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Shortfall Risk and Pension Fund Asset Management

The sponsor of a defined benefit pension plan is obliged to pay some minimum level of benefits, regardless of the performance of the pension fund's investment portfolio. To minimize the cost to the corporation of providing this guarantee, the plan sponsor should hedge it by investing in fixed income securities or by pursuing a strategy of portfolio insurance.

Investing in equities will increase the volatility of plan assets. While this may also increase their return, any advantage to corporate shareholders will in general be limited. The cost of insuring against shortfall risk (i.e., guaranteeing the minimum benefit) will increase with increased volatility and with the duration of the plan's liabilities. If management does not possess superior investment skills, this increased cost will not be covered by increased returns unless the corporation can be considered to own 100 per cent of any pension surplus. This is rarely the case.

If the goal is to hedge the guaranteed benefit, equities are not the answer (even in inflationary periods). Equity investments may be justifiable for funds being managed as if they were defined contribution plans and for some funds with active managers who possess superior investment skills. Also, for underfunded plans of financially distressed sponsors, investment in equities may be used to exploit the pension insurance provided by the Pension Benefit Guaranty Corporation.

SHORTFALL RISK is the risk that the rate of return earned on an investment portfolio will be less than the risk-free rate of interest over some time period. The conventional wisdom is that shortfall risk for a portfolio of stocks declines as the investment horizon gets longer.¹ The conclusion usually drawn from this is that the proportion of an investor's portfolio devoted to stocks should be larger, the longer the investment horizon. Pension funds should thus optimally hold more stock than individual investors, because they have a longer investment horizon.

Samuelson and Merton have proved most of these propositions false.² They show that, under standard assumptions about the probability distribution of stock returns and investor preferences, the *length* of an investor's time horizon

per se should not affect optimal asset mix. This article goes one step beyond the Samuelson-Merton analysis to explore the implications of option pricing theory for the investment policy of defined benefit pension plans. The basic conclusion is this: If the objective of pension asset management is to minimize the cost of providing guaranteed benefits, then the longer the time horizon, the *lower* the proportion of assets that should be invested in stocks.

Under a defined benefit pension plan, the sponsor guarantees benefits to plan participants. If the plan is fully funded, the shareholders of the sponsoring corporation absorb all the downside risk of the pension fund portfolio; however, they share in only part of the upside potential. The sponsor can minimize the cost of providing the benefit guarantee by investing in fixed income securities that hedge the promised benefits (that is, by "immunizing"). By contrast,

1. Footnotes appear at end of article.

Glossary

Shortfall Risk: The risk that the rate of return earned on an investment portfolio will be less than the risk-free rate of interest over some specified time period.

Immunization: An investment strategy that consists of investing in fixed income securities that match the benefits payable under the plan.

Contingent Immunization: An investment strategy that calls for investing some proportion of plan assets in risky securities such as equities as long as the value of the investment portfolio exceeds the present value of guaranteed benefits. If the value of plan assets should decline, the strategy calls for switching to an immunized fixed income portfolio.

Volatility: The degree to which the value of a security or an investment portfolio fluctuates unpredictably over time. It is usually measured by the standard deviation of the portfolio's total rate of return over a period.

investing in stocks increases the value (cost) of the benefit guarantee. Unless the sponsoring corporation's shareholders own the entire pension surplus, investing in stocks reduces the value of shareholder equity.

The result is the same if promised benefits are indexed for inflation. Stock returns are just as risky in real terms as they are in nominal terms, hence are not a reliable inflation hedge. Pension fund investment in stocks cannot be justified by the argument that stocks are not risky in the long run, or that they are a good hedge against inflation.

The Benefit Guarantee

In a defined benefit pension plan, the benefit is determined by a formula that takes into account the employee's history of service and wages or salary. The plan sponsor provides this benefit, regardless of the investment performance of the pension fund assets. In a typical defined benefit plan, employees might receive a pension benefit equal to 1.5 per cent of final salary per year of service. Thus an employee retiring after 40 years of service with a final salary of \$50,000 per year would receive a pension benefit of 60 per cent of \$50,000, or \$30,000 per year.

The annuity promised to the employee is the employer's liability. In the U.S., the Pension Benefit Guaranty Corporation (PBGC), an agency of the federal government, guarantees

the pension benefits promised under defined benefit plans, up to certain limits. Plan sponsors pay insurance premiums that depend on the number of employees covered by the plan and on how well funded the plan is. The plan's assets serve as collateral for the firm's pension liabilities.

Traditionally, pension funds have been viewed as separate from the corporation. Legally they are trusts, and funding and asset allocation decisions are supposed to be made in the best interests of the beneficiaries, regardless of the financial condition of the sponsoring organization.

