 20 | Year 30 |
| 10.0% | 227,284 | 323,710 | 635,749 | 1,000,000 |
| 25.0% | 227,284 | 322,053 | 718,088 | 1,000,000 |
| 50.0% | 227,284 | 300,156 | 676,047 | 1,000,000 |
| 75.0% | 227,284 | 373,865 | 705,548 | 1,000,000 |
| 90.0% | 227,284 | 453,610 | 499,714 | 1,000,000 |
| 95.0% | 227,284 | 573,715 | 546,829 | 1,000,000 |
| 99.0% | 227,284 | 498,512 | 439,015 | 1,000,000 |
| 99.5% | 227,284 | 490,978 | 590,106 | 1,000,000 |
| 99.9% | 227,284 | 480,672 | 615,564 | 1,000,000 |

These reported liabilities relate to the specified percentiles of the surplus/deficit CDF. This explains why the liability values are not always increasing with the increasing percentiles.

This table is more important to prepare pension plan stakeholders for the range of possible reporting values in the future as opposed to eliciting meaningful management initiatives because we know for sure \$1 million will have to be paid in year 30, and that figure does not change over the course of the 30 years.

Ratio of Asset/Liabilities

A final subsidiary metric that should assist pension fiduciaries is a CDF of the asset/liability ratio. This is the ratio of the market value of assets at time t to the present value of liabilities discounted by the risk free yield curve prevailing at time t . This metric is valuable in providing information as to the variability of two forces: asset growth and change in the fair value of the pension obligation.

Table 4

| Asset/Liability Ratio | | | | |
|-----------------------|--------|---------|---------|---------|
| Percentile | Year 0 | Year 10 | Year 20 | Year 30 |
| 10.0% | 33.2% | 144.2% | 281.2% | 477.8% |
| 25.0% | 33.2% | 99.1% | 182.7% | 297.1% |
| 50.0% | 33.2% | 66.4% | 114.3% | 175.4% |
| 75.0% | 33.2% | 45.4% | 72.2% | 103.3% |
| 90.0% | 33.2% | 32.3% | 47.7% | 63.4% |
| 95.0% | 33.2% | 26.0% | 37.4% | 46.8% |
| 99.0% | 33.2% | 17.6% | 22.2% | 26.4% |
| 99.5% | 33.2% | 15.5% | 18.8% | 22.3% |
| 99.9% | 33.2% | 11.9% | 14.4% | 11.2% |

At time zero, there is no variance in the ratio because the assets are equal to the contribution of \$75,371 and the liability value of \$227,284 is calculated using the initial risk free yield curve.

The percentages presented are the asset/liability ratios at specified times in the future. For example in year 10, there is a 25% chance that the ratio will be about 100%. This means that there is a 25% chance that by year 10, the equity assets will grow to a high enough level to permit converting them into a risk free bond and thereby perfectly hedging the obligation. Note that in year 30, the ratio must be in excess of 100% to satisfy the pension obligation.

While the asset and liability values on those subsidiary metrics were reported on the basis of the surplus/deficit percentiles, this asset/liabilities ratio is a CDF based on its own values.

It is interesting to note that an asset/liability ratio of 33% is sufficient to meet the obligation, with 75% probability. This is the case because the assets are assumed to grow at an average annual rate of 9.0% and the liabilities are assumed to grow at an average rate of 5.06% at time zero. (This can be viewed as a form of equity arbitrage in which the downside of relying on equity investments to pursue higher returns is the increased probability of not being able to meet the obligation because of variability of equity returns.)

Case Study

We have created a test portfolio of 10,000 payout annuities over various ages and various guarantee periods. The inforce block has starting monthly income of \$5.3 million. On a present value basis at a level 6.5%, the present value of expected benefit payments is \$717.9 million. (The PV of expected benefits based on the risk-free yield curve is \$843.0 million). For demonstration purposes, the \$717.9 million of assets will be invested in two funds:

35% Domestic Bond Fund
65% S&P 500 Index Fund

Both funds will be considered equity class investments. Sales of assets to meet benefit cash flows will be done in the same 35%/65% ratio.

The results of surplus/deficit risk metric are as follows:

Table 5
(‘000)

Surplus/Deficit Risk Metric

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 10.0% | 2,411,749 | 5,418,316 | 6,297,945 | 6,564,935 | 6,666,571 | 6,697,916 | 5,796,191 | 5,418,341 | 7,925,778 |
| 25.0% | 817,243 | 1,631,384 | 1,905,628 | 2,029,073 | 1,909,499 | 1,934,021 | 1,763,490 | 1,631,408 | 2,789,151 |
| 50.0% | 65,354 | 131,966 | 148,078 | 150,223 | 142,059 | 157,037 | 114,919 | 131,993 | 303,114 |
| 55.0% | 2,283 | 7,457 | 5,268 | 5,650 | 6,867 | 5,971 | 5,066 | 7,491 | 9,264 |
| 56.0% | (4,456) | (5,524) | (7,106) | (6,193) | (5,805) | (5,557) | (8,231) | (9,509) | (18,059) |
| 75.0% | (105,668) | (119,910) | (126,854) | (131,463) | (132,705) | (134,985) | (174,895) | (185,103) | (47,101) |
| 90.0% | (216,168) | (228,481) | (237,950) | (246,951) | (253,414) | (270,618) | (337,467) | (215,738) | (51,143) |
| 95.0% | (262,369) | (288,995) | (302,058) | (312,121) | (325,343) | (329,613) | (419,588) | (225,594) | (52,915) |
| 99.0% | (327,053) | (364,485) | (390,535) | (416,890) | (444,303) | (452,866) | (542,440) | (243,877) | (56,489) |
| 99.5% | (344,704) | (392,912) | (425,004) | (436,711) | (465,945) | (493,848) | (570,264) | (248,801) | (57,032) |
| 99.9% | (371,958) | (452,022) | (477,091) | (497,533) | (501,583) | (554,374) | (601,773) | (256,347) | (58,509) |

