An Options Pricing Method for Calculating the Market Price of Public Sector Pension Liabilities

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State and local public sector employee pensions are widely known to be underfunded, but pension financial reports do not reveal the true extent of funding shortfalls. Pension accounting methods assume that plan investments can earn high returns without taking any account of the market risk involved. This gives a false sense of the financial strength of public sector pensions and understates risks to taxpayers. Since accrued pension benefits are legally and constitutionally protected, any pension funding shortfalls must be met by taxpayers. This benefit guarantee amounts to an effective put option on plan investments, the cost of which is not disclosed under current actuarial accounting. This paper uses an options pricing method to calculate the market value of taxpayer guarantees underlying public sector pensions. The average funding ratio declines from 83 percent under actuarial accounting to 45 percent under this options pricing approach. The typical state has unfunded public pension liabilities three times larger than its explicit government debt. Public pension shortfalls equal an average of 27 percent of state gross domestic product, posing a significant fiscal challenge in coming years. Accurate measures of public pension liabilities are important for policy makers, taxpayers, investors considering the economic environment in which to start or locate a business, and bond purchasers considering the risk premia appropriate to municipal government bonds that are in practice subordinate to public pension liabilities.

INTRODUCTION

Most state and local governments provide a defined benefit (DB) pension plan for public employees as part of their overall compensation. These plans generally provide for retirement, disability, and survivors benefits and may either supplement or substitute for Social Security benefits. Around three-quarters of state and local government employees take part

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1. Defined benefit plans base retirement benefits upon a formula deriving from the employee’s earnings and years of service; any investment risk is borne by the plan sponsor.
in an employer-provided pension plan. Around 80 percent of these employees have only a DB pension, with 14 percent having only a defined contribution pension, and 6 percent having both.

The financing of public sector pensions constitutes a growing portion of most state and local budgets, with many state and local governments facing increasing funding obligations due to market declines over the past several years and prior failures to meet their recommended annual contributions. Given the size of public pension plans, it is important that plan assets and liabilities be properly measured. In recent years, the economics profession has posed a challenge to traditional actuarial techniques, arguing that current actuarial methods significantly understated the true value of public pension liabilities. A market valuation approach, economists argue, gives a more accurate picture of the burden facing the taxpayers who ultimately must fund these plans. Most public pension actuaries continue to support current practices, although opinion is divided within the actuarial profession as a whole and the Society of Actuaries and the Government Accounting Standards Board (GASB) are both investigating the merits of financial economics approaches.

Historically, accrued public pension benefits have been practically riskless for the beneficiary, effectively ranking senior to explicit state, or local government debt in order of payment. For this reason, the true size of public pension liabilities should be of interest to credit agencies, bond holders, and others stakeholders in state government finances. Credit rating agencies currently seem to pay little attention to the market value of public pension liabilities, even though these obligations directly threaten the creditworthiness of state governments.

Current actuarial methods calculate a pension’s liabilities by discounting future benefits payments to the present using the rate of return projected for the plan’s investment portfolio. Economists counter that the return expected for plan assets is irrelevant to the value of plan liabilities, which should be discounted using an interest rate that reflects the near-riskless character of accrued benefits. The most common approach to market valuation of public pension liabilities is through a discount rate matched to the assumed low risk of the benefit liability.

This paper presents an alternate approach based upon options pricing methods. Public pensions’ ability to access taxpayer funds if assets fall short of liabilities amounts to an

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4. A regression of Moody’s state credit ratings on public sector pension liabilities or total government liabilities does not improve predictive power relative to regressing only on the ratio of explicit government debt to state GDP, despite a correlation between explicit debt and market-valued pension obligations of only 0.35. The inclusion of implicit pension debt should provide more accurate measures of state government creditworthiness. Ratings are assumed to be cardinal, with ratings from Aaa to Baa3 assigned values of 1 through 10, respectively. A small effect can be found of unfunded pension obligations on municipal bond spreads.
explicit put option backing the funds’ investments. That is to say, while plan investments may provide the expectation of being sufficient to fund liabilities, it is the ability to turn to taxpayers that provides the guarantee of being able to do so. This taxpayer backstop provides an effective put option supporting the value of public pension benefits much as the Pension Benefit Guaranty Corporation has been said to provide a put option for corporate DB pensions.\textsuperscript{5} The value of this option represents the amount that members of the public would be willing to pay in financial markets to offload the risk of being called upon to provide additional funds to public sector pensions.

Accurate evaluation of unfunded public pension liabilities is not a mere academic matter. Individuals or firms considering the economic environment of a state or locality in which to settle or start businesses would be wise to take pension liabilities into their accounts of overall government finances. But the public is generally unaware of market values of pension debt because public pension administrators almost never calculate them and, indeed, are sometimes openly hostile towards such measures. The State of Montana, for instance, recently declared that actuaries favorable to market valuation would be disqualified from performing analyses of the state’s two public pension programs.\textsuperscript{6} Market-based measures of public pensions funding may better inform state governments and taxpayers of the liabilities and risks they face.

\section*{DATA SOURCES}

Public sector pension assets and actuarial liabilities are derived from data compiled by the National Association of State Retirement Administrators (NASRA).\textsuperscript{7} Information is contained on 125 mostly state-level programs. In most cases, actuarial data are through June 30, 2008, although in some cases figures are from 2007. Since that time, most pension plans’ financing has worsened somewhat.

Projected rates of return and other plan characteristics are derived from the Center for Retirement Research’s (CRR’s) State and Local Pensions dataset and are current through 2006.\textsuperscript{8} Changes in projected rates of return are relatively infrequent, so it is expected that

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these data remain reasonably current. The CRR dataset covers 107 of 221 state-level DB plans, including 89 percent of workers and 96 percent of assets. At the local level, the CRR sample is more limited: only 84 plans are included in the dataset, versus the Census Bureau’s reporting of 2,433 locally administered systems. However, most of the largest local plans are included the CRR dataset includes 58 percent of local plan assets and 55 percent of local workers relative to totals reported by the Census Bureau in the Employee Retirement Systems of State and Local Governments.

