Investors,

balancing abroad the ongoing concern with the consequences of a soft freeze. A few have even threatened to terminate the plans completely, with no further accruals even for the current employees, a “hard freeze.” Some plans have already instituted a hard freeze, and in high-profile moves, a few more have filed for bankruptcy to off-load their liabilities to the Pension Benefit Guaranty Corporation (PBGC) to avoid the ongoing labor cost associated with these benefits. Certainly, few sponsors are starting new DB plans. U.S. sponsors are telling us that if the proposed change to mark-to-market accounting for pension assets and liabilities is adopted, this nascent trend will accelerate.\(^1\) And if we look abroad, our plan sponsor cousins in the United Kingdom seem to have anticipated this malaise and have entertained it to an extreme: Most corporate DB plans there are now closed to new entrants and will “wind up” over time as existing participants work their slow way through the system.

Why is there a threat? From our conversations with sponsors, we think it is because DB pension plans are perceived as too dangerous, exposing the balance sheet and income statement to volatility that the sponsor doesn’t feel able to control, and because they expose the cash flow statement to wildly fluctuating demands for supporting contributions. Many sponsors, both corporate and public, do not see these risks as being manageable. Moreover, sponsors sense that these plans are more costly than can be justified. These concerns have been repeated often enough to take on the appearance of truth. For many executives, it seems to be a foregone conclusion that the DB plan has to go.

Although experience to date using current pension management technologies does justify these concerns, the problem is in the technology used to manage risk and cost; it is not intrinsic to the basic DB plan structure. And the good news is that we do, in fact, have better technologies today than we have been using in the past for managing these risks and controlling these costs. DB plans don’t have to feel “out of control.”\(^2\)

The actuarial cost management and asset/liability management (ALM) technologies that are in widespread use right now are daily proving themselves inadequate to their tasks, and those who use them share the perception that DB plans are not controllable. So, until the newer technologies are more widely understood and adopted by most pension plan advisers, this perception is understandable even if incorrect.

And if this perception leads sponsors to consider terminating their plans, it is an unnecessary tragedy, because DB plans are the only way that adequate retirement benefits can be provided to most employees. The emerging substitute for these plans, defined-contribution (DC) plans, have many flaws and, while beneficial to some employees, stand no chance (in today’s practical DC environment) of providing anything like an acceptable retirement income for most workers. Although the difference between DB and DC outcomes doesn’t have to be as great as it actually is, low contribution rates, misdirected purchasing practices for investment management services, liberal participant loan policies, and other matters effectively cripple U.S. DC plans. With median balances of $44,000 at retirement,\(^3\) they are not retirement plans at all (see Waring and Siegel 2006).\(^4\)

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M. Barton Waring is chief investment officer for investment policy and strategy, emeritus, at Barclays Global Investors, San Francisco. Laurence B. Siegel is director of research in the Investment Division of the Ford Foundation, New York City.

\(^1\) D. J. Tischler and B. G. Karl, “Pensions—Still a Problem for Main Street?” Business Week, April 14, 2003, p. 43.


\(^3\) Assuming a 3.0% rate of return.

The basic elements of the financial technology required to manage pension risks and costs have been around for a long time now. To be put to work, these elements have only needed to be synthesized into a general approach to cost management and to investment policy management—a synthesis that has been accomplished over the past few years. Our goal in this article is to outline the key ideas of this synthesis and to demonstrate that controlling the costs and risks to an acceptable level is within the reach of any plan sponsor. We hope to encourage sponsors to continue offering DB pension benefits, and we know that they need to feel in control of their risks and costs if they are going to do so.

We begin by comparing DB and DC plans. We then show how a pension liability can be understood in terms of its economic or market-related components (i.e., understanding it in terms of risks that we can do something about). With this understanding, we can begin to understand and control the benefit level, and thus the cost level, for DB plans and to match assets to the liability in the dimensions of financial risk that matter—by creating what financial economists call a “hedging portfolio.” We then discuss the use of surplus optimization to add, in judiciously chosen quantities, a “risky-asset portfolio” containing equities and other nonhedging assets.

Empowered with these tools, sponsors can provide retirement benefits that are secure, meaningful in size, appropriate in cost, and not dependent on extraordinary savings and investment behavior by individuals. The social as well as personal benefits of a meaningful system for spreading one’s working life income over one’s entire life are hard to overstate. And through salary negotiations, these benefits can be shared between employer and employee, producing a “win” for both parties relative to a replacement DC plan.

Why Save DB Plans: Advantages over DC Plans

Unlike typical DC plans, DB plans regularly create a number of gains from trade—a familiar concept from Economics 101. When two parties trade, both parties expect to be better off, and in some transactions, they are much better off. (Consider a farmer with only meat and no potatoes and another farmer with only potatoes and no meat.) In this section, we identify the sources of the gain from trade in DB plans and provide an example in which we put a rough dollar value on it.

The trade in this case is of labor for total compensation, and the opportunity for this gain lies in the level and regularity of the deferred (DB plan) component of compensation and how its payout is structured. Instead of receiving immediate compensation for all of their labor, participants in a DB plan accept a professionally managed deferred-compensation scheme for part of it. This compensation is guaranteed for the rest of their lives. If they had received all compensation as current compensation, they would have been individually responsible to save a substantial part of it, invest it wisely and at low cost, and then find an exit strategy upon retirement that protects against the risk of outliving one’s money. The DB plan does all this saving and annuitization for them.

Both parties benefit because a natural outcome of labor negotiations is that the lagniappe of the gain from trade is inevitably shared. (We do not need to know the exact split of the gain from trade between employer and employee to make our point.) In other words, both the employee and the employer get more than they pay for, as a result of participating in and sponsoring the plan.

It is theoretically possible to design and sponsor a DC plan that incorporates design features to match each of these advantages of a DB plan, but (at least in the current U.S. regulatory and legal setting) this is not being done nor is it likely to be done in the foreseeable future. Like a DB plan, a DC plan could incorporate higher, forced contribution rates; no loans; sponsor management of policy and active investment decisions; institutional-level fees; and sponsor annuitization of balances at retirement. A dollar of contribution to a DC plan could produce a level of ultimate benefits identical to those of a DB plan if all were set up appropriately for that purpose. But such a design is easier envisioned than executed, and we don’t see it happening any time soon. As a result, when a DC plan replaces a DB plan in U.S. practice today, the gains from trade are lost. Both parties wind up wasting money, destroying value, and reducing the employee’s retirement-income replacement ratio to a level dramatically below what it could be.

**Longevity Risk and the Insurance Principle: Annuitization.** Longevity risk is the risk that one will outlive one’s money. To manage this risk as an individual—as employees in DC plans are typically forced to do—one would have to save enough to live at the desired level of comfort to the extreme outer limit of his or her possible life span, say age 105 or so. In contrast, a DB plan, with its fairly priced, sponsor-provided annuitization, needs to be funded only to the employee’s lifetime expectancy, which is a much younger age than the extreme limit and thus requires a much smaller amount of savings. This characteristic is the biggest advantage of current DB
plans, and it makes such plans vastly less costly, in present value terms, to fund a retirement than other plans are. The reason for the cost savings in DB plans is that those who die sooner help “pay” for those who outline their life expectancy. A large pool can be run as if each participant’s life span were almost perfectly predictable, because the pool manager need worry about only the average life expectancy across the group, not about individual deviations from it. This elimination of risk through pooling of lives is known as “the insurance principle.”

