The Case for Stock in Pension Funds

OVER THE PAST FEW YEARS, several articles have been published in the financial press claiming that pension funds should not invest in stock. See, for instance, "The Case Against Stock in Public Pension Funds" by Lawrence N. Bader and Jeremy Gold, which appeared in the January/February 2007 *Financial Analysts Journal.* The typical argument against stock investing starts with the assertion that pension liabilities most closely resemble debt (i.e., they are a series of nearly risk-free cash flows extending over a certain period). Based on principles of financial economics, the argument continues, (1) a portfolio of assets that perfectly matches these future cash flows would consist of 100 percent risk-free bonds, and (2) the liability for these future payments should be calculated with the risk-free rates of return on bonds with the maturities matching the timing of the payments.

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The primary goal of this article is to show that stock investments are justified when the cash flows contain economic risk. Moreover, the appropriate discount rate is the expected rate of return of a cash-flow-matching portfolio rather than the risk-free rate. In fact, if the cash flows have economic risk that can be hedged in the market, investing 100 percent of the portfolio in bonds actually increases risk and discounting at the risk-free rate inaccurately represents the liability. These ideas are supported by the principles of financial economics and, in fact, clarify some of the myths about financial economics.

A secondary goal is to point out that while financial economics states that the cost of a cash-flow-matching portfolio gives the unique market price of a series of cash flows, market price and a cash-flow-matching portfolio aren't necessarily useful for meeting a pension sponsor's objectives. In fact, even with risk-free cash flows, the optimal asset allocation may involve investing in stock. Investment strategies and contribution policies involve risk management and capital allocation decisions. Knowing the market value of liabilities may provide useful information for risk management and capital allocation decisions, but market values alone don't dictate one approach to either subject. There are many new tools in financial engineering—and existing methods in actuarial science— that provide flexibility in risk management and capital allocation while maintaining benefit security.

Cash-Flow Matching and Market Liability

It's important to understand that the argument against pension stock investing is very much based on the initial assumptions. In particular, if a future cash flow is risk free, then the market price of that cash flow is the same as the market price of a matching risk-free bond. In fact, financial economics tells us much more in cases where pension benefits contain underlying economic risk. For example, if the benefit depends on an individual's future salary (as is often the case), then future salary growth is an economic component of risk in the benefit. What does financial economics say in this case?

MYTH 1: Financial economics implies pension plans should invest 100 percent in bonds.
FACT 1: Financial economics dictates that a portfolio of assets that matches the cash flows in all scenarios will eliminate economic risk. The matching portfolio may include stock to the extent that stock matches the risk of the cash flows.[1]

MYTH 2: Financial economics implies liabilities must be discounted at the risk-free rate.
FACT 2: Financial economics dictates that liabilities should be discounted at the expected return of the assets in a cash-flow matching portfolio.[2] In the case where the matching portfolio is 100 percent risk-free bonds, the expected return is the risk-free rate. In the case where the matching

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TABLE 1				
Economic Scenario	**Probability**	**Stock Return**	**Bond Return**	**Salary Growth**
Strong Economy	50%	16%	4%	10%
Weak Economy	50%	0%	4%	0%
Expected Value		8%	4%	5%

TABLE 2—PORTFOLIO VALUE AT TIME 1			
Economic Scenario	**Stock Value**	**Bond Value**	**Total Portfolio**
Strong Economy	72,500	37,500	110,000
Weak Economy	62,500	37,500	100,000
Expected Value	67,500	37,500	105,000
Expected Return	8%	4%	6.54%

portfolio is 100 percent stocks (unlikely for pensions), the expected return is the expected return on the stocks.

Debunking the Myths: An Example with Economic Risk

The underlying model in modern financial economics is the notion of the cash-flow-matching, or replicating, portfolio. The idea of the replicating portfolio is that if we can construct a portfolio today that exactly matches all possible future outcomes of a claim in all possible future economic scenarios, then the cost of this portfolio today is the unique market price of that claim. This process is sometimes referred to as perfect hedging and is at the root of models such as the Black Scholes option pricing formula.[3] Perfect hedging would occur when increases in future payments, are exactly offset by increases in future investment earnings.

If we make the assumption that a future payment is a fixed amount at a fixed future date regardless of the future economic scenarios, then a replicating portfolio consisting of a risk-free bond paying that same amount at that same date will be the unique replicating portfolio. The price of that bond today will depend on its yield rate—the risk-free interest rate.

Suppose we now assume that an employee has a salary of $100,000 and the pension plan offers her a lump sum benefit in one year equal to her salary one year from now. Suppose also that the employee's salary one year from now depends only on salary growth.

For simplicity, we assume an economic model with two future economic scenarios, both equally likely—a binomial model. Our market has one stock and one risk-free bond. The assumptions are summarized in Table 1.