BACKGROUND ON PUBLIC SECTOR PENSIONS

State and local pensions work similarly to DB pensions in the private sector. Once vested, an employee becomes entitled to a benefit based upon a percentage of final salary—ordinarily, an average of earnings over the last three to five years—multiplied by the number of years of service. Government employees typically receive benefits equal to around 2 percent of final earnings per year of employment, versus an average of around 1.5 percent in private sector DB pensions. Some public sector employees take part in Social Security, while others are not covered by Social Security and receive their principal retirement income from their employer's program.9

One important difference between public sector and private sector DB pensions is that adjustment for inflation is virtually absent in private plans but common in public sector programs. Provisions for inflation adjustment vary significantly from plan to plan. In some cases, adjustment to changes in the Consumer Price Index are automatic; in others, a fixed rate of increase is applied regardless of the realized rate of inflation; in others, inflation adjustment is provided only up to a limit. In many plans, inflation adjustments are ad hoc, such that adjustments are made only upon approval of the state legislature or when certain funding or investment return requirements are met. These requirements are less likely to be met in the near future, given low investment returns and widespread underfunding.

Public sector pensions generally allow earlier retirement than in the private sector, with public safety officers in particular retiring early. Reductions in benefits for early retirement are generally more generous than actuarially fair reductions. As a result, public sector employees tend to retire younger than private sector workers. The average age of retirement in the CRR dataset of public pension plans is 57, although only 13 of 109 plans report ages of benefit claiming.

Public sector pensions are financed through a combination of employee and employer contributions and investment earnings. Contribution rates vary from program to program, as do the criteria by which rates may be altered. In some cases, contribution rates are set in law, while in other cases, contributions are automatically adjusted based on regular

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9. For individuals spending part of their careers in public employment not covered by Social Security and part under Social Security covered employment, the Government Pension Offset and Windfall Elimination Provision may affect the Social Security benefits they or their spouses are eligible to receive.
FIGURE 1
Average State Pension Portfolio Allocations

Source: Author’s calculations, CRR pension dataset. Totals exceed 100 percent due to rounding.

actuarial valuations of plan financing. The average state employer contribution rate as of 2006 was 9.9 percent of employee salary, while the average employee contribution rate was 5.7 percent.

As of 2006, around 60 percent of public pension assets were held in domestic or foreign equities and slightly over one-quarter in bonds, with smaller allocations to real estate, cash, alternate investments such as private equity, or other asset classes (Figure 1). Public sector pensions tend to allocate around 10 percentage points more of their assets to equities than do private sector pensions, and allocations to stocks rose for both public and private sector plans during the period 1994–2004.10 The share of investments held in equities has risen from approximately 40 percent in 1990 to around 70 percent as of 2006. Administrative and management costs vary by plan size, from an average of 0.26 percent of plan assets for large plans to 0.48 percent of assets for small plans.11

Rates of return on plan assets are either projected by plan managers or established in statute. State pensions on average project future nominal returns of 8 percent, with a minimum projected return of 7 percent and a maximum of 8.5 percent. Subtracting assumptions for inflation, projected future real returns average 4.5 percent, ranging from 3.75 to 5 percent. Because public pension benefits are generally indexed to inflation, the real rate of return on assets often is of greater importance than the nominal return. The


percentage of plan assets in equities bears little relation to the plan’s projected rate of return.\textsuperscript{12}

**ACTUARIAL VALUATION OF PENSION FINANCING**

Public pension finances are currently analyzed using a method that is here termed “actuarial valuation” or “expected cost analysis.” The actuarial approach is based upon recommendations of the GASB, in particular GASB’s Statement 27 that recommends that plan obligations be discounted to the present using the long-term expected rate of return on plan assets. If the plan’s investments receive the projected rate of return every year in the future, plan finances will turn out as projected, abstracting from errors in the other factors plan actuaries must project. In effect, this approach amounts to a “best guess” of how a pension program’s finances will evolve over time.

The present value (PV) of a dollar amount paid in the future equals the future value (FV) divided by one plus the interest (or discount) rate \((r)\) compounded by the number of years \((n)\) until the liability must be paid. That is, \(PV = \frac{FV}{(1+r)^n}\). Using the discounted value of plan obligations, a plan’s finances are generally summarized in two ways:

- The ratio of assets to liabilities, known as the “funding ratio”; and
- The plan’s unfunded liability, which represents liabilities net of assets.

For instance, a plan that owed a lump sum of $10 billion in 15 years time with an expected return on assets of 8.5 percent would require current assets of \(\frac{\$10 \text{ billion}}{(1+0.085)^{15}} = \$2.94 \text{ billion}\) to have a funding ratio of 100 percent and zero unfunded liability. In practice, plans owe a stream of payments in each future year and annual liabilities are individually discounted to the present and then summed, but the logic is the same.

Financial economists object to the idea of a discount rate being chosen based on the assumed return on plan assets. Instead, they argue, the appropriate discount rate is a function of the risk characteristics of the liability. If accrued pension benefits are riskless, economists argue that they should be discounted using a riskless rate of return such at that on U.S. Treasury securities.\textsuperscript{13} Discounting the above example at a 3.6 percent yield paid on Treasury bonds with a maturity of 15 years, the $10 billion liability would have a PV of $5.88 billion, double the value when discounted at an 8.5 percent expected return.

Using actuarial methods where plan liabilities are discounted at the projected rate of return, the median public sector pension has a funding ratio of 83 percent and an unfunded liability of $1.9 billion. The lowest funding ratio was 45 percent (Indiana Teachers), while

\textsuperscript{12} The adjusted R-squared value for a regression of the nominal projected return on the percentage of plan assets in equities is 0.0124.