We can easily measure the savings from the insurance principle. First, we determine the amount that is required to fund a single-payment life annuity for a male retiring today at age 65. This annuity is assumed to pay $100,000 per year for the rest of the annuitant’s life. Using “modified” life tables that account for projected increases in life expectancy, we calculate that a sponsor would have to set aside $1,180,000 to fund this annuity at current interest rates. This figure is a good proxy for what a DB plan annuity might cost today in market-value terms.

We can now compare this price with the value of a bond portfolio that our retiree would have to accumulate on his own to provide this exact same level of unannuitized annual income on a riskless basis over the 40 years from age 65 to the maximum age of 105. The amount that would be needed in the bond portfolio, at current interest rates, is $1,802,431.

Compared with what is needed to provide this income to an unannuitized retiree, a DB annuity requires 35 percent less accumulated savings to provide the same guaranteed lifetime stream of payments! A DB plan thus creates a very substantial “gain from trade” by providing a convenient and fairly priced mechanism for annuitization. Sponsors owe it to themselves and their employees not to throw this huge gain from trade away.

We should note that, in theory, an annuity option could be added to a DC plan to capture that roughly 35 percent cost advantage. In practice, however, most DC plans just don’t foster sufficient accumulation for the benefit of annuitization to be meaningful even if it were offered.

The large magnitude of the gain from annuitization shouldn’t be a surprise: As George Burns is reputed to have said, “If you live past 100, you’ve got it made. Very few people die past that age.” Few people live to their maximum possible age, and some live only a short time after their retirement. The rest lie somewhere in between, spread out over time, with the average being at the predicted life expectancy (more or less). This fact is the basis for the insurance principle, and because of it, if everyone were actually “fully funded” in their conventional unannuitized DC plans, there would be a lot of unspent or “excess” deferred compensation. This excess does not happen with a DB plan.

But woe be to you if you do live past your life expectancy and your money is all in a DC plan, unannuitized—and spent.

Other Gains from Trade in DB Plans. Some smaller, but still important, gains from trade also arise from DB plans.

Skillful investment management. DB plans are generally managed by an in-house staff of skilled investment professionals who, in turn, place the assets with a number of other carefully chosen outside investment managers. The in-house professionals’ most important tasks are (1) to allocate among asset classes so the plan will be on the efficient frontier at a risk-appropriate location and (2) to select managers that have a fair expectation of earning a positive active return after fees and costs.

In contrast, DC plans are managed by the employees themselves—most of whom have neither the skill to select “good” managers nor access to any managers beyond those on their list. Almost all DC-plan investors—employees managing their own money—cannot get to the efficient frontier for lack of appropriate asset-class building blocks, nor can they identify a risk-appropriate location on it. Asking employees to be their own chief investment officers is not reasonable; they are experts in the job they’re doing, not in managing investment portfolios. Life-style funds (originally called by the more descriptive but less marketing-driven name “pre-mixed strategic asset allocation fund families”) were developed to address this issue but are still used by only a small portion of the DC population. For these reasons, the average DC plan participant’s realized realized alpha is likely to be negative in the amount of fees and costs, plus random noise.

A significant gain from trade, then, arises from the difference in investment return between a professionally implemented portfolio on the efficient frontier at an appropriate risk level and the almost surely inefficient and random portfolio that results when employees cobble one together on their own from whatever funds the sponsor has made available.

Wholesale levels of investment fees and other costs. Even if they had no greater investment skill than the employees, professional investment managers of large sponsor asset pools can take advantage of volume pricing. Investment fees are high for individual investors and much lower for institutions. The average fees for U.S. equity funds in most DB plans are well under 0.5 percent a year, whereas many retail mutual funds (as used in most DC plans) come in well above 1.0 percent a year.
This difference in fees and related investment costs is another component of the gain from trade in DB plans and is quite large. If a DB plan pays an average fee of 0.5 percent and DC plan participants pay 1.25 percent, that difference compounds to 23.2 percent of a given amount of invested capital over a working lifetime of 35 years. This factor provides another big savings for a DB plan relative to a typical DC plan. And we have not even counted the postretirement years!

**Summary Comparison.** Exhibit 1 summarizes the advantages and disadvantages of DB and DC plans from the viewpoint of the employee.

For employers, DC plans have many appealing features. The out-of-pocket deferred component of employee compensation, and particularly the employer contribution or “match,” is always far less in a DC plan than the contributions required in DB plans (a switch to DC may represent a reduction in total compensation, and that reduction may not be apparent to all employees). Administrative costs tend to shift to the employees as well. And DC plans are always “fully funded,” in an accounting sense from the sponsor’s perspective. (But watch out—they are not anywhere near fully funded with respect to the retirement income needed by employees, as we’ll soon note.)

From the employee perspective, DC plans also have some appealing features. First, DC plans are flexible. Employees who cannot afford to save are not required to do so, and for those who can save larger amounts, the plans provide a tax-advantaged savings vehicle. Employees can borrow against their DC savings. Moreover, DC-plan balances are entirely portable by design, and nothing—other than poor investment returns—can take away the value that an employee has set aside. For many employees, especially those in industries where a typical career path involves having many employers, portability is the decision variable that trumps all others.

<table>
<thead>
<tr>
<th>Exhibit 1. DB vs. DC Plans</th>
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<tr>
<td>Characteristic</td>
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<tr>
<td><strong>Investment characteristic</strong></td>
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<tr>
<td>Quality of strategy</td>
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<td>Can strategy be customized to employee’s personal situation?</td>
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<tr>
<td><strong>Cost of investment management</strong></td>
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<td>Who keeps unexpected investment gains?</td>
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<td>Who keeps unexpected investment losses?</td>
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<tr>
<td><strong>Funding and payout characteristics</strong></td>
</tr>
<tr>
<td>Forced savings</td>
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<td>Portability</td>
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<td>Ability to hedge longevity risk</td>
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<tr>
<td>Ability to hedge timing-of-retirement risk</td>
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<tr>
<td>Can contribution rate be customized to employee’s personal situation?</td>
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<tr>
<td>Can employee borrow against plan balance?</td>
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<td>Can plan balance be bequeathed?</td>
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aAt extreme levels of underfunding, investment risk is shared with the employee because a sufficiently underfunded plan will be taken over by PBGC, which pays only limited benefits. Note that PBGC is currently in a substantial deficit position, with no clear requirement that the federal government must stand behind it. Public employee plans have no PBGC protection. If the Pension Protection Act proves effective, most plans will be healthier in the future, although some may experience pain in the near term.

bSome benefits (per Section 414 of the Internal Revenue Code) provide that the employee is entitled to be paid any annuity benefit previously determined, in whole or in part, by the employer. These benefits are not subject to sharing with the PBGC. In such cases, the employee is protected; however, if the plan is underfunded and PBGC becomes its administrator, the employee’s protection is removed.
If we are going to have DC plans, we had better run them well. In our writings, we’ve supported efforts to improve DC plans by suggesting fund choice designs that are both mean–variance efficient—maximizing the expected portfolio return at each given level of risk—and cost-efficient (see Waring and Siegel 2006). These designs, alluded to earlier, are a family of well-engineered, premixed asset allocation funds (life-style funds) communicated to the employees in a manner that emphasizes the special benefits of being on the efficient frontier. We’re pleased to report that our proposals are meeting with growing acceptance and, where used, are proving their ability to make DC plans more effective, although such designs still represent only a small share of total DC plan assets.