If a corporate pension fund has a liability that exceeds the market value of the plan's assets, Financial Accounting Standards Board Statement 87 (FAS 87) requires that the corporation recognize the unfunded liability on its balance sheet. The sponsoring corporation is clearly liable for pension asset shortfalls. But what about pension surplus?

The question of ownership of the pension surplus is a central issue in the theory of corporate pension policy. Current law specifies that the employer owns the surplus as long as specific standards are satisfied.³ Most academic literature has assumed that the sponsoring corporation owns the entire surplus, and that the pension fund balance sheet can therefore be consolidated with the balance sheet of the sponsoring corporation. The economic significance of this approach is that the pension trust provides shareholders with an opportunity for tax arbitrage and, under certain circumstances, the possibility of exploiting PBGC insurance.⁴

FAS 87, however, specifies that the corporation cannot include the surplus on its balance sheet. The case for viewing shareholder ownership of the pension surplus as less than complete rests on the fact that virtually all parties to the pension contract view plan beneficiaries as having some claim to the pension surplus. Corporations that terminate overfunded plans, for example, face substantial tax penalties. Some legislators have even proposed measures that would require sponsors to use surplus pension assets to provide retroactive inflation protection of benefits. Even in the absence of such legislation, sponsors behave *as if* the corporation's shareholders and the plan beneficiaries actually share ownership of the surplus.⁵

What are the economic consequences of shareholders being liable for 100 per cent of the

Table I Cost of Benefit Guarantee as a Function of Maturity*

<i>N (years)</i>	<i>Value of Put as a Percentage of the Present Value of Benefits</i>
1	7.98
5	17.72
10	24.84
20	34.54
30	41.63
50	52.08

* The table was derived using the Black-Scholes option pricing formula with $\sigma = 0.2$ per year and $r = 0.08$ per year. The option is exactly at-the-money, in the sense that the present value of the exercise price equals the current market value of the underlying portfolio.

benefit guarantee but owning less than 100 per cent of the pension surplus?

Cost of the Benefit Guarantee

Suppose the sponsor has an obligation to pay \$100 N years from now. It can **immunize** this liability by investing $\$100e^{-rN}$ in zero-coupon bonds maturing in N years (where r is the continuously compounded risk-free rate of interest).⁶ To immunize an obligation of \$100 due in 20 years at a risk-free interest rate of 8 per cent per year would cost \$20.19 today ($=100e^{-0.08 \cdot 20}$). The pension plan will be fully funded. No additional funds will be required from the corporation (corporate shareholders) to cover any underfunding. Nor will there be a surplus.

Alternatively, the sponsor could choose to invest in equities yielding an expected annual rate of return of 16 per cent per year and a standard deviation of 20 per cent per year. It would still start out with pension assets having a current market value of \$20.19 and liabilities having a present value equal to that same amount. But how does it guarantee the \$100 terminal value against shortfall risk?

The sponsor could in effect purchase a put option with an exercise price of \$100 expiring in 20 years. How does the value (cost) of such a put vary as a function of the number of years until payment of benefits, N ? Table I provides the answer. It assumes that a portfolio is invested entirely in stocks with a standard deviation of 20 per cent per year.

The value of the put as a percentage of the present value of the pension benefits rises with the length of the time horizon. For benefits that are due in one year, the value of the put is 8 per cent of the present value of the benefits. For

those due in 10 years, it is 25 per cent. This effect is less pronounced, the smaller the proportion of the portfolio invested in stocks, because the portfolio's **volatility** declines as stock investment declines.

The values in Table I do not represent the net cost to the sponsor of providing insurance against shortfall risk. Any surplus in the pension fund will reduce the sponsor's cost because the sponsor owns some fraction, ϕ , of the surplus. The net cost to the sponsor of providing shortfall insurance is thus $(1 - \phi)$ times the value of the put. If the sponsor owns the entire pension surplus, its net cost of providing shortfall insurance is zero. If it does not own 100 per cent of the surplus, however, any gain from the surplus cannot completely offset the cost of the benefit guarantee.

How would this analysis differ if the benefit were denominated in real rather than nominal dollars? In that case, the risk-free rate would be 3 per cent per year, rather than 8 per cent per year, and the present value of promised benefits would be much higher. But the value of the put would be much higher, too. Since the standard deviation of real stock returns is about the same as that of nominal stock returns, the ratio of the put value to the present value of benefits would be roughly the same as Table I indicates. In other words, the values in Table I are independent of the interest rate, hence independent of whether benefits are defined in real or in nominal terms.