The first thing to note is that we have expanded the number of time periods presented relative to our previous example. This has been done because it important to show the early years in order to manage the expectations of pension plan fiduciaries as to the possible range of near-term fluctuations. These early year results are also important in managing liquidity risk.

The results show there is only a 55.4% chance of meeting the benefits obligations. This percentage does not change by time period because all calculations are on a prospective basis. In year 30, the range of possible surpluses or deficits extends from a surplus of \$7.9 billion to a deficit of \$58 million. This broad range shows the difficulty of the risk management function because lowering the mismatch risk means giving up the potential for very big gains. This new risk metric provides pension plan management with a better analysis of the true costs of risk mitigation.

The deficits presented in this table for future years can be misleading in that they are based only on future cash flows. This model assumes that the plan would borrow money to meet its obligations when all assets are depleted, and we decided to show the full extent of the downside risk in the assets metric.

The results of the asset valuations backing the surplus/deficit risk metric are as follows:

Table 6
(‘000)

| Assets | | | | | | | | | |
|------------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-------------|
| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
| 10.0% | 717,890 | 788,671 | 857,254 | 937,578 | 958,514 | 1,282,828 | 1,319,140 | 1,536,431 | 2,789,010 |
| 25.0% | 717,890 | 732,059 | 702,197 | 543,097 | 678,520 | 998,715 | 890,111 | 773,203 | 1,503,148 |
| 50.0% | 717,890 | 658,844 | 796,133 | 595,829 | 622,903 | 865,154 | 457,505 | 308,506 | 111,127 |
| 55.0% | 717,890 | 760,329 | 623,852 | 553,562 | 791,630 | 694,445 | 473,095 | 225,801 | 46,237 |
| 56.0% | 717,890 | 741,688 | 612,645 | 585,754 | 751,526 | 416,464 | 500,918 | 220,620 | 24,196 |
| 75.0% | 717,890 | 769,229 | 653,290 | 479,295 | 709,449 | 395,621 | 246,905 | (307,026) | (1,516,194) |
| 90.0% | 717,890 | 635,195 | 718,958 | 433,874 | 389,256 | 482,100 | 237,568 | (460,802) | (133,254) |
| 95.0% | 717,890 | 648,082 | 736,955 | 435,411 | 400,491 | 431,297 | 104,881 | (487,693) | (2,116,422) |
| 99.0% | 717,890 | 551,977 | 405,675 | 466,963 | 297,195 | 318,206 | 62,791 | (102,059) | (703,279) |
| 99.5% | 717,890 | 510,461 | 488,380 | 397,076 | 199,289 | 274,807 | (8,829) | (337,558) | (370,139) |
| 99.9% | 717,890 | 397,121 | 449,851 | 449,708 | 402,145 | 341,065 | (24,319) | (98,295) | (1,717,585) |

This table presents the market value of assets underlying the surplus/deficit risk metric. It shows the initial assets of \$717.9 million have a 10% chance of growing to at least \$2.8 billion over the 30 years after deducting the required pension payments.

As noted above, if the assets are depleted, the system will begin a borrowing program (with assumed borrowing costs of 10%/annum). The reason for this design is to ensure proper understanding of the full deficit position in the surplus/deficit risk metric. Since the risk metric is calculated on a prospective basis, it doesn't take into account the missed pension payments that would actually have occurred once the assets were depleted.

It is important to note that these asset values are calculated on a market value basis, whereas in the surplus/deficit calculation the value of the assets would be determined as

$\sum_{t=s}^{\infty} a_t v^t$ where s is the presentation time for future cash flows and v is the discounted risk-free yield curve. This methodology will usually produce a higher value than the market value. This difference highlights the anomaly that actuaries value equities more than the markets do because actuaries take into account future assumed values of stocks.

In the results above, for example, at the 10% percentile for year 30, the surplus is projected to be \$7.9 billion. But the market value of assets at that time for that percentile is only \$2.8 billion. The difference is that the surplus calculation takes into account future increases in market value that will be realized when the assets are sold. This phenomena gets magnified in the later years when there are minimal pension payments

still to be paid. We think this calculation approach is appropriate because the stocks can be held for a number of years before they need to be sold, making it possible to take advantage of time diversification. It is understood this is only true if stocks continue to provide average annual returns in excess of fixed income rates.

