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COMBINING FINANCIAL AND ACTUARIAL RISK: SIMULATION ANALYSIS

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Projecting the Financial Condition of a Pension Plan Using Simulation Analysis

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BECAUSE OF THE large amount of corporate wealth presently being absorbed by pension plans, the understanding of the potential future financial requirements of a pension plan is becoming increasingly important to plan sponsors [5]. Unfortunately, the dynamic behavior of a pension plan is one of the more complex processes in the world of finance. In order to obtain a reasonable estimate of the projected condition of a pension plan, sophisticated models are becoming more widely used [6]. These models are able to generate projections of all of the key elements of a pension plan and to display the range of conditions that might result from uncertain future conditions.

PENSIM is a pension projection model which allows the analysis of the potential future financial condition of a pension plan using simulation analysis. PENSIM, which stands for *Pension Simulation*, was developed by the staff of Wilshire Associates and has been used in the analysis of almost 800 pension plans over the last 5 years.

To understand the workings of a pension projection model, it is useful to first understand the overall structure of a pension plan. In a typical pension plan, the employer (or plan sponsor) promises to provide retirement benefits to employees upon the completion of certain service requirements. These benefits will usually be calculated by a formula based on years of service and level of pay. Ancillary provisions will typically be included, providing various benefits in the event of death, disability, or early retirement. There will usually be a requirement for the attainment of a minimum age or years of service before the employee obtains a non-forfeitable (or "vested") right to certain benefits in the event of separation prior to retirement age. The Employees Retirement Security Act (ERISA) of 1974 now prescribes minimum eligibility and vesting requirements for most pension plans.

The pension benefit obligations of an employer are called the liabilities of the pension plan. These liabilities represent the present value of the benefits that

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have been promised to the members of the pension plan. These present values are discounted using not only an assumed rate of interest, but also assumed rates of retirement, disability, separation and mortality. For example, if mortality rates are assumed to be very high, pension liabilities will be low, because relatively few of the members will be around long enough to collect many benefits.

Another assumed rate that will have a substantial effect on employees whose benefit is based on final average pay is the assumed rate of future salary increases. Note that the liabilities are determined on the basis of *assumed* rates, and not necessarily on actual rates that may occur. For this reason, the magnitude of the calculated liabilities will be extremely sensitive to the rates that are selected for use in the present value calculations.

To further complicate the calculation of liabilities, there are a wide range of methods that can be employed by actuaries. In some cases, the liability calculations will include the liability for only those benefits that have been earned based on current pay levels and accrued service. In other cases, the liabilities may comprise all benefits payable to the members based on all service, past, present and future, and on their projected pay levels at the time of separation or retirement. The method of liability calculation is usually related to the benefit formula and to the funding method that may be selected by the actuary.

The latitude available to be used in the calculation of pension plan liabilities can result in a wide range of liabilities that could be calculated for a plan. This situation could cause great difficulty in comparing the pension obligations of one pension plan with those of another. To provide a more meaningful and consistent way to compare the relative financial condition of various pension plans, regulatory authorities now require that plan actuaries calculate the accrued liability (based on pay and service to the present) and the accrued vested liability (that portion of the accrued liability which is non-forfeitable to the members) [3]. Although there may still be significant variations in the assumptions, the accrued and vested liabilities now being reported provide a much more rational basis for comparison than has been possible in the past.

Pension plan actuaries, however, still retain the flexibility to calculate the funding requirements for a plan based on the wide range of methods mentioned earlier. This process, which is at the heart of what is called the actuarial valuation, consists of comparing the assets to the liabilities in order to determine the appropriate contribution to the plan for the current year. This contribution will typically consist of two components: the normal cost and the amortization of unfunded past service liabilities. "Normal cost" is a term used to describe the regular ongoing contribution to the plan based on service to be accrued in the coming year. The amortization payment is the additional part of the total contribution that is designed to eventually fully fund any past service liabilities that are not yet funded.

With the passage of time, unanticipated investment results or plan population changes may cause unexpected shifts in both the assets and liabilities. These actuarial "gains" or "losses" will usually occur each year and will require an adjustment to the contribution to offset their effect, typically amortized over a fifteen-year period. Changes in the contractual pension obligation due to benefit formula increases or cost of living adjustments may also occur and will typically be amortized over a thirty-year time period [2].