DC plans have some profound shortcomings. We have focused thus far on longevity risk, lack of investment skill, and high investment costs. But the question of forced savings is equally, perhaps even more, important. Many U.S. employees contribute little or nothing to the DC plans they are offered, and today in the United States, these people cannot legally be required to contribute more. In addition, what is saved is often borrowed through loan provisions or otherwise withdrawn for legally allowed purposes. The Employee Benefit Research Institute (EBRI) has reported that the average DC plan balance is $150,000 at retirement; at the annuity rate discussed earlier, this converts to a meager $11,775 annual income supplement for life. And that figure is the average of a highly skewed distribution. The median balance is only $44,000.13

Unless their contributions increase dramatically as they age, few DC participants will have an accumulation at retirement sufficient to provide a meaningful contribution to their retirement income. And for most participants, the money just gets spent; no annuities are purchased at all. They will have to rely solely on other savings and their Social Security benefits.

In contrast, DB plans have the tremendous advantage of providing forced savings at a level sufficient to pay for a meaningful retirement benefit. The savings rate is not visible to the employee, however, so it doesn’t come with a perception that it is forced—even though it should be clear to all that the accumulated savings represented by the retirement plan promise can only be a form of deferred pay. Although the same savings rate could be required explicitly in a DC plan, there is just enough of a libertarian streak in the American public that mandatory contributions are unlikely to ever become a reality.

Let’s revisit the notion that DC plans are always “fully funded.” Although DC plans appear from the point of view of the employer’s balance sheet to be fully funded—there will never be any net balance sheet liability associated with them—that is not the whole picture of funding status. From the employee’s perspective, he or she is only rarely fully funded to a level that will provide anything like an acceptable retirement-income replacement ratio. The retirement liability of the vast majority of employees in today’s U.S. DC plans will not be fully funded in a manner meaningfully equivalent to even the most parsimonious DB plan. Instead, the retirement liability is barely funded at all, as we’ve shown with our data on mean and median plan balances.

Taking all these factors into consideration, it’s clear that few employees can ever expect a secure and prosperous retirement with reasonable income replacement from the DC-plan structure alone; for most, it is, at best, a very small contributor to retirement income. It is small enough that we are kidding ourselves when we even speak the phrase “defined-contribution retirement plan.” As they are typically configured today, they aren’t retirement plans at all, but modest savings plans. They might supplement a DB plan or other retirement income in small ways, but they aren’t replacements for them.

If a DC plan is all that you have, it can be improved. Given a choice, however, and in today’s regulatory and practical environment, even a DB plan with comparatively limited benefits provides a much better retirement than any but the most generous, well-designed, and appropriately annuitized DC plans that we see in practice today.

Managing Risks and Costs of DB Plans

We acknowledge that many sponsors experience the risks and costs of DB plans as unmanageable and overwhelming, but if one applies sound investment and management risk-control principles, it just isn’t so. The answer: If sound investment risk and management risk controls are applied, the risks and costs can be managed. Here, in grossly shortened form to demonstrate their simplicity, are the three principles for investment risk control:

- The hedging portfolio. A sponsor should hedge those risks that can be hedged. In formal finance language, the sponsor should hold some portion of the plan in a portfolio designed to hedge out the primary risks of the liability (which are risks related mostly to real interest rates and inflation). This need for hedging reinforces the prescription to look at the liability in economic, rather than in traditional actuarial, terms.
The risky-asset portfolio. If desired, the sponsor may take additional risk to try to achieve excess returns to help pay for the plan. Again in formal terms, the DB plan can hold a risky-asset portfolio, which is found by moving upward and to the right along the surplus efficient frontier. (The surplus efficient frontier is the analogue to the asset-only efficient frontier but with the pension liability held short so that the mean return and variance of return are for the pension surplus—that is, assets minus liabilities.) This step would mean, for example, holding an equity portfolio and/or other securities that are expected, at least on average, to outperform the liability-hedging portfolio. Notably, these risky assets can be held without abandoning the goal of having the asset portfolio hedge out all of the interest rate–related risks of the liability; that is, the liability can be completely hedged and the portfolio can also be exposed to risky assets at any place on the frontier.

The alpha portfolio. Those sponsors that want to seek additional value from active management decisions and that have the special skills required have opportunities to do so.

Readers who are experienced with investment theory will recognize this approach as a version of the “two-fund separation theorem,” stated here in the form that is required in the presence of a liability.

Because DB pension liabilities are generally bondlike in nature, the primary risks that can be hedged include inflation risk and real-interest-rate risk (and perhaps a small amount of equitylike risk). So, if a plan fully hedges these two interest rate–related risks by holding a liability-hedging portfolio with similar exposures, it will be about 80 percent of the way to a riskless pension plan. The risks are no longer unmanageable (most have been managed), nor are they overwhelming. Other risks remain that cannot be hedged, of course. But the risks that remain need not be all that large if properly managed.

If the sponsor decides to expose the portfolio to some measure of market risk through a risky-asset exposure, which is fairly rewarded in expectation, the sponsor is clearly in control of that decision and can choose as much or as little additional risk as desired. We believe that most sponsors are comfortable with taking on a measured amount of risk for a fair purpose, such as increasing expected return. And if that risk is properly controlled, sponsors need not avoid it.

In fact, nearly all sponsors today hold a good deal of equities and other risky assets. Sponsors who want to reduce overall pension risk might decrease this particular risk exposure, but there is no reason to expect risky-asset holdings to go away.

There is, however, every reason to expect to see sponsors begin to hold a hedging portfolio, canceling the interest rate risks held short in the liability with opposing long positions. This risk reduction opportunity is too important, and too easy, to pass by once it is pointed out.

The first element of “new” technology needed to manage DB plan risk and cost is an economic view of the liability. The only risks that are helpful to know about are the risks that can be hedged through investing the assets. Such risks are those in the liability that are market related—that is, correlated with the returns of assets or indices available in the markets. Therefore, sponsors need to set aside the actuarial and accounting views of the liability and rediscount the cash flows at appropriate, market-related rates. Plus, they need to understand how these market-related values, economically sensible measures of periodic pension cost, and economically required contributions change as market interest rates change.