\textsuperscript{13} Technically speaking, the discount rate should be derived from that of a “matching portfolio” that immunizes taxpayers against the risk of needing to supplement plan assets. As a simplification, the discount rate is derived from an asset with a similar probability of default.
the highest ratio was 122 percent (Washington State Law Enforcement Officers and Fire Fighters Plan I). The total unfunded public sector pension liability nationwide was $438 billion. For comparison, total explicit state government debt as of the close of fiscal year 2008 was $1.01 trillion.\(^{14}\)

As noted above, public sector pensions tend to hold more equities than private pensions. Given public sector pension accounting's focus on projected returns, high-risk/high-reward assets are most attractive from an accounting standpoint.\(^{15}\)

### CRITIQUES OF ACTUARIAL VALUATION

The rationale for discounting at the expected rate of return in assets is that, in contrast to private sector entities, governments have the power to tax and therefore are assumed to be infinitely lived. Thus, short-term fluctuations in returns are not a major concern. In a 2006 white paper, GASB (2006) argued that,

> Because governments have the power to tax—a right in perpetuity to impose charges on persons or property—they have the ability to continue operating in perpetuity. . . . The relative longevity of government is reflected in the long-term view applied in governmental financial reporting.\(^{16}\)

There is at least a plausible argument that can be made to this effect. Arrow and Lind\(^{17}\) concluded that the government has risk-bearing advantages over the private sector, such that the government can effectively ignore risk in cases in which risks are both small and uncorrelated to the government’s other liabilities.

However, public pension liabilities very clearly do not satisfy the Arrow-Lind criteria: pension liabilities are large relative to both state governments’ explicit debt obligations and total state output, as well as strongly correlated with other economic factors affecting the government’s financial health. Investment downturns are correlated with broader economic

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15. It is not clear that pension managers or legislators boost the expected rate of return to obscure measured poor funding ratios. A simple OLS regression of plan actuarial funding ratios on projected returns shows \(\text{ProjectedReturn} = 8.43 - 0.56 \text{ percent}\ \text{FundingRatio}\). This implies that a plan with a funding ratio of 50 percent would project an average future return around 0.3 percentage points higher than a plan with a funding ratio of 100 percent. Papke and Giertz (2007) [Leslie E. Papke and J. Fred Giertz, “Public Pension Plans: Myths and Realities for State Budgets,” National Tax Journal LX, no. 2 (2007; available from: <http://ntj.tax.org/wwtax%5Cntjrec.nsf/3C2F5DD2698EC05732C00036923/$FILE/Article%2007-Giertz%29.pdf>] also found some evidence of manipulation of projected returns. However, actuarial funding ratios do not appear to bear any relationship to the portfolio allocation to risky assets held by funds. This implies that funding ratios do not affect the allocation of assets so much as the projected return ascribed to that allocation.


declines, such that pension fund values will drop as the sponsoring government’s financial position weakens. Falling business activity reduces government’s other sources of revenue and increases the need for government transfer payments such as unemployment insurance. Thus, public sector pension finances are likely to weaken at the same time that governments’ capacity to support them is at their weakest.

Economists tend to view government as a pass-through entity, meaning that costs and benefits are not absorbed by the government itself but passed on. As the Congressional Budget Office (CBO), points out, “The government does not have a capacity to bear risk on its own.” Rather, government transfers risk between different stakeholders, who include taxpayers, public employees, bondholders, and those who receive funds from the government. The implication of this, as CBO has argued in contexts ranging from student loan guarantees, to bank deposit insurance, to guarantees against market risk for Social Security personal accounts, is that governments should value risk the same way that their stakeholders do, using market signals and market prices.

LEGAL PROTECTIONS FOR ACCRUED PUBLIC PENSION BENEFITS

Donald Kohn, then-Vice Chairman of the Federal Reserve Board, stated (2008) that “For all intents and purposes, accrued benefits have turned out to be riskless obligations.” That is to say, once benefits are earned they are almost sure to be paid. In many states, public employee pension benefits are guaranteed by law, legal precedent, or the state constitution. As a result, public pension benefits must be considered a binding obligation on state governments and the taxpayer who finance them.

As Brown and Wilcox note, in the mid-1970s New York City’s financial crisis forced it to cut 61,000 jobs and freeze employee wages while inflicting losses on its bondholders, yet it never failed to pay full pension benefits. Likewise, Orange County, California declared bankruptcy in the 1990s and was forced to cut 1,600 public sector jobs and default on $1.1 billion of bonds. Nevertheless, Orange County paid vested pension benefits in full. Rauh and Novy-Marx assume public pension benefits to have a probability of default similar to that of U.S Treasury bonds, making an accrued public pension benefit one of the most secure assets in the world.

This factor is extremely important, as it implies that plan funders, not plan beneficiaries, bear the risk that plan assets will be insufficient to meet obligations. As the prior section shows, this risk is considerable even for supposedly well-funded plans, but the cost of this risk is not represented in public pension financial reports. The advantage of market valuation methods is that they are adept at assigning a cost to risk. In the following section, a market valuation model is outlined.

**VALUING PENSION LIABILITIES USING OPTIONS PRICING**

The structure of public pension financing may be summarized in the following way: a plan holds a portfolio, which is invested in risky assets. If these assets prove to be sufficient to pay accrued benefits, then the plan is solvent and, in many cases, benefits may be increased. If assets fall short of the level needed to pay accrued benefits then the plan—meaning the government and ultimately the taxpayer—will make up the difference.

This arrangement resembles a financial instrument known as a “put option.” A put option gives the holder the right, though not the obligation, to sell a given asset at a given time for a given “strike price.” (A “call option,” by contrast, gives the holder the right to buy a given asset for a given price at a given time.) In effect, a put option guarantees against the value of a stock falling below a certain level. Public sector pensions effectively provide such a put option via their legal ability to call upon taxpayers for additional funds as needed.

The total cost of funding a pension obligation is the sum of the current contribution and the value of the implicit put option guaranteeing that accrued benefits will be paid. Importantly, the sum of the two will be approximately equal regardless of the funding strategy the plan takes: investment in risky, high-returning assets lowers current contributions but increases the value of the put option; likewise, a more conservative investment strategy implies higher upfront costs but a lower contingent liability.

The dominant method for pricing options is known as Black-Scholes, initially developed by Fischer Black and Myron Scholes and extended by Robert Merton. The Black-Scholes options pricing formula requires a small number of inputs, including

- The purchase price or current value of the asset.
- The strike price, meaning the value at which the holder of a put option may sell the underlying asset.
- The length of time between the option being issued and when it may be exercised.

23. Since the option does not imply the obligation to sell the stock at a given price, if the value of the asset exceeds the strike price then the option goes unexercised and the stock holder receives the extra return on the stock.

- The standard deviation of the return on the asset, which indicates market risk.
- The riskless rate of return.