One further complicating element of the valuation process is the asset valuation method employed in the valuation. Most actuaries currently employ asset valuation techniques which delay the full recognition of unrealized investment gains and losses due to recent market behavior. The objective of these techniques is to provide a "shock absorber" to minimize unnecessary fluctuations in annual funding requirements in response to the random behavior of the market. If there is a full and immediate recognition of all unrealized gains and losses as soon as they occur (i.e., if there is no shock absorber), asset values will be kept closer to target by frequent readjustments of the annual funding requirements. On the other hand, if the shock absorber is too soft (i.e., if the recognition of unrealized gains and losses is delayed for too long), the level of annual funding requirements may respond too slowly to adjustments dictated by significant changes in the market value of the assets.

The dynamic behavior of a pension plan is clearly dominated by rules and methodology which are discontinuous and non-linear functions of its potential financial condition. The task of developing a closed form solution to evaluate the potential state of a pension plan following a series of stochastic investment and inflation experiences would be extremely difficult, if not impossible. To date, the only approach that has proven feasible is the application of Monte Carlo Simulation, wherein an investment and inflation scenario is generated by random draws based on the expected probability distribution of year to year investment and inflation behavior. In order to develop an accurate assessment of the range of potential uncertainties, it is necessary to repeat this simulation process by generating dozens or hundreds of possible scenarios, consistent with statistical expectations. The greater the degree of required precision, the larger the number of simulated scenarios that it will be necessary to test. Given the level of uncertainty in the level of future inflation and investment results, experience has shown that several hundred scenarios are typically required to provide an adequate assessment of the range of possible experiences between the 5th and 95th percentiles.

The projection process in PENSIM is based on a year by year progression of the liability and investment results, from one actuarial valuation to the next. The process begins with the progression of the plan members. Using assumed membership progression rates, the model moves the members of the plan forward one year into the future, calculating the number of people that may die due to mortality expectations, retire from the active work force based on assumed retirement rates, or separate from the plan based on assumed termination rates. If the work force is to remain constant or grow, PENSIM assumes that new employees will be hired to maintain the projected work force, including the replacement of those who retire or terminate. The pay of each active member is projected based on the salary increase scale for his age as well as the effect of inflation on the overrall pay levels. Since inflation is treated as a stochastic variable, the inflation component will vary from year to year, and from scenario to scenario. The benefit paid to newly retiring members will be calculated based on the current benefit formula and their payroll history, both of which will be affected by the potential rate of inflation. Benefits being paid to previously retired members may also be adjusted upwards if there is a cost of living adjustment in the retired benefits.

Following a one year projection of this type, the membership of the plan will usually have a significantly different composition than in the previous year. Bulges in the demographic distribution will now be one year older and have an additional year of service. If an unusually large number of members is eligible to retire, a new bulge will be created by the hiring of a larger number of new people to replace them. These effects, plus any increases in the work force, will typically cause a change in the liabilities that was not fully anticipated at the last valuation. A significant increase in the liabilities will usually occur if the actual rate of pay inflation is larger than the rate of salary increase that had been assumed in the last valuation.

While all of these changes are occurring within the liability side of the plan, equally significant developments will take place within the assets of the plan. Large cash flows to the assets, representing the net effect of contributions less benefit payments, will have taken place. Significant changes in the market value of the assets may have occurred, and these changes will have to be recognized using the asset valuation method employed in the valuation.

At the end of each year in the projection, the evolving levels of assets and liabilities are compared with one another in a model of the actuarial valuation process to determine the amount of unfunded liabilities, if any, and the portion of the liabilities that will be accrued next year and funded by the normal cost. These cost calculations include a comparison with the funding limits imposed on the plan by ERISA and the IRS. The new contribution requirements, which are calculated to meet the changing financial condition of the plan, then become part of next year's assumed cash flow to the plan assets.

This process of progressing the membership, payroll, benefits and investment results of the plan then continues to the time of the next actuarial valuation, one year hence. The liabilities and assets of the plan are calculated and compared with one another to determine the new funding requirements. The process (Figure 1) can be continued for as far into the future as desired, but a ten or twenty year projection is usually adequate for most planning purposes.