Using accounting values as drivers of this risk-control process does not make sense because those values are often heavily smoothed and otherwise manipulated. First, a smoothed liability cannot be hedged (no matching asset is available). Second, the accounting numbers may be somewhat disconnected from the economic truth. Third, over time, the accounting must always follow the economics. It cannot be otherwise. So, if you manage the economics, you will have also managed the accounting.

Using this notion as a starting point, one can develop a model of the liability to use in “surplus asset allocation” (that is, asset allocation in the presence of a liability). We start by noting that every liability is someone else’s asset. So, the “economic” model of the liability will have the same form as a model of the return on an asset or portfolio of assets. The simplest and most familiar such model is the single-factor capital asset pricing model:

$$R_{port} = R_f + \beta_{port} r_{mkkt} + \alpha_{port},$$

(1)

which links the return on an asset or portfolio ($r_{port}$) to the excess return (risk premium) of the stock market (denoted by $r_{mkkt}$).

Researchers have noted that many assets are sensitive to risk factors other than the movement of the stock market. Interest rates and other risk factors are also important. So, a multifactor model of an asset might be

$$R_{port} = R_f + \beta_{1} \eta_{1} + \beta_{2} \eta_{2} + \beta_{3} \eta_{3} + \ldots + \alpha_{port},$$

(2)
where $\beta_1$, $\beta_2$, and so on, are systematic, market-related risk factors that influence the return on the portfolio. A risk factor can be called systematic if the return on that factor can be obtained from an index fund or from a portfolio constructed according to another simple, mechanical decision rule. Thus, nominal or real interest rates and inflation are systematic risk factors in the same sense that exposure to the stock market is a systematic risk factor.

A DB pension liability is the present value of a set of forecast cash flows to be made for benefit payments. Thus, its size is influenced primarily by interest rates rather than by the stock market or other factors. Moreover, the nominal interest rate has two major components: the inflation rate that is expected over the life of the bond, denoted by $i$, and the real interest rate (i.e., the nominal interest rate minus inflation), denoted by $r$.

In this analysis, the distinction between the real-interest-rate component and the inflation component is important because a DB pension liability is sensitive to each in a different way. For example, the liability for an active employee whose pension is based on final pay is very sensitive to the amount of inflation experienced between the time a unit of pension benefit is earned and the time the final rate of pay is determined (because wage inflation affects final average pay). In contrast, once the pension payment is set at the time of retirement—a pension that is made in nominal terms, with no cost-of-living adjustment (COLA)—it is not sensitive to inflation.

So, we must keep track of the sensitivity of the overall DB plan liability, $L$, to each of the two major components of the nominal interest rate. A “pretty good” model of the liability’s return is the sum of the risk-free rate [in this case, one appropriate to the long time horizon of the liability, $R_{f[LT]}$] and factor returns related to capital appreciation returns when 1) real-interest-rate levels change, $\Delta r$, or 2) inflation changes, $\Delta \pi$.\footnote{19}

$$R_L = R_{f[LT]} + \beta_1(\Delta r) + \beta_2(\Delta \pi) + \alpha_L.$$  

Putting some plausible numbers from a typical corporate plan into Equation 3, we find that the liability would have a return as follows:

$$R_L = R_{f[LT]} + (-15)(\Delta r) + (-8)(\Delta \pi) + \alpha_L.$$  

Note that we have reduced the liability model to two factors (other than the long-term risk-free rate): 1) sensitivity to real interest rates and 2) sensitivity to inflation—plus a nonfactor residual return, alpha. There is some method to our reductionist madness: These two factors happen to be the same two risk factors that we can hedge through investment policy; of course, the alpha, or residual liability risks, cannot be hedged (because alpha is by definition uncorrelated with asset-class returns) but must be managed through non-investment-related business practices.

Here is the payoff to understanding the liability return: If we can hedge away the two interest rate–related risks in the liability by holding a hedging portfolio on the asset side, we have eliminated most of the risk of sponsoring a DB plan.

**Hedging the Market-Related Risks in the Liability: Dual Durations.** We now need to find the investment portfolio that hedges the real-interest-rate risk and inflation risk in Equation 4 as fully as possible. This task turns out to be surprisingly simple. All assets have two durations—a sensitivity to real-interest-rate risk and a separate sensitivity to inflation risk—not the single, ordinary duration used to measure the sensitivity of the price of a nominal bond to changes in nominal interest rates (see Siegel and Waring 2004; Waring 2004a). Only for nominal bonds do the two durations happen to have the same numerical value, a natural result of having a fixed cash flow in the pricing formula numerator. For all other assets—equities, Treasury Inflation-Protected Securities (TIPS), real estate, and so forth—and for liabilities, which are simply someone else’s assets, the two durations differ. TIPS provide the clearest example of dual duration: Their sensitivity to changes in the real interest rate is much like that of a nominal bond of comparable maturity, whereas their sensitivity to changes in inflation is essentially zero. In other words, because all of the cash flows in a TIPS are fully indexed to inflation, the price of a TIPS does not change when the inflation rate changes. The dual duration of typical long-dated TIPS may be written as the ordered pair (15, 0): The real-interest-rate duration of the TIPS bond is 15 “years” (or, more expressively, 15 percent; that is, its price falls by 15 percent for each 1 percentage point rise in the real interest rate). The inflation duration of the TIPS is zero.

The dual duration of a nominal bond of comparable maturity can be written (15, 15). The pension liability described in Equation 4 has a dual duration of (15, 8).\footnote{20} And U.S. equities, as proxied by the S&P 500 Index, have a dual duration that has been estimated at approximately (8, 0).\footnote{21}

**Hedging Portfolio Only.** By recognizing that all assets and liabilities have dual durations, we can find an asset/liability portfolio that is fully hedged to the liability in both dimensions of duration. This solution, sometimes called the “liability-matching portfolio” (located at the extreme left end of the surplus efficient frontier), is a hedging portfolio that uses only nominal bonds and TIPS (see Siegel and Waring 2004). For this portfolio, the plan is assumed to have a liability with a dual duration of (17.5, 7.6)
and assets equal in dollar size to the liability. A portfolio of fixed-income investments that is fully hedged to the liability, by also having a dual duration of (17.5, 7.6) if fully funded, would consist of 51.6 percent nominal bonds with a duration of 15.0 and 48.4 percent TIPS with a real-interest-rate duration of 20.17.

This portfolio has a large weight in TIPS, and the real-interest-rate durations are quite long—longer than what the T-bond market typically has to offer. Strips and/or leverage (through swaps or futures contracts) can often be used, however, to achieve the needed durations through an appropriately engineered and maintained overlay.

Adding Equities to the Mix. Some analysts, having found a way to build a portfolio of pension assets that is fully hedged to the liability in both dimensions of duration, would stop at this point. Just about all pension plans, however, also include exposures to the full range of market instruments beyond those required simply for hedging the liability. These market instruments include equities and other risky assets, sometimes held in large proportions. So, we now incorporate a risky-asset portfolio in the analysis.