Under these assumptions, the benefit promised to the employee will be $110,000 if the economy is strong one year from now and $100,000 if the economy is weak.

Suppose we buy $62,500 worth of stock and $36,058 in bonds today. Our total portfolio value today is $98,558. What happens one year from now? (See Table 2.)

In both economic outcomes, the portfolio is worth exactly the same amount as the benefit. Thus, the portfolio perfectly hedges the economic risk of the benefit. The initial cost of the portfolio is $98,558, and its expected value next year is $105,000. Or equivalently, the expected value of the benefit next year is $105,000, and its present value is $98,558. This is equal to a 6.54 percent rate of return—greater than the risk-free rate of return of 4 percent. Therefore, in these specific circumstances, the principles of financial economics would lead us to conclude:

- The asset mix of the replicating portfolio should be 63 percent/37 percent stocks/bonds.
- The discount rate for the market value of the liability should be 6.54 percent, not the risk-free rate of 4 percent.

However, before continuing, it's important to note that this binomial model is very simplistic. It was set up so that the salary growth risk could be fully hedged with the stock and the bond. In the real world, the best we can hope for is partial hedging. Moreover, this specific example was set up to create a high equity allocation to illustrate the point that equities should not be ignored. In general, the binomial model will generate different asset mixes under different assumptions. Nevertheless, the principles illustrated with the binomial model are sound: Stock can be used to reduce risk in pension plans, and the expected return on assets is the appropriate discount rate.

How Did We Wind Up with 63 Percent in Stocks?

To the extent that salary growth is an economic risk and to the extent that stocks even partially hedge that risk, stocks can be used to hedge risk in a pension plan. In the binomial model, this is completely achieved. In a more robust model, we can use correlations between salary growth and various asset classes to develop a matching or near-matching portfolio in much the same way. In fact, when the benefit contains economic risk, using a portfolio entirely consisting of bonds would increase the risk of the pension plan by mismatching assets and liabilities.

Why Don't we Discount at the Risk-Free Rate?

The use of a discount rate other than the risk-free rate can be justified only under financial economics when it is the expected rate of return on the replicating portfolio. Any other portfolio that has a mismatch of liabilities and assets would result in a different rate of return and wouldn't be appropriate.

There's no trick here, just a technicality. In practice, there are two alternatives for calculating the market value of the liability when salaries are involved. Either:

(1) Project the salary with the expected salary growth and discount the benefit with the expected return on assets, or

(2) Project the salary with the risk-adjusted salary growth and discount the benefit at the risk-free rate.

In the case where the benefit is fixed and is independent of the economic scenarios, the salary-growth assumption doesn't come into play and the outcome is that we must use the risk-free rate.

In this example, the risk-adjusted salary growth assumption is 2.5 percent.[4] Under the first approach, the market value of the liability is:

$100,000 × 1.05 / 1.0654 = 98,558.

Under the second approach, the market value of the liability is:

$100,000 × 1.025 / 1.04 = 98,558.

For the practicing actuary, the choice of all economic assumptions must be internally consistent. If the risk-free rate is used to discount liabilities, then a risk-adjusted salary growth assumption must also be used.

Cash-Flow Matching Isn't Always Optimal

Suppose we return to the example of a future payment that is a fixed amount at a fixed future date, regardless of the future economic scenarios. In this case, the replicating portfolio consisting of a risk-free bond paying that same amount at that same date will be the unique replicating portfolio. This can be extended to a fixed series of cash flows that don't depend on future economic scenarios. The cost of a portfolio consisting of risk-free bonds that exactly match those cash flows would be the unique market price. But would it be optimal to invest in such a portfolio? Not necessarily. In a recent article, authors Moore and Young show how an optimal investment strategy may involve as much as 40 percent equity, not 100 percent bonds—even in the case with a fixed series of cash flows.

More precisely, suppose a retiree has a retirement account, will receive no future income, and has fixed future consumption needs. Moore and Young investigate the retiree's optimal investment strategy needed to minimize the probability of ruin (where ruin is defined as running out of money before death). The result? If the retiree's account balance is at least as great as the market value of her liability, she should invest in the cash-flow-matching portfolio. However, if she doesn't have enough to fully match cash flows, investing 100 percent in bonds will make ruin a certainty. If she takes on any stock risk, she will have a chance (a non-zero probability) of achieving gains that will meet her consumption needs. Moore and Young go further in their analysis of the optimal investment strategy and show that in general, the less "well-funded" the retiree is, the more risk she should take. The optimal solution requires stock even when the cash-flow-matching portfolio is 100 percent bonds.