Figure 2 illustrates the projection process for a typical plan. The current total

Integration of the Valuation and Projection Processes

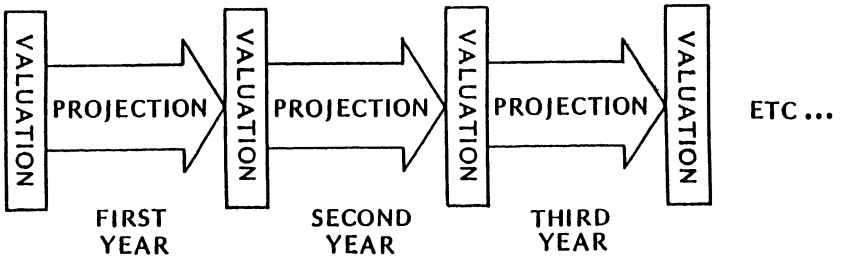

Figure 1

The Projection Process for a Typical Pension Plan

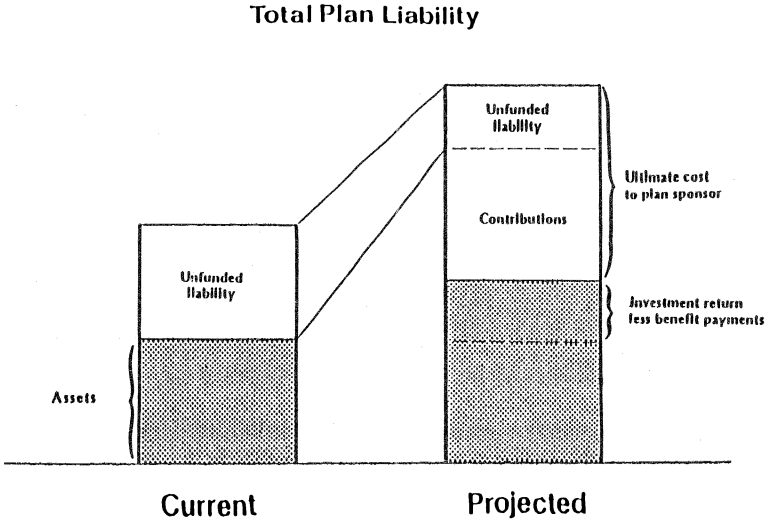

Figure 2

plan liabilities are shown on the left, with current assets covering a portion of the liability, leaving a certain amount of unfunded liability. The projected liability shown on the right represents the condition of the plan at the end of some time period, say 5 to 10 years. At the end of that time period, the total liabilities will have grown to some new level due to inflation, work force growth and/or benefit increases. The original assets may have increased to some new level due to investment return less the payout of benefits. The portion labeled "projected contributions" represents the cumulative amount expected to be contributed between the current and projected time points, leaving some new unfunded liability balance.

One of the major uses of a projection of this type is in the evaluation of investment policy (Figure 3). Many plan sponsors are no longer content to evaluate only the potential rates of return that might result from their investment posture. As the magnitude of the dollars involved in a pension plan becomes more significant, there is a growing demand on the part of plan sponsors to understand the impact of the investment results on their contribution requirements and unfunded liabilities, measured in actual dollars [4].

The composition of the projected plan liabilities in Figure 2 provides a very direct way to evaluate the impact of investment results on the financial condition of a pension plan. When viewed from the perspective of the plan sponsor, the projected contributions and the projected unfunded liability, both stated on a present-value basis, sum to a total that represents the ultimate cost of the plan to the plan sponsor. The variations allowed in the actuarial valuation and in the funding process can change the rate at which contributions are made to the plan,