If the plan is fully funded, then the only way to minimize the cost of the benefit guarantee is to immunize the pension liability. If the plan sponsor has to pay \$100 per year for the next five years, it can hedge this stream of benefit obligations by buying a set of five zero-coupon bonds, each with a face value of \$100 and each maturing sequentially starting one year from now. Having purchased the five zeros, the plan sponsor could put them away and forget about the benefit obligation.

Effect of Overfunding

Most U.S. pension plans are overfunded. The average asset-to-liability ratio is 1.74 (assuming no automatic inflation indexation of benefits).⁷

If a pension fund is overfunded, then a 100 per cent fixed income portfolio is not required to minimize the cost of the pension guarantee. Management can invest surplus pension assets in stocks, provided it reduces the equity portion

when the market value of pension assets nears the value of the pension liability. Such an investment strategy is a type of portfolio insurance known as contingent immunization.

To understand how **contingent immunization** works, consider a very simple version based on use of a stop-loss order. Imagine that the present value of the pension liability is \$100 and that the fund has \$120 in assets, entirely invested in stocks. The fund can protect itself against downside risk by maintaining a stop-loss order on all its stocks at a price of \$100. Should the price of the stocks fall to \$100, the fund manager would liquidate all the stocks and immunize the liability.

A stop-loss order at \$100 is not a perfect hedge, because there is no guarantee that the sell order can be executed at \$100. But the sponsor could place a series of stop-loss orders, starting at prices well above \$100. The result would be even better protection against downside risk.

Investing in Equities

If maximization of shareholder wealth is the only goal guiding corporate pension policy, it is hard to understand why a financially sound pension sponsor would invest in equities at all. Yet, in general, pension funds invest from 40 to 60 per cent of their portfolios in equities.⁸ Even a casual glance at the literature suggests that they do so for a variety of reasons—some right and some wrong. There are three possible correct reasons.

First, corporate management may view the pension plan as a trust for employees and manage the fund as if it were a defined contribution plan. In this case, corporate management may believe that a successful policy of investment in equities would allow it to pay extra benefits to employees, hence it is worth taking the risk.⁹

The second possible correct reason is that management believes that superior market timing and security selection will create value (net of management fees and expenses). Even weak-form market efficiency suggests, however, that management cannot create shareholder value simply by shifting pension investment from bonds to stocks. In the absence of superior skills, investing in stocks simply offers shareholders higher expected return at a higher risk level. And when the net cost of providing plan beneficiaries with shortfall risk insurance is

taken into account, increasing equity exposure reduces shareholder value. This implies that it makes sense for a pension fund to invest in equities only *if* it intends to pursue an active strategy of beating the market through superior timing or security selection.

For an underfunded plan of a corporation in financial distress, there is another possible reason for investing in stocks and other risky assets—PBGC insurance. The PBGC's insurance of pension benefits in effect gives the sponsoring firm a put option. The value of this PBGC put increases with the risk of the underlying assets, but the cost of the insurance to the sponsor does not. Before the Single-Employer Pension Plan Amendments Act of 1986, even healthy firms with underfunded pension plans had some incentive to exploit the PBGC put by voluntarily terminating an underfunded plan.¹⁰ The new law has eliminated this possibility.¹¹ Firms in financial distress, however, still have an incentive to invest pension fund money in the riskiest assets, just as troubled thrift institutions insured by the Federal Savings and Loan Insurance Corporation (FSLIC) had similar motivation with respect to their loan portfolios.

Wrong Reasons to Invest in Equities

The notion that stocks are not risky in the long run, because the probability of an equity portfolio shortfall declines with the length of the time horizon, is based on a faulty definition of risk when it comes to pension funds. For defined benefit plan sponsors, the cost of insuring against shortfall risk is a better measure of risk than the probability of a shortfall. As we have shown, the cost of providing this insurance increases with the length of the time horizon.

A related fallacy is the notion that stocks provide a hedge against inflation because they are an ownership claim over real physical capital, and owners of real capital should not be hurt by inflation, which enhances or has no effect on real profits. But even if the real rate of return on stocks is uncorrelated or slightly positively correlated with inflation, the nominal return on stocks would have to be *highly* positively correlated with inflation to make stocks a good inflation hedge in the conventional sense.

Suppose the benefit the sponsor is obliged to pay is indexed for inflation. The best way to immunize an inflation-protected pension obligation is with zero-coupon bonds linked to the price index, not with an equity portfolio. While

stocks may be free of inflation risk, they are not free of stock market risk.