The results of the liability valuations – on a fair value basis - backing the surplus/deficit risk metric are as follows:

Table 7
(‘000)

Liabilities

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 10.0% | 843,026 | 829,901 | 814,513 | 769,198 | 780,844 | 638,400 | 511,882 | 194,120 | 43,420 |
| 25.0% | 843,027 | 817,194 | 730,455 | 572,166 | 678,653 | 642,280 | 510,874 | 193,456 | 43,530 |
| 50.0% | 843,027 | 820,912 | 735,836 | 888,273 | 606,103 | 673,784 | 470,078 | 174,851 | 46,552 |
| 55.0% | 843,027 | 852,987 | 766,787 | 589,191 | 794,200 | 617,174 | 314,472 | 185,988 | 41,569 |
| 56.0% | 843,025 | 781,196 | 794,293 | 601,425 | 698,799 | 581,669 | 507,577 | 195,528 | 43,335 |
| 75.0% | 843,029 | 824,425 | 792,700 | 697,920 | 688,959 | 577,646 | 435,712 | 185,103 | 47,101 |
| 90.0% | 843,028 | 911,250 | 782,078 | 698,916 | 674,951 | 666,994 | 531,501 | 215,738 | 51,144 |
| 95.0% | 843,024 | 822,047 | 806,732 | 703,945 | 735,592 | 752,649 | 532,345 | 225,594 | 52,915 |
| 99.0% | 843,027 | 810,494 | 786,157 | 777,380 | 728,806 | 777,457 | 599,069 | 243,878 | 56,490 |
| 99.5% | 843,027 | 893,641 | 930,190 | 833,919 | 733,594 | 751,041 | 570,264 | 248,801 | 57,032 |
| 99.9% | 843,025 | 911,538 | 888,985 | 961,720 | 908,019 | 906,738 | 601,773 | 256,348 | 58,509 |

The liability cash flows were projected assuming RP-2000 Healthy Annuitant mortality. The underlying deaths of the annuitants were not simulated – the payment obligations were deterministically calculated. The differences in results are solely related to the assumed range of risk-free yield curves developed in the stochastic simulation.

The results of the asset/liability ratio metric are as follows:

Table 8
(‘000)

Asset/Liability Ratio

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|--------|--------|--------|--------|--------|--------|---------|---------|---------|
| 10.0% | 85.2% | 101.0% | 110.0% | 119.7% | 130.4% | 143.8% | 229.4% | 978.0% | 8838.6% |
| 25.0% | 85.2% | 93.0% | 98.8% | 103.9% | 109.9% | 116.3% | 159.8% | 478.3% | 3400.6% |
| 50.0% | 85.2% | 86.3% | 86.7% | 89.4% | 90.9% | 91.2% | 101.7% | 140.5% | 461.9% |
| 55.0% | 85.2% | 84.9% | 84.8% | 86.6% | 87.0% | 86.8% | 94.0% | 98.3% | 104.6% |
| 56.0% | 85.2% | 84.7% | 84.4% | 85.9% | 86.1% | 86.1% | 91.5% | 89.9% | 55.8% |
| 75.0% | 85.2% | 79.0% | 77.0% | 75.1% | 73.8% | 72.1% | 59.8% | 0.0% | 0.0% |
| 90.0% | 85.2% | 72.9% | 67.4% | 64.1% | 60.5% | 56.1% | 31.4% | 0.0% | 0.0% |
| 95.0% | 85.2% | 68.3% | 62.8% | 57.6% | 53.8% | 48.5% | 16.7% | 0.0% | 0.0% |
| 99.0% | 85.2% | 59.3% | 52.4% | 46.9% | 43.8% | 37.3% | 0.0% | 0.0% | 0.0% |
| 99.5% | 85.2% | 57.4% | 50.5% | 44.7% | 38.0% | 33.1% | 0.0% | 0.0% | 0.0% |
| 99.9% | 85.2% | 43.6% | 45.1% | 37.8% | 27.2% | 25.6% | 0.0% | 0.0% | 0.0% |

A ratio greater than 100% means the pension plan could achieve perfect cash flow matching because there are enough assets to buy the risk free yield curve. A ratio of zero means the assets of the pension plan has been exhausted.

Scenario testing

The power of this methodology lies in its ability to test different assumptions in order to arrive at an improved risk profile.

Three scenarios were tested:

- 1) Liquidate the bond fund and use the proceeds to cash flow match the early durations
- 2) Liquidate the bond fund and part of the equity fund to cash flow match the first 7 years.
- 3) Increase the funding by 15% but maintain the same asset allocation.

In the first scenario, by liquidating the bond fund and using the proceeds to cash flow match the early durations, the probability of meeting all pension obligations is increased to 59.6% from 55.4%. (See Table 1.1 in the Appendix. Note that the full results of testing all of these scenarios, which are summarized in the text, are presented in full in the Appendix.) The assets have a 10% chance of being at least \$5.93 billion (See Table 1.2) in year 30 (\$2.79 in base case) with a 5% chance of being short by at least \$0.94 billion (\$2.12 in base case). The reason for this improvement is that there is increased time diversification on the equity portfolio since no equity assets have to be sold for 4 ¼

years [the period of benefit cash flows that can be matched with the proceeds of the bond fund.]