The application of these inputs to public pensions is explained further below.\(^{25}\)

Applying the Black-Scholes options pricing formula to public sector pensions requires a number of simplifying assumptions. The current value of the asset in the Black-Scholes formula is represented by the value of the pension’s assets as of the most recent valuation date. For this analysis, we use a value known as “actuarial assets,” which differs from the actual market value of assets in that the fund’s returns are “smoothed” to reduce measured year-to-year volatility. Actuarial assets can differ significantly from the current market value of assets when recent market returns have fluctuated.\(^{26}\) Under a typical five-year smoothing period, market losses during 2008 will not be fully integrated into plan funding reports until 2013.

Some plans place limits on the degree to which the smoothed asset value may differ from the market value. In the Kansas Public Employee Retirement System, for instance, the actuarial value may equal no more than 120 percent of the market value. While these limits have merit, they can also be one-sided: in Kansas, the smoothed asset value may equal no less than 90 percent of the market value, meaning that actuarial asset values will be a biased measure over time.\(^{27}\) The current market value assets is the more appropriate measure, but

\[C_0 = S_0 N(d_1) - X e^{-rT} N(d_2)\]

where

\[d_1 = \frac{\ln(S_0/X) + (r + \sigma^2/2)T}{\sigma \sqrt{T}}\]

and

\[d_2 = d_1 - \sigma \sqrt{T}\]

and

- \(C_0\) = the call option price;
- \(S_0\) = the purchase price or current value of asset;
- \(N(d)\) = the probability that a random draw from a standard normal distribution will be less than the value \(d\);
- \(X\) = the exercise price;
- \(e\) = the base of the natural log function (2.71828);
- \(r\) = the riskless rate of return;
- \(\sigma\) = the standard deviation of the log of gross portfolio returns;
- \(T\) = the length of the option, or the time until maturity.

The put-call parity relationship implies that the put option price is equal to

\[P = C_0 + PV(X) - S_0 = C + X e^{-rT} - S_0\]

where \(P\) equals the put option price, and \(PV(X)\) equals the present value of the exercise price.

\(^{25}\) The Black-Scholes price of a call option is equal to

\[^{26}\] Arizona public pension plans, for instance, smooth returns over a 10-year period. For the state’s public safety officers’ plan, actuarial assets as of June 2009 were one-third larger than the market value of assets.

\[^{27}\] Barry W. Poulson and Arthur P. Hall, “State Pension Funds Fall Off a Cliff,” American Legislative Exchange Council, January 2010; available from: <http://www.alec.org/AM/Template.cfm?Section=State_Pension_Funds_Fall_Off_a_Cliff>
we use smoothed actuarial assets to highlight the larger differences generated by the liability valuation method.28

One result of return smoothing is that we can expect funding ratios calculated using smoothed values to decline over the next several years even if the stock market recovers. To maintain continuity with public pension financial statements and focus on more fundamental differences between actuarial and market valuation methods, we here rely on the smoothed value of plan assets as reported in financial reports.

The strike price is the value at which assets are sufficient to pay plan liabilities. For reasons of simplicity, we use a single summary value of a plan's future liabilities rather than simulating annual costs. Waring29 finds that the mid-point of a public pension's stream of future benefit payments generally is around 15 years in the future, meaning that the stream of annual payments may be approximated by a single lump sum taking place 15 years hence. To calculate this figure, we compound the PV of plan liabilities presented in actuarial reports forward 15 years at the plan portfolio’s projected rate of return. This figure represents the strike price in the Black-Scholes calculation. That is to say, the put option effectively guarantees that the plan’s current assets will be sufficient to pay this approximation of plan liabilities.

The time until the option can be exercised is 15 years, consistent with the calculation above that the stream of future pension obligations can be approximated using a single lump-sum payment 15 years in the future.

As noted above, the risk of the plan’s portfolio of assets must be estimated, as pension plans do not in general disclose the expected variation in asset returns. For each plan, the standard deviation of annual returns is estimated based upon the historical risk of reported asset allocations.

Finally, these calculations use the yield on U.S. Treasury debt as the riskless interest rate.30 Based on the U.S Treasury yield curve as of late November 2009, the nominal yield over 15 years would be approximately 3.6 percent.

This analysis is complicated when we consider what happens if plan assets turn out to be more than is needed to pay accrued benefits. In one case, assets above these needed to pay accrued benefits might be returned to the plan; in another, surplus assets might be used to

28. It is worth noting, however, that financial economics makes the distinction between how a plan is valued and how it is funded. Plan sponsors may wish to smooth returns or otherwise devise funding plans that differ from the market valuation of the plan. In particular, funding strategies that increased plan contributions in good economic times and reduced them in bad times may be optimal if overall funding discipline can be maintained.


30. Ruah and Novy-Marx similarly use the Treasury yield as the discount rate for public pension liabilities. This is a simplification since, as Brown and Wilcox argue, the risk characteristics of public pension liabilities differ from those of most marketable debt. However, these distinctions become more important when analyzing more sophisticated questions, such as whether long-term correlations between stock returns and wage growth (which generates pension liabilities) might allow plans to hedge risk by holding some stocks.
increase benefits. In the former case, the value of potential plan surpluses can be credited toward plan funding by assuming that the plan sells a call option giving up any returns in excess of those needed to pay accrued benefits. The sale of this call option would help offset the cost of the put option guaranteeing that plan assets will not fall short of needed levels. If surplus plan assets would be used to increase benefits, by contrast, then the call option is effectively not sold.

In practice, most public sector pensions fall somewhere in between these two extremes. If assets prove more than sufficient to pay benefits—or, more commonly, if asset returns in a given year exceed the projected return—than some of that excess may be devoted to either temporary or permanent increases in future benefits. In some cases, these benefit increases written into law are paid as contingent Cost of Living Adjustments (COLAs), while in others they are paid via a so-called “13th check.” California, New Jersey, and Washington State are examples of states that increased benefits in good times rather than allow high market returns to buttress plan funding for bad times; attempts to repeal those benefits increases have to date been unsuccessful.