Most readers are familiar with the concept of an efficient frontier. Figure 1 shows asset-only and surplus (asset minus liability) efficient frontiers. The asset-only efficient frontier is a curve that extends from the lowest-risk, lowest-return portfolio (which consists mostly of cash) at the lower left corner to the highest-risk, highest-return portfolio at the upper right corner. From among the portfolios on this frontier, no single best portfolio exists; the portfolio that is best for a given investor depends on the risk aversion of that investor.

The same principles apply to a surplus efficient frontier used for developing an asset/liability policy portfolio. The fully hedged pension portfolio, with real-interest-rate risk and inflation risk essentially eliminated, is the minimum-risk point on the surplus efficient frontier and is shown in Figure 1 as the liability-matching or hedging portfolio. (Note that the liability is visible below the x-axis as a mirror image of this minimum-risk portfolio.) The pension manager may, and usually will, choose a riskier point on the frontier in the hope of earning a higher average return over time and reducing the plan’s contribution requirements. Such a portfolio combines the hedging portfolio with the risky-asset portfolio. This risky-asset position can be described in terms of its “surplus beta” to underline that it is risk taken on beyond what is needed to hedge the liability. How much surplus beta risk should be taken depends on the risk tolerance of the sponsor: The sponsor is in total control, able to choose from zero surplus beta exposure all the way up to a great deal of it.

Figure 1. Surplus Efficient Frontier
(in asset space)
Several second-order effects occur when a risky-asset portfolio is introduced into the mix, and they need to be identified for a complete understanding of how the surplus optimal solution varies from current practice. First, equities and most other components of the risky-asset portfolio have, among their many risk-factor exposures, both real-interest-rate risk and inflation risk—the dual durations. So, some portion of the dual-duration exposures needed to hedge the liability may actually come from the risky assets. Waring (2004a, 2004b) discussed the mathematical details of this interaction. But obtaining the liability-hedging and risky-asset exposures that the sponsor wants is simply a matter of parsing the various risk-factor exposures and keeping track of them.

Second, if the sponsor wants to physically hold, say, one-half of the portfolio in risky assets, then it can hold the other half of the portfolio only in bonds, which are the primary source of the desired dual duration–risk hedge. If this is the strategy chosen, the durations of those bonds must increase by a factor of 2 to provide all required hedging (less any contribution to the dual durations found in the risky-asset portfolio, as noted). And the required hedging instruments may not be available in the ordinary bond market (the “physicals” market); the sponsor may need to tap the futures and swaps markets.

The sponsor can purchase equity exposure by using futures contracts to seamlessly replace index funds and simultaneously free up cash with which to purchase more long-duration physical assets. This strategy reduces the degree of dependence on interest rate derivatives for providing long dual-duration exposure. Because of the long durations required to match the liability, the sponsor may have to free his or her mind of the stricture to invest only in physical assets. After all, what is important is not capital asset allocation but the allocation of risk exposures.

Although some might be tempted to refer to this approach to investing as “leverage,” that is not the most helpful term. The approach is simply managing the assets so that they have the risk-factor exposures required to provide the desired blend of hedging portfolio and risky-asset portfolio, an ordinary exercise in risk control.

**How Much Surplus Beta Risk Should the Plan Sponsor Take?** Capital market theory says that the market-related risk represented by a fully diversified portfolio is rewarded, in expectation, by higher excess returns—with the expected excess return proportional to the amount of beta risk (in this case, surplus beta risk) taken. So, a sponsor starts at the extreme left end of the frontier, with no risky-asset portfolio and zero surplus beta, and progressively moves up the surplus efficient frontier until the sponsor is unwilling to take on any additional risk.

The motivation is the hope of achieving higher expected returns, which if realized, will help reduce the contributions and economic pension expense required to pay for the plan. But the beta risk that the sponsor takes on is genuine risk: If “risk happens” (if the market goes down), the result will be higher contributions and expense. This is the risk-return trade-off faced by the plan sponsor.

Today’s portfolios seem to average 70 percent or more in equities and other risky assets. One may question whether this exposure to risky assets is greater than many sponsors are really willing to tolerate. We know that sponsors are aware that higher expected returns come with these exposures; we hope, but we cannot be sure, that they are aware of the downside risk also.

The question of how much surplus beta risk to take is most appropriately evaluated at the enterprise level by an assessment of the ability of the enterprise to tolerate additional pension contributions if “risk happens.” This ability is related to the size and probability of the potential pension shortfall from bad investment returns compared with the size, profitability, and variability of profitability of the rest of the enterprise (and related to the expected correlation between poor investment returns and tough times for the sponsor). Merton (2006) provides a useful discussion of these issues. If the entire enterprise would be stressed by bad pension investment performance, that enterprise will probably tolerate little risk, and so on. Therefore, healthy and wealthy sponsors that have small pension liabilities in proportion to their overall balance sheets may be willing and able to take on more market risk than those sponsors that are less healthy and wealthy.

Because of enterprise and other factors, sponsors will differ widely in their risk tolerance, so we should expect to see widely varying exposures to risky-asset portfolios among sponsors. But we do not see that variation today, which is an indication that traditional approaches and technologies are not working well.

**Conventional ALM Practice.** How are plans doing under today’s conventional ALM technologies compared with this surplus optimization approach? Not so well. Most sponsors take a lot of surplus beta risk, with total exposures to equities and equitilylike assets bunching tightly around 70 percent of assets. Furthermore, few sponsors hold...
a hedging portfolio, as evidenced by the fact that the fixed-income benchmark is nearly always the Lehman Aggregate bond index or a similar short-duration equivalent. So, the plans are massively exposed to risk from interest rate decreases, to facilitate an equally large bet on interest rate increases in the hope of restoring full funding.

The riskiness of such large equity exposure is clear from the damage caused by the quite ordinary bear market in equities and decrease in interest rates that happened in 2000–2002. This damage was a fully predictable result of applying conventional actuarial ALM technologies: With so little hedging and so much equity exposure, of course the funding status and the expected contribution levels of such plans were hurt badly.

In any period, equities may fall by 50 percent from peak to trough and long-term interest rates may fall by 3 percentage points; this is a virtual certainty over a reasonably long period of time. Yet, the traditional technologies promote exposure to these fluctuations.

We believe that sponsors who understand the true risk–return trade-offs in pension asset management will want to (1) match the dual durations of the assets more closely to the liabilities by holding a good hedging portfolio, (2) hold smaller risky-asset portfolios by taking somewhat lower levels of surplus beta risk than typically found in current practice (i.e., connect their investment policy more closely with their liabilities), and (3) consider whether (and how) they should incorporate sources of expected alpha from active management (discussed in the next section). These three decisions have to be considered by any sponsor seriously concerned about bringing under control those pension-funding risk exposures that arise from investment policy.

We are not saying sponsors should abandon equities. To the contrary, we believe getting out of equities altogether would be an extreme position, as much so as taking large doses of equity risk. If held in reasonable quantities, equities and other risky assets can help pay for the plan, in expectation, at risk levels that most sponsors find perfectly acceptable.25

The Alpha Decision. Another investment policy decision for sponsors is whether to try to increase returns by skillfully taking on active risk, alpha risk—and alpha returns—are independent of and incremental to the surplus beta risk we have been primarily discussing.