In the second scenario, the cash flow match is extended from 4 ¼ years (where it was in the previous scenario) to seven years. The additional funds come from the sale of a portion of the equity fund. This investment strategy actually reduces the probability of meeting all pension obligations to 56.2% (see table 2.1) from the previous 59.6%, and it also decreases the upside to a 10% chance of being at least \$3.43 billion in year 30 (see Table 2.2) from \$5.93 billion in previous scenario. But the downside risk has been reduced. There is a 5% chance of being out \$0.64 billion (from a short fall of \$0.94 billion in previous scenario). The improved cash flow match of Scenario #2 has actually reduced the likelihood of meeting the pension obligations by 3.4%, reduced the upside potential by \$2.49 billion with a reduced downside of \$0.30 billion. By lowering the mismatch risk the plan has actually given up some of the opportunity to earn higher investment returns because it has sold some of the equity assets.

The results of this sensitivity testing demonstrates both the power of the tool but also a potential weakness. The results show that the investment strategy of the base case would be improved by cash flow matching in the early years instead of using a bond fund. This can be seen from the fact that Scenario 1 has improved the probability of success while offering a higher upside and lower downside. The sensitivity testing also shows that cash flow matching for too many years is actually counter-productive because the pension plan loses the potentially higher reward that can come from holding equity investments. It is clear that one criticism of the tool is that the analysis hinges on the assumption that future investment returns on various asset classes will be similar to historical norms. In all the underlying presentation of probabilities involving a diversified stock portfolio, for example, we have used the AAA stochastic simulations which have a “bias” of 7.5%/ average annual returns. This methodology does not measure the risk of being wrong in that assumption. Obviously there would be great distress if equities don’t live up to expectations. It should be the responsibility of the actuary to show to the pension fiduciaries in advance what would happen to the solvency of the plan if equities produce lower returns.

Finally, in the third scenario, we show the value of additional plan sponsor contributions in increasing the likelihood of meeting all pension obligations. We increased the assets to \$780.8 billion from \$717.9 billion. This new asset level was determined by discounting all future pension cash flows at 5.5% rather than 6.5%. The original asset allocation was retained. With these additional assets, the probability of meeting all pension obligations is 69.4% (compared to 55.3% in the base case). This probability could be further increased by cash flow matching in the early years.

These scenarios demonstrate the power of this tool in providing pension plan managers with analytics that can be custom-tailored to their own situation in order to show the upside and downside of specific risk mitigation tactics. These additional analytics don’t necessarily make the decision easier, but they do make them more disciplined.

Further research required

There are several areas in which additional research would be beneficial:

1. **Active Life Funding**
Include active lives and the new contributions they bring. This provides the plan sponsor with a new risk mitigation opportunity and generates new cash for the plan but it also adds a new pricing risk by raising the issue of whether the new obligations can be satisfied by the new funding.

2. **Capital Market Solutions**
As can be seen in Table 5, there is a non-symmetrical result curve. In year 30 there is a 10% chance of being \$7.9 billion over funded with a 5% of chance of having a \$2.1 billion deficit (as measured by the asset metric in Table 6). Is there a capital market solution to trade that upside for downside protection?

This is where the adherents of financial economics may get their revenge because it is our guess that if you are able to execute such a transaction it will likely cost the pension plan so much that the returns will be lowered to effectively a risk-free rate.

3. **Modifications for Corporations**
The plan sponsor presented in this report was a tax-exempt religious organization. No assumption was made as to how any asset insufficiency in its pension plan would be satisfied. In the case of a corporate pension plan, the resources of the corporation would be available to the retirees. In this setting, modeling should take into account two elements:

- 1) Whether the funding percentage is sufficient
- 2) Whether the asset allocation and investment strategy is appropriate given the risk variables that could affect the health of the corporate plan sponsor..

Criticism of the Methodology

The most glaring weakness of the system is the reliability of the assumption of future growth in the asset classes. In all the underlying presentation of probabilities involving a diversified stock portfolio we have used the AAA stochastic simulations which have a “bias” of 7.5%/annum average growth in the simulations. This methodology does not measure the risk of being wrong in that assumption. At this time what can be – and should be – presented to pension fiduciaries is scenario testing with lower assumed equity growth rates to at least put borders around the risk.

Summary

We believe the risk metrics described in this paper are a start at improving the quantitative analysis necessary for managing the risk of a defined benefit pension plan.

##

Appendix

Results of Scenario Testing

Scenario 1
Liquidate bond fund and use proceeds to cash flow match early (4 ¼) years.

Table 1.1
(‘000)

Surplus/Deficit Risk Metric

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 10.0% | 3,161,858 | 7,083,337 | 7,640,882 | 8,156,794 | 8,510,722 | 8,466,621 | 6,978,543 | 7,065,187 | 9,999,711 |
| 25.0% | 1,101,703 | 2,401,601 | 2,619,375 | 2,711,851 | 2,746,658 | 2,628,803 | 2,437,291 | 2,166,175 | 3,752,248 |
| 50.0% | 140,112 | 306,958 | 342,739 | 339,793 | 327,495 | 340,338 | 280,539 | 293,428 | 755,822 |
| 59.0% | 10,175 | 23,022 | 23,752 | 27,682 | 20,276 | 23,171 | 15,672 | 22,451 | 45,092 |
| 60.0% | (1,940) | (4,103) | (4,567) | (2,451) | (1,926) | (2,178) | (3,006) | (6,331) | (11,609) |
| 75.0% | (99,110) | (113,898) | (119,060) | (122,112) | (128,337) | (126,369) | (162,991) | (184,289) | (46,308) |
| 90.0% | (218,996) | (241,995) | (251,409) | (260,969) | (268,372) | (279,955) | (355,830) | (215,384) | (50,775) |
| 95.0% | (278,564) | (306,831) | (317,283) | (324,879) | (333,129) | (346,686) | (442,228) | (225,407) | (52,763) |
| 99.0% | (341,234) | (385,053) | (404,197) | (439,682) | (453,334) | (482,954) | (550,086) | (243,091) | (56,490) |
| 99.5% | (352,587) | (414,414) | (441,620) | (454,713) | (500,612) | (532,203) | (575,579) | (244,901) | (57,032) |
| 99.9% | (399,073) | (467,275) | (476,458) | (497,299) | (551,168) | (582,470) | (601,773) | (249,054) | (58,509) |