Aronson et al., relying on data from around 100 public sector plans, find that the average plan distributes around 16 percent of excess earnings to plan participants, with the remainder being held by the plan itself or implicitly returned to the government through lower contribution rates. There is significant variation in sharing rules, with a standard deviation of participants’ shares of 37 percentage points. The minimum participant share of excess earnings is zero and the maximum 100 percent.

In other cases, benefit increases are passed informally during periods in which asset values are rising and plans appear to be well-funded under actuarial accounting standards. For this analysis, we assume that all excess assets as of the 15th year are used to increase plan benefits, which is an unrealistic simplification of actual plan rules. In practice, however, this assumption has only a tiny effect on the results. Because most plans are significantly underfunded from a market valuation perspective, the revenue from selling a call option giving up returns in excess of those needed to pay accrued benefits is tiny relative to the cost of a put option insuring against the possibility of falling short. However, the treatment of surplus assets will matter more when the effects of portfolio choice are discussed in later sections.

As a single illustration, we consider the Illinois State Employee Retirement System (SERS). According to the Illinois SERS June 30, 2008 financial report—the most recent available—the plan holds $10.995 billion in assets. These assets are invested in a mix of

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stocks, bonds, and real estate that the plan projects will earn 8.5 percent on average in coming years. Illinois SERS has benefit liabilities with a PV of $23.841 billion, discounted at the 8.5 percent expected rate of return. Using conventional actuarial methods, SERS’ funding ratio is 46 percent—that is, $10.995/$23.841—and its unfunded obligation is $12.846 billion ($23.841 billion minus $10.995 billion). Even using actuarial methods, this shortfall is large, coming to around $1,000 for every resident of Illinois.

Using a market valuation method, however, the Illinois SERS debt is significantly larger. The FV to which its current assets must accumulate to pay full benefits is $81.054 billion. A put option guaranteeing that SERS’ current assets of $10.995 billion may be sold in 15 years time for no less than $81.054 billion would cost $36.245 billion. To truly be fully funded, Illinois SERS would need to hold both its current $10.995 billion assets and a put option with a current value of $36.245 billion, for a total value of $47.241 billion. Since Illinois SERS holds only the first of those two, it can be considered only 23 percent funded and carrying an unfunded liability of $36.245 billion. This shortfall equals to around $3,000 for every resident of Illinois.

If we assumed that Illinois SERS sold a call option giving up all assets above the level needed to pay accrued benefits, the market funding ratio would be unchanged at 23.3 percent. The reason is that the value of the call option would be only $10.27 million, versus the $36.245 billion price of the put option.

The value of the implicit put option provided by taxpayers is not strictly speaking the pension plan’s shortfall, which cannot be known in advance given the uncertainty regarding the fund’s investment returns. Rather, it approximates the amount that the public would be willing to pay today to be freed from the possibility of being called upon to provide additional revenues to public sector pension funds in the future. Public pension finances pose a significant financial risk to the public and the price of the put option represents the amount the public would pay to insure against that risk.

Put another way, the actuarially measured unfunded liability represents the plan’s shortfall if plan assets produce the predicted return. The market-valued unfunded liability represents the plans’ shortfall recognizing that we cannot predict what future plan returns will be.

A pension fund that wished to guarantee benefits to retirees while also protecting residents against the risk of tax increases would purchase put options ensuring the right to sell their portfolio for no less than the level needed to fund accrued benefits. If not purchased, the cost of these options is implicitly placed on taxpayers, who must make up the difference if plan assets fall below levels needed to pay accrued benefits.

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33. Were we to use the conventional market valuation approach, where future benefit liabilities are discounted to the present using the Treasury interest rate, the results would be almost identical.
34. In practice, options could be purchased on an annual basis, ensuring that assets met projected goals for the year.
PENSION UNDERFUNDING NATIONALLY

This section utilizes the options pricing technique outlined above to calculate the market value of unfunded public pension liabilities by program and by state. As noted above, the median funding ratio using actuarial methods was 83 percent, with a minimum value of 45 percent and a maximum of 122 percent. Aggregate unfunded liabilities using actuarial methods equalled $438 billion.

Market valuation produces markedly higher public pension unfunded liabilities and lower funding ratios, as it explicitly accounts for the guarantee against market risk provided by pensions and implicitly funded by taxpayers. When the cost of the put option guaranteeing full payment of benefits is included in funding calculations, the mean and median funding ratios are 46 and 45 percent, respectively, a reduction of 37 percentage points from the actuarial valuation. The maximum funding ratio falls to 63 percent while the lowest funding ratio declines to only 23 percent (see Table 1).

The total market value of public sector pension unfunded liabilities as of mid-2008 was $3.04 trillion, a value that dwarfs explicit state government debt of $1.01 trillion. As shown above, these pension liabilities are if anything more binding than explicit state debt.

As the largest state, California not surprisingly has the largest absolute public pension funding shortfall at $454 billion, followed by New York with $284 billion and Illinois with $208 billion. Figure 2 shows the market value of unfunded pension liabilities by state.

While the absolute value of state pension liabilities is of interest, a dollar figure alone cannot give an accurate indication of whether these shortfalls are financially sustainable. This section compares state pension shortfalls to two other measures: states’ explicit government debt and state gross domestic product (GDP).

In only two of 50 states are accumulated public pension liabilities smaller than explicit government debt (Figure 3). Massachusetts has the lowest ratio of pension debt to explicit debt at 84 percent, while Nevada has the highest ratio, with unfunded pension liabilities equal to 789 percent of explicit government debt. The sum of pension debt and explicit government obligations gives a good measure of total state indebtedness. The ability to service government debt, however, depends upon the size of the state’s economy.

Charting unfunded pension liabilities against state GDP better shows the states’ ability to service and/or retire public pension liabilities in conjunction with other state responsibilities (Figure 4). There is a wide dispersion by state of the ratio of unfunded pension liabilities to GDP (Table 2). The median pension debt/GDP ratio is 28 percent, while the lowest figure is 11 percent (Nebraska) and the highest is 49 percent (Ohio). Ten percent of states have a pension debt/GDP ratio below 16 percent, while 10 percent have a ratio above 38 percent.