There are other examples that use sophisticated tools of financial engineering to show that optimal investment strategies for pension plans can result in the same portfolio allocations as the traditional Markowitz portfolio selection. The definition of optimal depends on the needs of the investor (or plan sponsor), but the results can be quantified and explained quite specifically. The tool in this case is stochastic optimal control, one of the most sophisticated available in financial engineering.

Perhaps the most surprising aspect of stochastic optimal control is that optimal decisions are based on the expected return of the portfolio (which may include stock), not the risk-free rate. The market value of a liability is a snapshot at a point in time. Stochastic optimal control looks over the entire investment horizon and allows continuous changes to asset allocations and contributions. In the case where asset allocations are fixed, stochastic optimal control can still be used to determine optimal contribution strategies over time.

A traditional actuarial valuation is another tool that determines a contribution strategy that meets a plan sponsor's objectives based on an investment policy. Stochastic optimal control and traditional actuarial valuations share properties in that they consider long investment horizons and make determinations based on the expected return on assets. Stochastic optimal control has an advantage in that the allocations can be allowed to vary over time. However, for actuaries who don't have a say in investment policy decisions, the traditional actuarial valuation using the long-term expected return on assets is a well-established tool for determining contributions. In fact, if the plan sponsor's objective is to have contributions that are stable over time as a percentage of payroll given a fixed-investment strategy, the aggregate method can be shown to be optimal or nearly optimal using stochastic optimal control.

Conclusion

Clearly, it wouldn't be prudent to switch a pension plan's investment strategy based on simplistic examples. The purpose of such examples is to illustrate that certain risks inherent in pension plans can be reduced (or increased) by matching (or mismatching) the assets and the liabilities. If we start with a simplistic example with no economic risk, then the logical outcome of hedging is creating a portfolio with no economic risk. By the same logic, if there is economic risk in the benefits promised by a pension plan, there should be matching economic risk in the assets in a fully hedged portfolio.

Benefits that depend on future salary bear some economic risk. The principles of financial economics clearly dictate that we must take these economic risks into account to determine the market value of liabilities. The cash-flow-matching portfolio will contain stock to the extent that the stock successfully hedges economic risk in the benefits promised.

The market value of liabilities provides a snapshot of the cost of fully hedging an obligation. Long-term investment and contribution decisions regarding an obligation must be based on more than the market value alone. There have been major advancements in financial economics and the financial markets that enhance our ability to provide more in-depth risk management and assist in capital allocation decisions. However, these advancements don't dictate that pension plans should entirely divest from stock. On the contrary, financial economics dictates that we must consider the economic risk and use the available tools to determine optimal asset allocations and contribution strategies.

As actuaries, we must take care when explaining a change in methodology such as reporting a market value of liabilities where the market value has been reported before. Consider the case of public-sector pension plans where disclosing market value of liabilities is not currently required and is rarely done. If the change in measurement appears to cause unfunded liabilities to increase at a time when the political environment calls for tax cuts, some feel that the change would be misused to justify a switch from defined benefit plans to defined contribution plans.

Defined contribution plans have the appeal that they have no unfunded liability. Or do they? Employers don't have to report any unfunded liability for a defined contribution plan, but this effectively pushes the unfunded obligation onto the individual, and it never gets measured. For an individual in a defined contribution plan, the true unfunded liability is the present value of future income needs less his or her current account balance. Since nothing of this kind is ever calculated, the overall retirement security of the population isn't transparent in defined contribution plans; it's completely ignored. ●

Notes

1. H.H. Panjer, Ed. *Financial Economics, With Applications to Investments, Insurance and Pensions.* The Actuarial Foundation 1998. See Section 5.2.4, "Valuation of Cash Flows"

2. Ibid. Theorem 5.2.3, (Fundamental Theorem of Asset Pricing)

3. R.C. Merton. *Continuous Time Finance.* Cambridge, Mass. Blackwell, 1990

4. *Technical Note:* In general, the risk-adjusted salary growth assumption will depend on the correlation of salaries and stocks (or other risky assets). Suppose r is the risk-free rate, the stock has expected return i and standard deviation s, the salary has expected growth k with standard deviation j, and the correlation coefficient between stock and salary is ρ. Then the risk-adjusted salary growth assumption is $k^* = k + \rho\ j\ (r - i) / s$. Alternatively, the risk-adjusted salary growth assumption is the expected value of salary growth with respect to the risk-neutral probabilities.

5. K.S. Moore and V.R., Young. Optimal and Simple, Nearly Optimal Rules for Minimizing the Probability of Financial Ruin in Retirement. North American Actuarial Journal, Volume 10, Number 4, October 2006.

6. A.J.G. Cairns, Some notes on the dynamics and optimal control of stochastic pension fund models in continuous time. ASTIN Bulletin 30: 19-55

7. T. Björk. Arbitrage Theory in Continuous Time. Second Edition. 2004 Oxford University Press. See "Stochastic Optimal Control"