Table 1.2
(‘000)

Assets

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-------------|
| 10.0% | 717,890 | 682,712 | 951,037 | 664,586 | 871,543 | 634,533 | 807,330 | 1,678,864 | 5,927,095 |
| 25.0% | 717,890 | 720,355 | 609,361 | 577,056 | 525,480 | 1,215,326 | 1,311,280 | 892,529 | 1,878,132 |
| 50.0% | 717,890 | 818,342 | 569,272 | 850,909 | 603,019 | 411,752 | 442,418 | 432,703 | 355,260 |
| 59.0% | 717,890 | 685,834 | 695,204 | 737,860 | 641,521 | 569,410 | 515,625 | 244,347 | 67,127 |
| 60.0% | 717,890 | 512,119 | 465,912 | 491,797 | 517,305 | 500,206 | 407,072 | 269,163 | 36,385 |
| 75.0% | 717,890 | 657,221 | 793,038 | 485,131 | 877,317 | 460,915 | 287,767 | (783,631) | (810,281) |
| 90.0% | 717,890 | 665,830 | 576,020 | 616,924 | 316,632 | 523,462 | 87,012 | (563,048) | (402,742) |
| 95.0% | 717,890 | 515,669 | 565,847 | 462,163 | 407,979 | 381,538 | 35,489 | (289,862) | (941,901) |
| 99.0% | 717,890 | 644,907 | 473,163 | 456,938 | 294,317 | 313,079 | (23,085) | (128,241) | (884,463) |
| 99.5% | 717,890 | 637,874 | 572,197 | 599,209 | 447,280 | 490,201 | (1,642) | (215,439) | (256,168) |
| 99.9% | 717,890 | 781,911 | 696,223 | 427,916 | 293,741 | 306,640 | (63,861) | (169,207) | (1,260,051) |

Appendix

Results of Scenario Testing

Table 1.3
(‘000)

Liabilities

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 10.0% | 843,027 | 783,589 | 848,220 | 794,687 | 784,719 | 698,808 | 600,491 | 193,928 | 46,463 |
| 25.0% | 843,026 | 787,995 | 748,958 | 784,716 | 818,283 | 687,618 | 361,962 | 221,003 | 29,152 |
| 50.0% | 843,028 | 786,046 | 806,102 | 669,165 | 842,168 | 767,895 | 524,767 | 221,215 | 39,049 |
| 59.0% | 843,027 | 829,834 | 750,462 | 750,816 | 731,498 | 686,557 | 459,534 | 209,352 | 49,130 |
| 60.0% | 843,028 | 878,549 | 814,179 | 697,920 | 661,758 | 632,822 | 519,259 | 218,563 | 52,231 |
| 75.0% | 843,026 | 855,899 | 763,511 | 719,689 | 658,342 | 634,032 | 532,463 | 184,289 | 46,308 |
| 90.0% | 843,029 | 720,069 | 806,769 | 749,320 | 656,842 | 718,586 | 431,408 | 215,384 | 50,775 |
| 95.0% | 843,027 | 699,500 | 772,105 | 713,710 | 665,137 | 778,485 | 481,978 | 225,407 | 52,763 |
| 99.0% | 843,026 | 856,556 | 888,985 | 812,081 | 772,977 | 751,041 | 550,086 | 243,091 | 56,490 |
| 99.5% | 843,025 | 910,872 | 839,967 | 797,508 | 767,709 | 824,590 | 575,579 | 244,901 | 57,032 |
| 99.9% | 843,027 | 879,416 | 865,871 | 961,720 | 896,028 | 864,217 | 601,773 | 249,054 | 58,509 |

Table 1.4
(‘000)

Assets/Liability Ratio

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|--------|--------|--------|--------|--------|--------|---------|---------|----------|
| 10.0% | 85.2% | 99.8% | 109.2% | 119.3% | 133.3% | 151.4% | 260.6% | 1160.4% | 10709.6% |
| 25.0% | 85.2% | 92.0% | 97.6% | 104.1% | 111.8% | 119.7% | 176.4% | 591.4% | 4346.2% |
| 50.0% | 85.2% | 85.5% | 86.2% | 88.9% | 91.0% | 92.9% | 109.8% | 194.5% | 961.3% |
| 59.0% | 85.2% | 82.8% | 82.8% | 84.1% | 84.5% | 84.4% | 90.2% | 102.9% | 140.7% |
| 60.0% | 85.2% | 82.6% | 82.3% | 83.7% | 84.0% | 83.7% | 88.3% | 89.8% | 69.7% |
| 75.0% | 85.2% | 78.6% | 76.0% | 75.4% | 73.6% | 72.5% | 60.4% | 0.0% | 0.0% |
| 90.0% | 85.2% | 72.4% | 66.4% | 62.6% | 59.8% | 56.7% | 28.8% | 0.0% | 0.0% |
| 95.0% | 85.2% | 68.4% | 61.9% | 57.6% | 51.9% | 47.1% | 12.8% | 0.0% | 0.0% |
| 99.0% | 85.2% | 58.9% | 52.5% | 45.1% | 42.3% | 35.0% | 0.0% | 0.0% | 0.0% |
| 99.5% | 85.2% | 57.6% | 50.2% | 43.7% | 40.1% | 33.3% | 0.0% | 0.0% | 0.0% |
| 99.9% | 85.2% | 41.8% | 45.4% | 39.1% | 26.5% | 24.7% | 0.0% | 0.0% | 0.0% |