35. For purposes of comparison, Rauh and Novy-Marx calculate a 2008 total unfunded pension liability of $3.23 trillion using a somewhat different method and parameters, ibid.
<table>
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<th>Plan</th>
<th>Funding ratio</th>
<th>Unfunded liability</th>
<th>Plan</th>
<th>Funding ratio</th>
<th>Unfunded liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska PERS</td>
<td>46%</td>
<td>$8,050,237</td>
<td>Missouri DOT and Highway Patrol</td>
<td>31%</td>
<td>$4,003,514</td>
</tr>
<tr>
<td>Alaska Teachers</td>
<td>37%</td>
<td>$6,380,078</td>
<td>St. Louis School Employees</td>
<td>48%</td>
<td>$1,086,775</td>
</tr>
<tr>
<td>Alabama Teachers</td>
<td>42%</td>
<td>$29,111,963</td>
<td>Mississippi PERS</td>
<td>39%</td>
<td>$32,225,716</td>
</tr>
<tr>
<td>Alabama ERS</td>
<td>41%</td>
<td>$14,432,917</td>
<td>Montana PERS</td>
<td>48%</td>
<td>$4,390,299</td>
</tr>
<tr>
<td>Arkansas Teachers</td>
<td>45%</td>
<td>$13,616,284</td>
<td>Montana Teachers</td>
<td>43%</td>
<td>$4,243,003</td>
</tr>
<tr>
<td>Arkansas PERS</td>
<td>48%</td>
<td>$6,410,030</td>
<td>North Carolina Teachers and State Employees</td>
<td>60%</td>
<td>$36,576,881</td>
</tr>
<tr>
<td>Arizona SRS</td>
<td>44%</td>
<td>$35,386,811</td>
<td>North Carolina Local Government</td>
<td>58%</td>
<td>$12,321,531</td>
</tr>
<tr>
<td>Arizona Public Safety Personnel</td>
<td>35%</td>
<td>$9,617,279</td>
<td>North Dakota Teachers</td>
<td>44%</td>
<td>$2,441,111</td>
</tr>
<tr>
<td>Phoenix ERS</td>
<td>40%</td>
<td>$2,900,971</td>
<td>North Dakota PERS</td>
<td>49%</td>
<td>$1,657,941</td>
</tr>
<tr>
<td>California PERF</td>
<td>48%</td>
<td>$233,543,336</td>
<td>Nebraska Schools</td>
<td>48%</td>
<td>$7,438,589</td>
</tr>
<tr>
<td>California Teachers</td>
<td>47%</td>
<td>$164,947,238</td>
<td>New Hampshire Retirement System</td>
<td>34%</td>
<td>$10,233,796</td>
</tr>
<tr>
<td>LA County ERS</td>
<td>53%</td>
<td>$32,755,300</td>
<td>New Jersey Teachers</td>
<td>38%</td>
<td>$60,832,717</td>
</tr>
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<td>San Francisco City and County</td>
<td>58%</td>
<td>$11,008,846</td>
<td>New Jersey PERS</td>
<td>38%</td>
<td>$47,885,415</td>
</tr>
<tr>
<td>San Diego County</td>
<td>50%</td>
<td>$8,191,004</td>
<td>New Jersey Police and Fire</td>
<td>39%</td>
<td>$36,151,554</td>
</tr>
<tr>
<td>Contra Costa County</td>
<td>45%</td>
<td>$6,162,321</td>
<td>New Mexico PERF</td>
<td>50%</td>
<td>$13,057,695</td>
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<td>Colorado School</td>
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<td>$39,875,871</td>
<td>New Mexico Teachers</td>
<td>38%</td>
<td>$14,817,485</td>
</tr>
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<td>Colorado State</td>
<td>34%</td>
<td>$26,803,823</td>
<td>Nevada Regular Employees</td>
<td>42%</td>
<td>$26,065,679</td>
</tr>
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<td>Denver Schools</td>
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<td>Nevada Police Officer and Firefighter</td>
<td>38%</td>
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<tr>
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<td>38%</td>
<td>$4,708,149</td>
<td>NY State and Local ERS</td>
<td>56%</td>
<td>$97,060,712</td>
</tr>
<tr>
<td>Denver Employees</td>
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<td>$1,802,717</td>
<td>New York State Teachers</td>
<td>55%</td>
<td>$68,393,049</td>
</tr>
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<td>Connecticut Teachers</td>
<td>32%</td>
<td>$25,338,342</td>
<td>New York City ERS</td>
<td>44%</td>
<td>$48,427,183</td>
</tr>
<tr>
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<td>27%</td>
<td>$23,176,899</td>
<td>New York City Teachers</td>
<td>38%</td>
<td>$55,214,745</td>
</tr>
<tr>
<td>Plan</td>
<td>Funding ratio</td>
<td>Unfunded liability</td>
<td>Plan</td>
<td>Funding ratio</td>
<td>Unfunded liability</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------</td>
<td>--------------------</td>
<td>---------------------------</td>
<td>---------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>DC Police and Fire</td>
<td>58%</td>
<td>$2,141,724</td>
<td>NY State and Local Police and Fire</td>
<td>56%</td>
<td>$16,896,343</td>
</tr>
<tr>
<td>DC Teachers</td>
<td>62%</td>
<td>$893,004</td>
<td>Ohio Teachers</td>
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<td>$93,770,630</td>
</tr>
<tr>
<td>Delaware State Employees</td>
<td>54%</td>
<td>$5,688,663</td>
<td>Ohio PERS</td>
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<td>$64,405,880</td>
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<td>Florida RS</td>
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<td>$98,505,110</td>
<td>Ohio School Employees</td>
<td>44%</td>
<td>$14,342,118</td>
</tr>
<tr>
<td>Georgia Teachers</td>
<td>54%</td>
<td>$45,177,962</td>
<td>Oklahoma Teachers</td>
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<td>$15,274,853</td>
</tr>
<tr>
<td>Georgia ERS</td>
<td>51%</td>
<td>$13,564,822</td>
<td>Oklahoma PERS</td>
<td>42%</td>
<td>$8,964,897</td>
</tr>
<tr>
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<td>$18,533,398</td>
<td>Oregon PERS</td>
<td>58%</td>
<td>$42,203,565</td>
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<tr>
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<td>$21,266,226</td>
<td>Pennsylvania School Employees</td>
<td>43%</td>
<td>$75,841,353</td>
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<td>$10,022,613</td>
<td>Pennsylvania State ERS</td>
<td>44%</td>
<td>$38,303,543</td>
</tr>
<tr>
<td>Illinois Teachers</td>
<td>28%</td>
<td>$97,660,583</td>
<td>Rhode Island ERS</td>
<td>29%</td>
<td>$13,918,497</td>
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<td>47%</td>
<td>$23,711,290</td>
<td>Rhode Island Municipal</td>
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<td>$1,087,343</td>
</tr>
<tr>
<td>Illinois Universities</td>
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<td>South Carolina RS</td>
<td>42%</td>
<td>$33,102,372</td>
</tr>
<tr>
<td>Chicago Teachers</td>
<td>43%</td>
<td>$15,611,551</td>
<td>South Carolina Police</td>
<td>50%</td>
<td>$3,166,538</td>
</tr>
<tr>
<td>Illinois SERS</td>
<td>23%</td>
<td>$36,250,750</td>
<td>South Dakota PERS</td>
<td>53%</td>
<td>$5,982,103</td>
</tr>
<tr>
<td>Indiana PERF</td>
<td>57%</td>
<td>$9,772,242</td>
<td>Texas ERS</td>
<td>49%</td>
<td>$24,258,117</td>
</tr>
<tr>
<td>Indiana Teachers</td>
<td>26%</td>
<td>$23,984,413</td>
<td>Texas County and District</td>
<td>47%</td>
<td>$16,514,425</td>
</tr>
<tr>
<td>Kansas PERS</td>
<td>38%</td>
<td>$21,827,991</td>
<td>TN State and Teachers</td>
<td>51%</td>
<td>$25,172,217</td>
</tr>
<tr>
<td>Kentucky Teachers</td>
<td>39%</td>
<td>$23,623,659</td>
<td>Tennessee Firefighters</td>
<td>48%</td>
<td>$5,373,882</td>
</tr>
<tr>
<td>Kentucky County</td>
<td>43%</td>
<td>$9,999,298</td>
<td>Texas Teachers</td>
<td>48%</td>
<td>$118,359,305</td>
</tr>
<tr>
<td>Kentucky ERS</td>
<td>30%</td>
<td>$13,393,425</td>
<td>Texas ERS</td>
<td>49%</td>
<td>$24,258,117</td>
</tr>
<tr>
<td>Louisiana Teachers</td>
<td>37%</td>
<td>$26,929,309</td>
<td>Texas Municipal</td>
<td>46%</td>
<td>$17,981,171</td>
</tr>
<tr>
<td>Louisiana SERS</td>
<td>35%</td>
<td>$16,868,589</td>
<td>Texas County and District</td>
<td>47%</td>
<td>$16,514,425</td>
</tr>
<tr>
<td>Massachusetts Teachers</td>
<td>38%</td>
<td>$36,653,317</td>
<td>Houston Firefighters</td>
<td>48%</td>
<td>$2,799,275</td>
</tr>
<tr>
<td>Massachusetts SERS</td>
<td>46%</td>
<td>$23,822,957</td>
<td>City of Austin ERS</td>
<td>36%</td>
<td>$2,685,697</td>
</tr>
<tr>
<td>Maryland Teachers</td>
<td>44%</td>
<td>$30,083,495</td>
<td>Utah Noncontributory</td>
<td>45%</td>
<td>$18,626,024</td>
</tr>
<tr>
<td>Maryland PERS</td>
<td>43%</td>
<td>$18,115,763</td>
<td>Virginia Retirement System</td>
<td>47%</td>
<td>$53,783,973</td>
</tr>
</tbody>
</table>
## TABLE 1 (Continued)