The search for alpha is a legitimate search—as long as one fully understands the ground rules. Although this article is not the place for an extensive discussion of alpha and active risk, we remind readers that every dollar of alpha is earned at the expense of some other investor: Active management is a zero-sum game. This doesn’t mean that you can’t earn alpha; it just means that to do so, you have to take it away from someone else. In practice, to earn alpha, the sponsor must have skill in picking managers who, in turn, have skill in picking securities or at making other investment bets.26

Although adding alpha is highly desirable, it is by no means assured. It may be the most difficult task in finance. But for sponsors who have the required skill, it provides an unambiguous improvement in the pension funding risk–return trade-off.

Summary. The technology we have outlined allows an enterprise to sponsor a DB plan at manageable levels of risk. It does not eliminate all risk, but it (1) nearly eliminates some risks, (2) takes controlled amounts of other risks, and (3) leaves some modest risks that cannot be controlled through investment policy. It leaves the sponsor in control of the risks of the plan, and being in control is a good thing.

Reducing Surplus Risk: An Example

The risk–return trade-off facing an employer that is considering moving from a risky to a lower-risk pension investment policy is illustrated in Figure 2. Two probability distributions of the pension surplus for a typical corporate DB plan are shown. The plan has an initial, Year 0, liability of $13.2 billion (economically valued), with a small economic surplus of $0.65 billion. One probability distribution is for a starting portfolio such as is typically generated from conventional ALM approaches—75 percent equities and 25 percent nominal bonds benchmarked to the Lehman Aggregate (thus not duration matched in the two dimensions of duration). The other distribution is for an alternative portfolio built using the approaches espoused here: The portfolio is a mix of a hedging portfolio and a risky-asset portfolio and is fully dual-duration matched.27 This alternative portfolio has only 45 percent in equities and 55 percent in a mixture of nominal bonds and TIPS, and thus has less risk than the conventional portfolio. (Forecast future contributions are not deducted because these data are interactive with investment results; to include them would hide big portions of the true risk–return trade-off implied by investment policy decisions being made today.)28

Figure 2 does not show an estimate of liability alpha risk because we wanted to focus on risk–return trade-offs related to investment policy. The central line in each probability distribution represents the 50th percentile, or median, scenario (with the top lines representing the 95th percentile and the bottom lines, the 5th percentile).
Compared with the starting or conventional portfolio, the better hedged and more conservative alternative portfolio naturally has a lower median outcome (dollar value of the surplus); in Year 10, the median outcome is lower by $2.2 billion. Thus, the effort to reduce risk has the exact downside that one would expect. By lowering exposure to risky assets, the sponsor increases the expected (we show the median) contributions to the plan measured at some future point in time; lower average or median growth of surplus does translate into higher expected contributions to the plan.\textsuperscript{29}

But the alternative portfolio provides an offsetting benefit as a result of that lower expected asset return and higher expected contribution level: It reduces contributions in times of poor equity returns. If "risk happens"—if the market goes down—the funded status and the contribution requirement are not damaged as much as they are in the conventional portfolio. The lowest line in each probability distribution—which represents the 5th percentile (or the 1-in-20 worst-case scenario) and is a proxy for risk—improves tremendously when the alternative portfolio is used. In this scenario, the alternative portfolio's $1.8 billion deficit at the end of 10 years is a much better outcome than the $9.6 billion deficit produced by the conventional portfolio.

Clearly, despite the lower expected or median return, most sponsors would prefer the alternative distribution that results from using these modern tools over the distribution provided by the conventional, old-technology methods.

"But DB Plans Are Too Expensive!"

OK, let's circle back to cost control. We have heard from sponsors who feel that, despite their understanding of the availability of tools to better manage the risks of DB plans, these plans are simply too costly (where "cost" has the proper economic, not actuarial, definition).\textsuperscript{30}

Economic cost, which is what we mean by using the word "cost" in this context, can be precisely defined. Each year that the employee works, a portion of total compensation represents the accrual of pension benefits (another year of service, perhaps a real pay increase, perhaps an inflation increase). We do not have space in this discussion to show in detail how to measure this year-by-year accrual of pension liability, but one can define a measure of it that meets a financial economist's sensibilities.\textsuperscript{31} For some precision, note that cost is the change (from all sources) in the present value of a particular measure of the pension liability from one period to the next, $PV_t - PV_{t-1}$. This is the cost that is relevant to decision making and is the cost that we seek to control in this discussion.

Periodic economic pension costs are obviously directly related to benefit levels. So, what do you do if you conclude that the plan's economic costs are too high? You refine the benefit policy so that costs are in line! Maybe the plan's 2.5 multiplier on years of service, times final average pay, works out to be too expensive and too generous. The sponsor
may conclude that, when the pension is combined with cash payroll and other benefits, total compensation is beyond what is required to attract, retain, and motivate the employees. Or maybe it is not—in which case, the economic cost of the pension plan is not too high after all. Whether the cost is too high is the sponsor’s call.

If the economic cost of the pension plan is considered to be too high, the sponsor must work with the employees to set a level of benefits, and thus a level of economic cost, that is not too high. For example, change the 2.5 multiplier to 1.5 or make other adjustments that change the true, economic present value of benefits. Some benefit features are expensive; for example, providing full inflation protection through a COLA is likely to add 50 percent or more to the economic cost of a basic, fixed benefit. Such benefit features are highly prized, of course, but are not always affordable.

We do not mean to trivialize the effort that must go into negotiating benefit-level adjustments or the strength of feelings that might be involved. These changes are not easy (the same is true for increases in contribution levels, which are another means of balancing a troubled plan). There is room, however, for all to agree on a level of benefits and a level of costs that is appropriate—but only if the costs can be made meaningful and transparent to all the constituencies (i.e., all parties take an economic view of pension cost rather than a traditional actuarial view). After all, a reduced benefit is still much better than a replacement DC plan, with all of its typical design shortcomings. Moreover, if a compromise makes the DB plan sustainable over the long term and if it also protects the economic viability of the employee’s job for the long term, a reduced benefit is a win for both sides.

Such tough choices are hard to discuss, but the discussions must take place because the alternatives might be even more difficult. Let us acknowledge that these are conversations that no one, either in labor or in management, wants to start. Discussions about greater contributions or reduced benefits are bound to be wound up in passion and anger. Until recently, such conversations were simply totally out of bounds, not held in polite company. But today, it is becoming clearer that for DB plans to be sustainable, their benefit and contribution formulas will have to be set with an eye on true economic cost and in the context of total labor cost.

Once the level of total compensation that is sufficient to attract, retain, and motivate the workforce is known, if benefits are to be secure, the portion that is in the form of deferred pay (pension benefits) needs to be actually paid for (that is, set aside as it accrues) through the use of an economically reasonable method of calculating required contributions. Although labor and management will always have opposing views on exactly what the level of total labor cost should be, they will surely agree with these general principles and they have repeatedly proven that they can find agreement on other tough issues. We believe that labor and management will negotiate better decisions if they are given better information, economic information, about year-by-year pension costs, required contributions, and the accumulated present values of liabilities.