An Integrated Model of Pension Finance

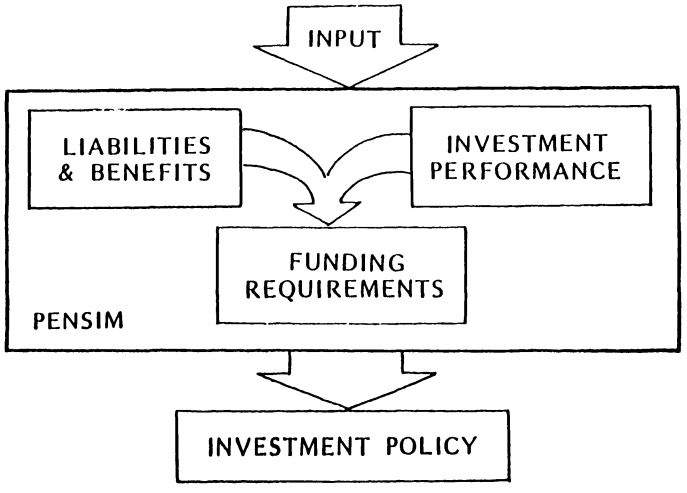

Figure 3

Projected Level of Assets versus Liabilities

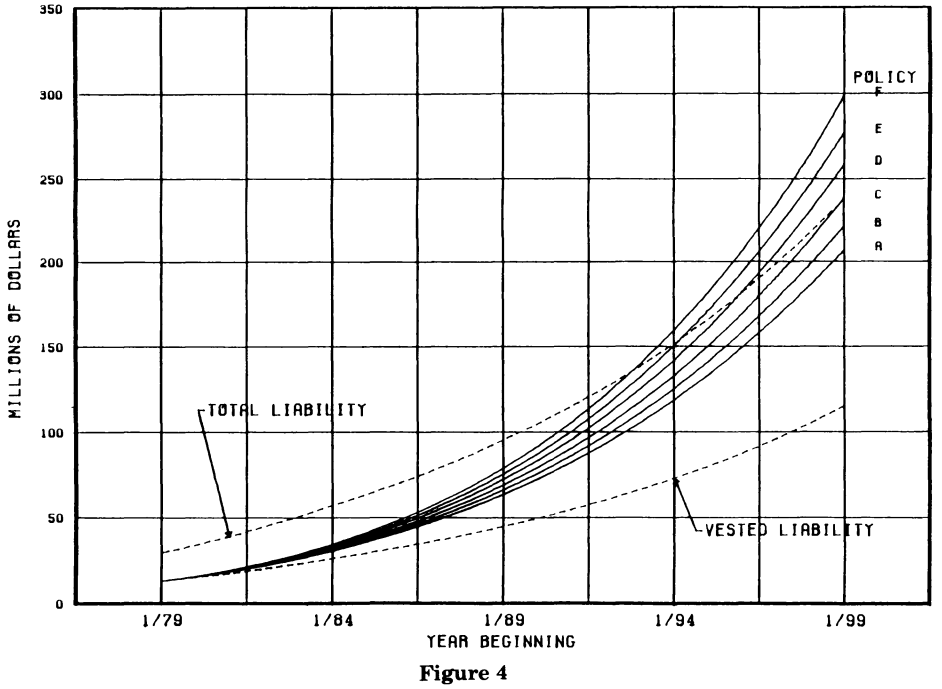

Figure 4

but will not have any effect on the total ultimate cost of the plan to the plan sponsor. The investment results will have a very direct effect on this ultimate cost, however. Each dollar of investment return in excess of the assumed rate of return will represent a dollar that the plan sponsor will never have to contribute

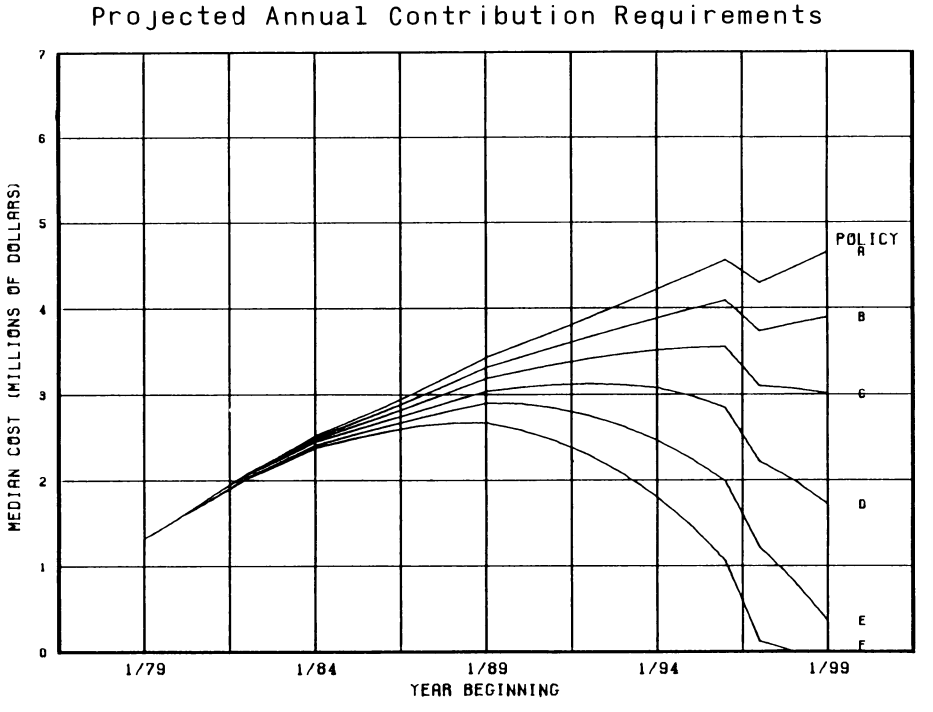

Figure 5

to the plan, while each investment shortfall represents a loss that will ultimately have to be made up by the plan sponsor, "sooner" in the form of near-term contributions or "later" in the form of an unfunded liability that will eventually have to be paid off.