Appendix

Results of Scenario Testing

Scenario 2
Cash flow match first seven years.

Table 2.1
(‘000)

Surplus/Deficit Risk Metric

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 10.0% | 2,324,069 | 5,213,365 | 5,846,578 | 6,247,427 | 6,378,420 | 6,161,986 | 5,169,316 | 5,153,163 | 7,670,332 |
| 25.0% | 794,363 | 1,724,913 | 1,928,081 | 1,976,160 | 1,906,610 | 1,851,062 | 1,783,209 | 1,549,601 | 2,625,585 |
| 50.0% | 80,144 | 158,530 | 167,311 | 176,521 | 178,018 | 170,900 | 153,989 | 141,560 | 358,367 |
| 56.0% | 1,523 | 2,453 | 3,065 | 2,722 | 3,110 | 3,018 | 2,913 | 2,569 | 8,608 |
| 57.0% | (5,264) | (8,093) | (7,687) | (7,279) | (7,709) | (8,008) | (6,926) | (13,399) | (27,176) |
| 75.0% | (100,059) | (112,058) | (114,805) | (116,700) | (120,326) | (124,734) | (154,373) | (185,225) | (46,659) |
| 90.0% | (191,829) | (214,245) | (222,519) | (229,635) | (233,525) | (243,050) | (309,670) | (216,462) | (51,020) |
| 95.0% | (233,756) | (257,843) | (267,258) | (277,353) | (284,890) | (299,881) | (375,907) | (227,068) | (52,837) |
| 99.0% | (292,513) | (324,917) | (345,426) | (388,069) | (387,766) | (411,241) | (490,475) | (243,091) | (56,330) |
| 99.5% | (312,352) | (343,200) | (363,709) | (401,213) | (447,218) | (459,723) | (544,708) | (244,901) | (57,032) |
| 99.9% | (358,969) | (422,264) | (437,748) | (433,639) | (521,264) | (552,404) | (601,773) | (249,054) | (58,509) |

Table 2.2
(‘000)

Assets

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|---------|---------|---------|---------|---------|---------|---------|-----------|-----------|
| 10.0% | 717,890 | 743,026 | 766,804 | 765,233 | 639,159 | 648,440 | 687,433 | 2,644,843 | 3,433,459 |
| 25.0% | 717,890 | 680,351 | 629,741 | 808,749 | 761,089 | 912,516 | 646,196 | 410,919 | 1,220,645 |
| 50.0% | 717,890 | 668,671 | 649,168 | 663,107 | 539,954 | 608,636 | 733,591 | 1,012,894 | 328,326 |
| 56.0% | 717,890 | 682,560 | 512,684 | 596,388 | 611,896 | 613,769 | 494,423 | 245,701 | 46,731 |
| 57.0% | 717,890 | 633,975 | 589,512 | 685,356 | 686,812 | 567,020 | 725,056 | 126,186 | 20,823 |
| 75.0% | 717,890 | 638,887 | 731,471 | 570,680 | 486,873 | 588,721 | 309,645 | (594,286) | (115,377) |
| 90.0% | 717,890 | 654,914 | 682,402 | 549,889 | 473,800 | 392,259 | 159,326 | (599,551) | (519,976) |
| 95.0% | 717,890 | 701,215 | 674,374 | 553,380 | 473,675 | 347,351 | 214,601 | (279,581) | (639,855) |
| 99.0% | 717,890 | 704,349 | 630,893 | 581,844 | 450,660 | 524,423 | 48,488 | (116,543) | (34,776) |
| 99.5% | 717,890 | 691,201 | 571,485 | 420,008 | 377,084 | 325,233 | 57,577 | (219,333) | (406,343) |
| 99.9% | 717,890 | 741,772 | 516,257 | 435,088 | 362,523 | 363,210 | (8,212) | (83,351) | (616,102) |

Appendix

Results of Scenario Testing

Table 2.3
(‘000)