A DB plan can thus be made to be cost effective and can be saved, even if the current benefit levels are too expensive, by revisiting benefit levels based on true economic costs and in the context of the total compensation package.

**Conclusion**

We have discussed the pension liability in purely economic terms, with infrequent reference to actuarial or accounting conventions. We strongly believe that if the risks in the liability are going to be managed successfully and if the costs in the liability are going to be negotiated and set at arm’s length, this economic view of the liability is the only one that provides useful insights for decision making. We acknowledge, however, that the actuarial and accounting views represent pressures on the chief financial officer (CFO) that are real, or at least perceived to be real, even though they are no more real than many other “book values” that are typically stale, smoothed, or otherwise artificial. It is the search for “more real” measures that is driving the move toward mark-to-market accounting, and that, we argue, is a good thing for sponsors.

We have stated that if a sponsor manages the true economic risks and costs of the DB pension plan, the accounting risks and costs will be managed also. This point of view is not typically that of the actuarial and accounting professions. They have treated the traditional actuarial values as if they were real and have asked sponsors to give their values that level of dignity. But few sponsors are fooled by this misdirection; they have participated in too many discussions where assumptions and measures were changed for purely cosmetic reasons.

Sponsors have inevitably, and appropriately, become skeptical of the reported valuation, expense, and contribution values. And they intuit that these liabilities must have true, or central, values—the law of one price is not lost on most well-trained executives. How did it get lost in pension accounting?

This article addresses primarily those insightful sponsors. They know that true value is neither created nor destroyed by the accounting system,
only by real economic or market transactions and occurrences. The real economic impact of the pension plan on the sponsor will come out sooner or later, regardless of efforts to manipulate it in the short term.32

Not only is mark-to-market accounting (the current buzzword for economic accounting) not "more risky," but it will actually improve sponsors' ability to manage their plans more effectively, with less economic risk and less cost, because it will enable sponsors to make benefit decisions, contribution decisions, and investment decisions that are better informed by the economic reality of the plan.

Marking to market, then, is not destructive, but constructive; You can't manage what you can't see, and it is economic accounting that lets a sponsor "see" what is really happening inside the plan.

We are deeply disappointed that there is a pension underfunding crisis. The technology needed to manage DB pension plans with a minimum of risk and cost has been available, in concept if not in practical application, for decades. Little that we have to say is literally new, although we've connected the dots in ways that haven't been fully connected before and have made the technology practical and usable (particularly in terms of combining detailed economic views of liability measures with surplus optimization). Most sponsors, consultants, and actuaries simply did not use this technology, even though the basics were known; they favored traditional ALM studies and traditional actuarial cost methods instead.

As a result, sponsors are exposed to a lot of surplus beta risk and left hoping that a rising stock market will eliminate or sharply reduce the need for pension contributions. And they are also exposed to a lot of real-interest-rate and inflation risk for lack of understanding the immediate benefits of holding an asset portfolio that is hedged to the liability. Both exposures have had painful consequences, 2001 and 2002 being the poster child examples. Yet, a portfolio with the same expected returns could have been held, with much less risk, by using the new toolkit.

We want to make sure that sponsors, desperate to control what wrongly appears to be uncontrollable, do not kill the goose that lays the golden eggs that are DB retirement plans. These plans spread employees' working-life income over their entire life and thus provide security that, in nonworking later years, is not available in DC plans.

There is no other practical way to achieve this redistribution of income over time or for the employer to share in the benefits. And, as demonstrated by the failure of DC plans to achieve adequate savings rates, there is also no other lawful way to force employees to save enough to retire. You have to "do it for them," through a DB plan.

The techniques needed to manage the risks and costs of DB plans are known and have been described here, albeit briefly. For the sake of our employees, and for our own sake to help us compete in a labor market that increasingly cherishes secure retirement benefits, let's keep the goose that lays the golden eggs healthy, or make her healthy where she is not. Let's strengthen DB plans by using technologies that make their risks manageable and cost-effective and that enable such plans to thrive for generations to come.

The tools to control risk and cost are right in front of us. The need is urgent. Don't kill the golden goose.

This article qualifies for 0.5 PD credit.

Notes

1. Since this was first written, the Pension Protection Act was passed, moving us closer to a mark-to-market system for funding; the FASB (Financial Accounting Standards Board) is still reviewing its standards for GAAP accounting under the act.

2. We'll digest rather than repeat these technologies in this article. They deal with economic views of the liability and lessons from economic accounting with respect to both risk and cost control and with surplus optimization and dual-duration matching of that economic view of the liability with respect to risk control. For more complete but more technical discussions, see Waring (2004a, 2004b), Siegel and Waring (2004), and the unpublished manuscript cited as Waring (forthcoming 2007).


4. In theory, virtually everything a DB plan does could be done in a DC plan. In practice in the United States today, DC plans aren't anywhere close. Other countries do better; Australia is a good example with its 9 percent mandatory contribution level.

5. The same analysis would apply if we assumed a midcareer age instead of age 65.

6. We are using the Retirement Protection Act of 2000 mortality table, which is also mandated by the Pension Protection Act. It has mortality improvement projection through 204. The relevant interest rate is the full forward rate curve for U.S. T-bonds; as of this writing (October 2006), the Treasury yield curve is relatively flat and close to 4.8 percent for 10- to 30-year bonds, so we have used 4.8 percent as the assumed interest rate, getting an annuity factor of 11.8.
7. Although a retiree could replace this employer-provided annuity with a commercial annuity, it isn’t clear that it would be an advantage to the employee, even presuming that the employer shared in the gains from annuitization. Individual purchases of annuities are often subject to high sales loads. Often, the annuity tables are “tilted” against purchasers, to protect or overprotect the insurer from annuitant selection bias. Of course, insurance companies also want to profit, so they will charge a “spread” or risk charge. There is risk: Insurance companies offering annuities, although regulated, are usually regulated in a book-value rather than a market-value framework, which gives rise to substantial credit risk over the long life of an annuity. And as we can observe, in any event, few employees actually arrange annuitization on their own.

8. The tools supporting better investment policies, which include proper asset-class “building blocks” consisting of index funds and thoughtfully chosen active funds, as well as families of premixed asset allocation funds that are on the efficient frontier by design (today, usually called “life-style” or “life-cycle” funds), are described in Waring and Assaf (1992), Waring (1994), Waring, Siegel, and Kohn (2004), and Waring and Siegel (2006). To the best of our knowledge, Waring and Assaf (1992) is the first incidence of these tools and configurations in the literature, and it draws on work performed by Waring and presented to clients and at conferences as early as 1989, suggesting that life-style funds may owe their origin to this effort. If others were independently working on the concept before then, which wouldn’t surprise us, we’d like to know about it.

9. Funds offered in DC plans are typically retail mutual funds, with retail pricing. A commingled trust fund (CTF) structure, which may follow the same strategy as a given retail mutual fund but with lower fees and other expenses, can be used to achieve cost savings for DC-plan investors. Although this opportunity is well known, it is not as widely used as one would expect, probably because it generates objections from the record keeper—who is often also the mutual fund provider.