Alternatively, suppose you are a retiree living on a fixed pension, hence concerned about inflation risk. You could eliminate this risk to your real income stream by hedging with CPI-linked bonds. You might want to invest some of your money in stocks to increase your expected return, but by doing so you increase your exposure to market risk. There is no way to use stocks to reduce risk in any significant way.¹²

In any case, the proposition that stocks are a good inflation hedge rests on the proposition that nominal stock returns tend to rise and fall in proportion to changes in the rate of inflation.¹³ In fact, empirical studies show that stock returns have been negatively correlated with inflation in the past, with a low R^2 . This implies that if you want to use equities to hedge inflation risk, you should sell them short, and you will not reduce risk by much at that.¹⁴

Conclusion

Most plan sponsors today have overfunded pension plans and are healthy corporations. In its Omnibus Budget Reconciliation Act (OBRA) of 1987, however, Congress defined the current liability (essentially the accumulated benefit obligation) as the measure of a corporation's pension liability and limited corporate tax-qualified contributions to 150 per cent of this liability. This will drastically reduce the amount of overfunding in pension plans. The results will be a reduction in stock investment by defined benefit pension plans sponsored by financially healthy firms and an increase in immunization strategies using long-duration nominal bonds.¹⁵ ■

Footnotes

1. M. L. Leibowitz and W. S. Krasker, "The Persistence of Risk: Shortfall Probabilities Over the Long Term," *Financial Analysts Journal*, November/December 1988.
2. See R. C. Merton, "Lifetime Consumption and Portfolio Rules in a Continuous Time Model," *Journal of Economic Theory* 1971; R. C. Merton and P. A. Samuelson, "Fallacy of the Log-Normal Approximation to Portfolio Decision-Making Over Many Periods," *Journal of Financial Economics*, March 1974; and P. A. Samuelson, "Risk and Uncertainty: A Fallacy of Large Numbers," *Scientia*, April-May 1963 and "The Judgement of Economic Science on Rational Portfolio Manage-

ment: Timing and Long-Horizon Effects," *Journal of Portfolio Management*, Fall 1989.

3. J. L. VanDerhei, "Plan Termination Insurance for Single-Employer Pension Plans," in Rosenbloom, ed., *The Handbook of Employee Benefits*, 2nd ed. (Homewood, IL: Dow Jones-Irwin, 1988).
4. See, e.g., W. F. Sharpe, "Corporate Pension Funding Policy," *Journal of Financial Economics* 3 (1976), pp. 186-193; J. L. Treynor, "The Principles of Corporate Pension Finance," *Journal of Finance* 1977, pp. 627-638; F. Black, "The Tax Consequences of Long-Run Pension Policy," *Financial Analysts Journal*, July/August 1980; J. Bicksler and A. Chen, "The Integration of Insurance and Taxes in Corporate Pension Strategy," *Journal of Finance*, July 1985.
5. See J. Bulow and M. Scholes, "Who Owns the Assets in a Defined-Benefit Pension Plan?" in Bodie and Shoven, eds., *Financial Aspects of the U.S. Pension System* (Chicago: University of Chicago, 1983).
6. See M. L. Leibowitz, "The Dedicated Bond Portfolio in Pension Funds," *Financial Analysts Journal*, January/February and March/April 1986.
7. Z. Bodie and L. E. Papke, "Pension Fund Finance," in Z. Bodie and A. Munnell, eds., *Pensions and the Economy: Sources, Uses and Limitations of Data* (Philadelphia: University of Pennsylvania, 1991) estimate that in 1986 76 per cent of single-employer pension plans had assets with market values exceeding the present values of the accumulated benefits.
8. *Ibid.*
9. J. O. Light and A. F. Perold, "Risk Sharing and Corporate Pension Policies" (Working paper, Harvard Business School, October 1987).
10. See M. J. Harrison and W. F. Sharpe, "Optimal Funding and Asset Allocation Rules for Defined Benefit Pension Plans," in Bodie and Shoven, eds., *Financial Aspects of the U.S. Pension System*, *op. cit.*
11. K. P. Utgoff, "Pension Reform Strengthens Defined-Benefit Plans," *Compensation and Benefits Management*, Summer 1988.
12. See Z. Bodie, "Inflation, Index-Linked Bonds and Asset Allocation," *Journal of Portfolio Management*, Winter 1990.
13. In other words, in a regression of stock returns against the rate of inflation, the slope coefficient is one.
14. See Z. Bodie, "Common Stocks as a Hedge Against Inflation," *Journal of Finance*, May 1976.
15. Research for this article was supported by U.S. Department of Labor Contract Number J-9-P-8-0097. The contents do not necessarily represent the position of the Department of Labor.

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