<table>
<thead>
<tr>
<th>Plan</th>
<th>Funding ratio</th>
<th>Unfunded liability</th>
<th>Plan</th>
<th>Funding ratio</th>
<th>Unfunded liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine State and Teacher</td>
<td>41%</td>
<td>$11,815,963</td>
<td>Fairfax County Schools</td>
<td>47%</td>
<td>$2,173,151</td>
</tr>
<tr>
<td>Maine Local</td>
<td>59%</td>
<td>$1,411,326</td>
<td>Vermont Teachers</td>
<td>42%</td>
<td>$2,223,024</td>
</tr>
<tr>
<td>Michigan Public Schools</td>
<td>47%</td>
<td>$50,485,669</td>
<td>Vermont State Employees</td>
<td>50%</td>
<td>$1,379,728</td>
</tr>
<tr>
<td>Michigan SERS</td>
<td>46%</td>
<td>$13,290,401</td>
<td>Washington PERS 2/3</td>
<td>54%</td>
<td>$12,913,141</td>
</tr>
<tr>
<td>Michigan Municipal</td>
<td>42%</td>
<td>$8,411,128</td>
<td>Washington PERS 1</td>
<td>38%</td>
<td>$15,804,162</td>
</tr>
<tr>
<td>Minnesota Teachers</td>
<td>41%</td>
<td>$26,126,326</td>
<td>Washington Teachers Plan 1</td>
<td>41%</td>
<td>$11,853,097</td>
</tr>
<tr>
<td>Minnesota PERF</td>
<td>37%</td>
<td>$22,219,455</td>
<td>Washington LEOFF Plan 1</td>
<td>63%</td>
<td>$3,156,316</td>
</tr>
<tr>
<td>Minnesota State Employees</td>
<td>45%</td>
<td>$11,008,549</td>
<td>Washington Teachers Plan 2/3</td>
<td>59%</td>
<td>$3,720,025</td>
</tr>
<tr>
<td>Minneapolis ERF</td>
<td>49%</td>
<td>$1,575,351</td>
<td>Washington LEOFF Plan 2</td>
<td>62%</td>
<td>$2,683,403</td>
</tr>
<tr>
<td>St. Paul Teachers</td>
<td>42%</td>
<td>$1,500,369</td>
<td>Washington School Employees Plan 2/3</td>
<td>56%</td>
<td>$1,677,759</td>
</tr>
<tr>
<td>Duluth Teachers</td>
<td>44%</td>
<td>$379,706</td>
<td>Wisconsin Retirement System Teachers</td>
<td>54%</td>
<td>$62,691,675</td>
</tr>
<tr>
<td>Missouri Teachers</td>
<td>45%</td>
<td>$35,686,962</td>
<td>West Virginia Teachers</td>
<td>29%</td>
<td>$10,139,294</td>
</tr>
<tr>
<td>Missouri State Employees</td>
<td>43%</td>
<td>$10,406,075</td>
<td>West Virginia PERS</td>
<td>48%</td>
<td>$4,239,620</td>
</tr>
<tr>
<td>Missouri Local</td>
<td>55%</td>
<td>$3,245,199</td>
<td>Wyoming Public Employees</td>
<td>42%</td>
<td>$6,628,204</td>
</tr>
<tr>
<td>Missouri PEERS</td>
<td>44%</td>
<td>$3,418,397</td>
<td>Total</td>
<td>46%</td>
<td>$3,061,058,582</td>
</tr>
</tbody>
</table>