10. Reckoned in the simplest possible manner, this calculation assumes a zero investment return. Of course, the investment path in a pension plan is more complex, with continuing cash flows, but our estimate is both directionally correct and sized at least somewhat appropriately.

11. Except that the employer-match component of an employee’s DC plan balance may, in some cases, be subject to vesting requirements.

12. However, the authors imagine that there are really very few industries where portability truly serves the employers’ interest, which is to retain experienced employees.

13. Note, however, that these data refer to the balances in the plan in which the individual is a participant at time of retirement. It does not take into account DC balances that he or she might have from plans associated with previous employers. But the point remains: Even if actual totals are twice these single-plan figures, the amount is still way too little. Moreover, one’s last employer is typically also the employer one worked for the longest—and at the highest rate of pay (for ERBI reports, see www.eri.org/publications/erbi/).

14. We sometimes joke that, by construction, the employees are always fully funded in a DC plan—but they might not like the benefit level! Such gargles humor calls attention to the difference between the liability associated with a desired level of retirement spending and the assets that would be accumulated in most DC plans.

15. Strictly speaking, there are more than two interest rate–related risk factors or durations at issue, but real interest rates and inflation are the two that matter most, so we focus on them.

16. For plans that are in deficit, the best approach (for semantic consistency) is still to think of assets minus liabilities as the surplus, which has a negative value.

17. These unhedgeable, residual, or “alpha” risks involve estimating nonmarket factors that affect benefit levels and benefit timing in the participant population. With good estimation practices, the errors should be unbiased over time; that is, the mean should be zero and the volatility should be small if dealt with each year. The largest risk is usually considered to be mortality risk. When sponsors use ordinary (unmodified) life-expectancy tables, they routinely experience longer-living employees and thus surprise costs, which is not a zero-mean experience. Modified life tables that incorporate an estimate of increasing life expectancies should go a long way toward returning this error to a mean of zero and reducing the surprise. Life-expectancy forecasts, however, will always have some error. Residual risks also include the possibility that benefits will be negotiated upward, as well as other liability surprises that occur when prior years’ estimates of pay, population, and other variables require updating.

18. “Economically sensible measures of periodic pension cost” are an economically sensible version of what actuaries refer to as “normal cost” (see Note 31).

19. For an investor with a long-term liability, such as a pension fund, long-term U.S. T-bonds are safe and short-term bonds (usually referred to in finance as yielding the risk-free rate) are risky (see Modigliani and Sutch 1966). Thus, we frame this equation in terms of the “long-term risk-free rate,” which is the yield to maturity on long-term T-bonds or strips (principal-only bonds). In the notation of Ibbotson Associates (2006), the long-term risk-free rate consists of the short-term risk-free rate plus a “horizon premium,” the extra return required by investors for investing in long-term rather than short-term Treasuries.

20. We have dropped the minus signs in the transition from Equation 4 to the current discussion to follow the convention used in the bond market.

21. Waring (2004a) originally estimated equities as being close to (17, 0). Based on research since that time, the (8, 0) values in the text are an improvement. Equity duration is a challenging issue for many analysts. Many argue that it is zero, yet the same people will estimate stock-bond correlations as 0.3 or 0.4. If equities have a nonzero correlation with nominal bonds, then, mathematically, they must have a nonzero nominal duration. And if equities have a nonzero correlation with TIPS, which is easily demonstrated mathematically, they must have a nonzero real-interest-rate duration. (Both facts taken together suggest a difference between real-rate duration and inflation duration.) So, although we cannot yet estimate or measure equity durations with the precision we are accustomed to when calculating bond durations, we can satisfy ourselves that the estimates we have used here are in the ballpark.

22. These estimates are for a prototypical pension plan (not any specific actual plan) and are from Goodman and Marshall (1988).

23. Because one can vary the durations of the bond portfolios at will, one can also vary the weights of the holdings so that the total fixed-income (bonds plus TIPS) portfolio still has a dual duration of (17.5, 7.6). Thus, a whole family of solutions, not merely the solution shown here, is available.

24. The accounting measure called “pension expense” today is a net value including normal cost, investment returns on the assets, interest cost on the liability, and actuarial gains and losses. The fact that these items are netted to a single value called “pension expense” is somewhat controversial and may be addressed by the FASB.

25. The real cost, risk adjusted, is not changed by holding equities. Risk premiums from the risky-asset portfolio are not relevant to the discount rate used in valuing the plan; only the expected return of the liability-matching or hedging portfolio is relevant.
26. These criteria are the “two conditions of active management” of Waring, Whitney, Pirrone, and Castille (2000) and Waring and Siegel (2003) but with managers instead of securities as the unit of selection.

27. That is, the quantities and durations of the nominal bond and TIPS subportfolios are engineered so that the inflation dollar duration of the total portfolio (including equities) equals that of the liability and the real-interest-rate dollar duration of the total portfolio also equals that of the liability.

28. The probability, given an investment policy decision made today, of needing additional contributions in the future to support today’s funded ratio or level of surplus can be directly read, however, from Figure 2. Specifically, at any point in time, a vertical cross-section of the chart represents a probability density function (the difference between two lognormal distributions). Thus, the portion of that cross-section line under a line drawn at the level of today’s funded status represents the probability of additional contributions being required at that point in the future as a result of downside investment risk. The area above represents the probability of reduced future contributions from good returns (relative to holding a fully hedged zero-surplus-beta portfolio). Generally, the probability of future contributions being required can be determined from this distribution for any funded ratio or level of surplus. This knowledge can dramatically improve the sponsor’s ability to make proper risk-return trade-offs among investment policies.

29. This effect is not a reduction in the “present value of future contributions” but a reduction in the “expected future value of the then present value of future contributions.” Although a mouthful, the distinction is important.

30. In our experience, sponsors intuitively use the correct, economic notion of cost in conversation even if they cannot precisely define it.

31. Actuaries refer to this periodic cost as “normal cost” or “service cost.” It is a function of what is sometimes referred to as the “full economic liability,” which can be broken down into smaller, component measures of the liability. One of these smaller measures is usually used for cost purposes and contribution purposes. Cost is one of several elements of “pension expense,” along with interest costs, investment returns, and supplemental costs. Interest cost and investment returns are not really costs in any strict sense of the word. Supplemental costs are simply the changes in the liability required to reflect updates and improvements in estimates of mortality, length of service, and so on. Although actuarial normal cost measures would not usually be the same as a market or economic cost measure, a functional, albeit complex, relationship exists between the two: Actuarial measures have to follow the economic measures—at least over long periods of time. The economic cost is whatever it is, regardless of accounting, and it will show up even if manipulated for deferral. Relating actuaries’ and accountants’ versions of all pension measures to economic measures is a subject in itself and has been a focus of the Waring (forthcoming 2007).

32. Waring (forthcoming 2007) shows in detail how the economic and accounting versions of the balance sheet, income statement, and cash flow statement entries for the liability are related to each other.

References