To illustrate the application of simulation analysis in understanding the projected financial condition of a pension plan, let us examine an example where the results are used in a risk-reward analysis concerning investment strategy. In this example, we will evaluate the financial risk tolerance of a pension plan to a set of alternate investment policies, ranging from conservative to aggressive. To do this, we select six equally efficient investment asset mixes (maximum rate of return for a specified level of volatility) to determine the sensitivity of the ultimate cost of the plan to the range of potential investment results. Figure 4 shows the projected level of assets versus liabilities for the next twenty years, assuming average results for each of the six asset mixes. The corresponding annual contribution requirements are shown in Figure 5.

Using simulation analysis we can calculate the range of ultimate cost that might result from these investment alternatives projected over a five year period. Figure 6 shows the range of ultimate cost (cumulative five year contributions plus unfunded liability) for six investment alternatives, ranging from conservative (Policy A) to aggressive (Policy F). Clearly the more aggressive policies provide a more favorable average result, but at the expense of more unfavorable conditions in the event of poorer-than-average experience.

Simulation analysis of this type usually shows that a mature, well funded plan

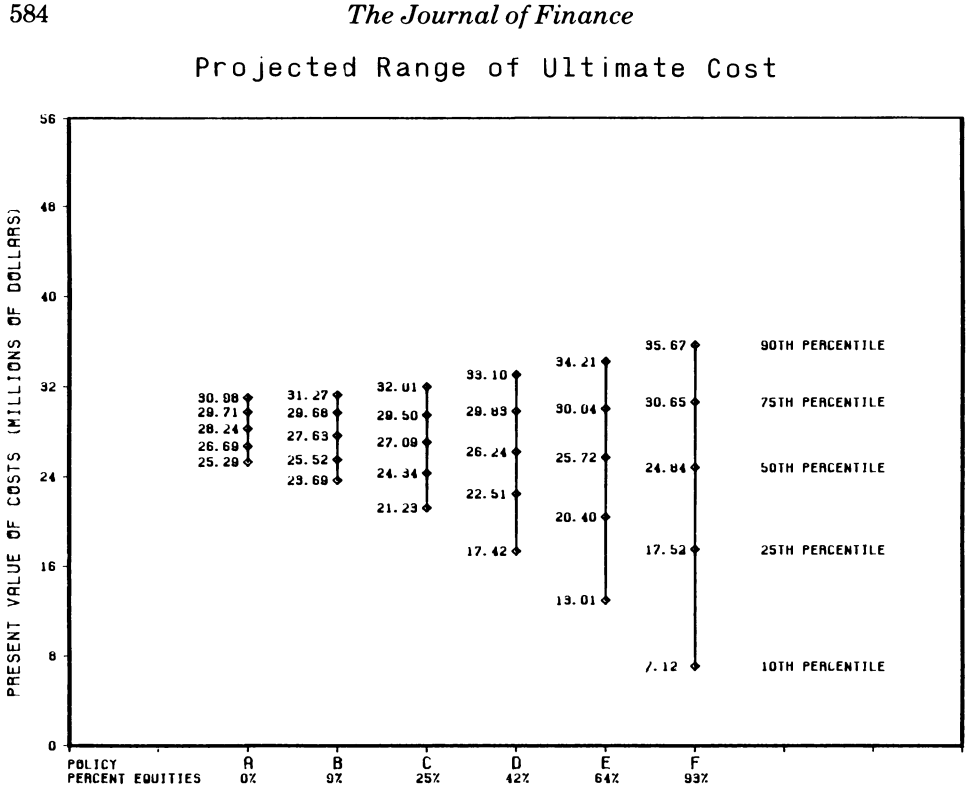

Figure 6

with a low level of expected work force growth should be conservative, while a young plan with few assets but a large anticipated work force growth rate could benefit from a more aggressive investment posture.

This example illustrates only one of the potential applications of simulation analysis in evaluating the projected financial condition of a pension plan. Simulation techniques can also be very helpful in understanding the impact of actuarial assumptions, funding policy, and potential benefit formula changes [1]. By allowing a clear understanding of the full range of potential results, simulation analysis allows plan sponsors to "pre-experience" future conditions and to make better decisions today based on a more complete understanding of what the future may hold.

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