Liabilities

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 10.0% | 843,025 | 893,976 | 817,543 | 767,235 | 646,903 | 688,591 | 640,313 | 229,972 | 49,182 |
| 25.0% | 843,025 | 849,920 | 863,914 | 635,824 | 753,355 | 622,747 | 515,637 | 210,459 | 41,295 |
| 50.0% | 843,027 | 829,882 | 735,329 | 623,044 | 688,426 | 754,572 | 479,827 | 168,682 | 41,968 |
| 56.0% | 843,028 | 805,117 | 804,226 | 761,450 | 755,902 | 642,021 | 490,362 | 205,350 | 48,169 |
| 57.0% | 843,027 | 806,189 | 757,008 | 732,156 | 738,078 | 709,821 | 518,508 | 152,602 | 49,621 |
| 75.0% | 843,025 | 804,821 | 806,720 | 646,606 | 724,249 | 628,051 | 443,489 | 185,225 | 46,659 |
| 90.0% | 843,028 | 864,669 | 745,552 | 834,859 | 764,715 | 709,859 | 509,644 | 216,462 | 51,021 |
| 95.0% | 843,027 | 874,677 | 789,621 | 775,463 | 661,680 | 733,219 | 594,214 | 227,068 | 52,837 |
| 99.0% | 843,026 | 826,953 | 736,761 | 890,469 | 841,590 | 851,160 | 546,895 | 243,091 | 56,330 |
| 99.5% | 843,027 | 843,645 | 839,967 | 809,383 | 733,062 | 751,457 | 583,651 | 244,901 | 57,032 |
| 99.9% | 843,027 | 879,416 | 899,735 | 777,380 | 896,028 | 864,217 | 601,773 | 249,054 | 58,509 |

Table 2.4
(‘000)

Assets/Liability Ratio

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|--------|--------|--------|--------|--------|--------|---------|---------|---------|
| 10.0% | 85.2% | 94.2% | 99.2% | 107.4% | 117.6% | 129.5% | 213.6% | 892.1% | 8130.7% |
| 25.0% | 85.2% | 88.6% | 90.9% | 96.3% | 102.2% | 107.4% | 153.0% | 467.2% | 3200.1% |
| 50.0% | 85.2% | 83.6% | 82.4% | 84.6% | 86.7% | 87.3% | 99.8% | 144.9% | 554.0% |
| 56.0% | 85.2% | 82.3% | 80.3% | 82.1% | 83.6% | 82.9% | 88.8% | 98.5% | 97.0% |
| 57.0% | 85.2% | 82.0% | 80.0% | 81.6% | 83.3% | 82.2% | 87.2% | 87.7% | 42.0% |
| 75.0% | 85.2% | 78.4% | 74.3% | 74.0% | 73.1% | 73.0% | 62.1% | 0.0% | 0.0% |
| 90.0% | 85.2% | 73.7% | 67.7% | 65.6% | 62.9% | 60.9% | 36.3% | 0.0% | 0.0% |
| 95.0% | 85.2% | 70.8% | 64.2% | 61.0% | 57.6% | 54.6% | 26.2% | 0.0% | 0.0% |
| 99.0% | 85.2% | 62.9% | 56.4% | 52.0% | 49.1% | 44.1% | 8.9% | 0.0% | 0.0% |
| 99.5% | 85.2% | 61.6% | 55.9% | 50.3% | 47.0% | 42.0% | 2.5% | 0.0% | 0.0% |
| 99.9% | 85.2% | 50.2% | 51.1% | 48.3% | 39.8% | 39.1% | 0.0% | 0.0% | 0.0% |

Appendix

Results of Scenario Testing

Scenario 3 Increased Funding

Table 3.1
(‘000)

Surplus/Deficit Risk Metric

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| 10.0% | 3,270,124 | 7,449,750 | 8,316,354 | 8,699,108 | 8,965,853 | 8,604,417 | 7,645,688 | 7,449,693 | 10,077,279 |
| 25.0% | 1,236,304 | 2,431,156 | 2,906,674 | 3,077,754 | 2,947,600 | 2,930,989 | 2,839,036 | 2,431,151 | 4,049,149 |
| 50.0% | 255,039 | 511,056 | 618,657 | 555,151 | 587,998 | 595,732 | 494,773 | 511,075 | 1,146,961 |
| 69.0% | 6,571 | 8,626 | 17,973 | 15,055 | 12,113 | 13,096 | 11,676 | 8,648 | 41,514 |
| 70.0% | (3,991) | (6,925) | (5,969) | (4,258) | (4,137) | (4,652) | (5,452) | (8,266) | (13,300) |
| 75.0% | (37,142) | (40,037) | (46,205) | (48,379) | (48,558) | (51,858) | (57,744) | (97,719) | (42,461) |
| 90.0% | (161,656) | (174,486) | (179,279) | (186,164) | (190,379) | (198,764) | (250,284) | (208,326) | (49,737) |
| 95.0% | (210,794) | (237,710) | (244,647) | (256,663) | (266,339) | (267,712) | (346,146) | (222,005) | (52,027) |
| 99.0% | (289,563) | (329,273) | (335,938) | (363,386) | (401,221) | (398,930) | (495,129) | (241,440) | (55,989) |
| 99.5% | (308,425) | (347,219) | (375,886) | (392,473) | (418,734) | (446,300) | (527,739) | (244,901) | (56,572) |
| 99.9% | (330,897) | (396,700) | (424,695) | (434,451) | (448,973) | (486,348) | (600,395) | (249,054) | (58,509) |

Table 3.2

Assets

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|---------|---------|---------|-----------|---------|---------|-----------|-----------|-------------|
| 10.0% | 780,843 | 846,168 | 726,889 | 827,199 | 949,494 | 816,900 | 883,410 | 2,334,290 | 3,536,066 |
| 25.0% | 780,843 | 818,923 | 990,666 | 529,677 | 689,229 | 734,069 | 426,439 | 1,557,267 | 2,260,296 |
| 50.0% | 780,843 | 945,268 | 674,194 | 757,798 | 687,545 | 839,111 | 1,189,971 | 1,051,543 | 597,683 |
| 69.0% | 780,843 | 709,632 | 642,126 | 1,100,609 | 729,133 | 666,513 | 593,919 | 189,891 | 87,667 |
| 70.0% | 780,843 | 851,562 | 716,107 | 499,038 | 802,710 | 687,164 | 603,704 | 182,478 | 24,718 |
| 75.0% | 780,843 | 716,985 | 742,839 | 673,558 | 633,080 | 507,948 | 340,756 | 113,861 | (1,037,689) |
| 90.0% | 780,843 | 662,940 | 672,193 | 443,465 | 633,585 | 393,925 | 239,659 | (429,510) | (974,878) |
| 95.0% | 780,843 | 786,813 | 557,032 | 503,937 | 468,100 | 403,300 | 144,874 | (83,760) | (1,360,580) |
| 99.0% | 780,843 | 720,320 | 553,255 | 460,603 | 449,615 | 372,727 | 38,627 | (774,570) | (713,837) |
| 99.5% | 780,843 | 560,828 | 567,019 | 370,602 | 330,139 | 327,168 | 17,169 | (199,852) | (637,230) |
| 99.9% | 780,843 | 437,549 | 500,338 | 506,671 | 388,688 | 400,189 | (15,315) | (33,838) | (1,157,647) |

Appendix

Results of Scenario Testing

Table 3.3
(‘000)

Liabilities

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 10.0% | 843,026 | 853,255 | 802,621 | 686,264 | 697,949 | 575,567 | 466,821 | 234,550 | 43,420 |
| 25.0% | 843,026 | 852,173 | 769,658 | 703,273 | 717,149 | 728,206 | 485,694 | 193,787 | 50,465 |
| 50.0% | 843,027 | 787,574 | 777,885 | 674,362 | 784,616 | 562,388 | 525,264 | 212,296 | 51,044 |
| 69.0% | 843,028 | 809,722 | 859,191 | 779,458 | 796,687 | 733,303 | 512,535 | 184,164 | 45,024 |
| 70.0% | 843,024 | 813,686 | 686,894 | 756,382 | 708,399 | 691,114 | 439,787 | 193,853 | 39,326 |
| 75.0% | 843,026 | 799,652 | 722,696 | 751,403 | 566,839 | 632,822 | 566,600 | 208,110 | 42,461 |
| 90.0% | 843,026 | 761,383 | 804,761 | 692,155 | 665,235 | 625,119 | 512,644 | 208,326 | 49,738 |
| 95.0% | 843,028 | 821,637 | 821,757 | 778,036 | 750,502 | 669,643 | 483,036 | 222,005 | 52,028 |
| 99.0% | 843,026 | 910,872 | 785,739 | 912,757 | 841,590 | 777,457 | 538,841 | 241,441 | 55,990 |
| 99.5% | 843,026 | 893,641 | 899,735 | 783,933 | 772,977 | 751,041 | 544,690 | 244,901 | 56,573 |
| 99.9% | 843,025 | 911,538 | 888,985 | 961,720 | 896,028 | 906,738 | 600,395 | 249,054 | 58,509 |

Table 3.4
(‘000)

Assets/Liability Ratio

| Percentile | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 10 | Year 20 | Year 30 |
|------------|--------|--------|--------|--------|--------|--------|---------|---------|----------|
| 10.0% | 92.6% | 110.5% | 121.1% | 132.8% | 145.6% | 162.3% | 268.0% | 1210.7% | 11535.2% |
| 25.0% | 92.6% | 101.8% | 109.0% | 115.7% | 123.2% | 131.2% | 191.9% | 657.8% | 4954.6% |
| 50.0% | 92.6% | 94.6% | 95.8% | 99.8% | 102.4% | 104.0% | 125.6% | 268.6% | 1505.7% |
| 69.0% | 92.6% | 88.7% | 88.5% | 87.9% | 88.0% | 88.2% | 90.6% | 99.3% | 149.8% |
| 70.0% | 92.6% | 88.5% | 87.4% | 86.8% | 87.4% | 87.2% | 89.0% | 94.3% | 62.9% |
| 75.0% | 92.6% | 86.6% | 85.1% | 83.9% | 83.7% | 83.0% | 80.3% | 48.3% | 0.0% |
| 90.0% | 92.6% | 80.0% | 74.7% | 71.6% | 68.9% | 65.1% | 48.7% | 0.0% | 0.0% |
| 95.0% | 92.6% | 74.9% | 69.7% | 64.8% | 61.3% | 57.6% | 31.4% | 0.0% | 0.0% |
| 99.0% | 92.6% | 65.2% | 58.3% | 53.0% | 50.8% | 44.1% | 9.6% | 0.0% | 0.0% |
| 99.5% | 92.6% | 63.1% | 56.1% | 50.5% | 44.3% | 40.7% | 3.6% | 0.0% | 0.0% |
| 99.9% | 92.6% | 48.0% | 50.5% | 43.0% | 32.1% | 32.0% | 0.0% | 0.0% | 0.0% |