*Source: Author’s calculations, based on 2008 data from the Center for Retirement Research.*

Combined explicit debt and public pension shortfalls average 35 percent of state GDP. The highest ratio of total government obligations to state GDP is 63 percent in Rhode Island, while the lowest is 15 percent in Nebraska (Figure 5). If states were independent entities these debt levels would, on average, be sustainable given reasonable rates of economic growth. However, these state obligations will be coupled with rising federal debt levels, which the Congressional Budget Office\(^{37}\) projects could reach 87 percent of GDP by 2020. It is questionable whether and how these total debt burdens are sustainable.

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TABLE 2

Distribution of Unfunded Pension Liabilities Relative to State Gross Domestic Product

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Pension liability/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>12%</td>
</tr>
<tr>
<td>10th</td>
<td>16%</td>
</tr>
<tr>
<td>25th</td>
<td>19%</td>
</tr>
<tr>
<td>50th</td>
<td>28%</td>
</tr>
<tr>
<td>75th</td>
<td>32%</td>
</tr>
<tr>
<td>90th</td>
<td>39%</td>
</tr>
<tr>
<td>Max</td>
<td>54%</td>
</tr>
</tbody>
</table>

Source: Author’s calculations; state GDP from Bureau of Economic Analysis.

FIGURE 2

Market-Valued Unfunded Pension Liabilities by State

Source: Author’s calculations.

Furthermore, these state figures take no account of public sector retiree health expenses, which present an even more complicated picture. On one hand, the legal protections of health benefits are considerably less robust than the protections afforded to pension benefits—good news for taxpayers, even if not for current or former municipal employees. Thus, states could
reduce health coverage or increase deductibles or copayments levied on workers and retirees. On the other hand, health benefits are prefunded to a much lesser extent than are pension benefits, and health costs are, of course, escalating rapidly, a fact that bodes ill for taxpayers.

Some, including Steven Brull, have speculated regarding an eventual federal bailout of state public sector pension funds and such a step is not unimaginable given the scale of funding shortfalls and the amount of market risk to which pension investments subject state governments. However, the significant disparities in unfunded liabilities between states imply that political consensus may be hard to obtain. Residents of relatively well-prepared states, such as Nebraska and Delaware, may resist their federal taxes being transferred to public sector pensions in Ohio, Illinois, or other poorly funded states.

THE EFFECT OF PORTFOLIO ALLOCATION ON PENSION FUNDING

Under market valuation, the best funded public sector pension nationally remains the Washington State LEOFF Plan 1. However, the poorest funded plan under market valuation is the Illinois SERS, while under conventional actuarial valuation it is the Indiana Teachers

Illinois SERS assumes a future investment return of 8.5 percent, while Indiana Teachers assumes a more conservative 7.5 percent return. Under conventional actuarial valuation, this difference in projected rates of return is free money: that is, the Indiana Teachers plan could costlessly improve its actuarial valuation simply by increasing the allocation of stocks in its portfolio to achieve the 8.5 percent return that Illinois SERS projects. Doing so would increase Indiana Teachers’ 45 percent actuarial funding ratio to 52 percent, a stroke-of-the-pen reduction in unfunded liabilities of $2.5 billion with no apparent cost to the taxpayer.

This actuarial gain, of course, would be illusory: higher expected returns are provided as compensation for market risk and a valuation method that accurately accounts for both would recognize this trade-off. Under market valuation, the higher projected rate of return adopted by Illinois SERS comes with a cost: the price of a put option guaranteeing Illinois SERS fund will meet its obligations is more expensive due to the higher risk of the plan’s investment portfolio.

The effects of portfolio allocation on the plans analyzed here are modest because most plans are significantly underfunded under market valuation measures. However, at higher
funding levels, portfolio effects can be large. For instance, a plan that was 85 percent funded under market valuation with a portfolio with a standard deviation of 13 percent would be 95 percent funded if it shifted to a portfolio with a standard deviation of 5 percent. With a more conservative portfolio it is less likely the plan would earn very high returns and be able to increase benefits, but also less likely that it would earn very low returns and require additional funds to pay accrued liabilities.

These differences are contingent upon the assumption that plan surpluses, should they arise, would be used to increase benefits rather than be held by the plan itself. Put another way, portfolio allocations affect pension funding ratios only if we assume that plans do not implicitly sell a call option giving up assets in excess of those needed to pay benefits. If a pension both purchases a put option and sells a call option then funding ratios will be invariant to the assets held by the plan. That is, while a more conservative portfolio might require more funding upfront, the contingent liability on taxpayers is reduced by a proportional amount, keeping the total cost of funding the same. Since the reality for most plans is that part but not all of any excess returns could be used to increase benefits, we can conclude that portfolio affects may occur for better funded plans but would not be as large as those illustrated here.
COMPARISONS TO OTHER MARKET VALUATION TECHNIQUES

The options pricing approach introduced above is neither the only nor the most prominent means by which to calculate the market value of public sector pension liabilities. The more common approach, which is well illustrated by Rauh and Novy-Marx, is to utilize a risk-adjusted discount rate in calculating the PV of plan liabilities. This method follows the established precept in financial economics that, as Kohn (2008)\textsuperscript{39} puts it, “The only appropriate way to calculate the PV of a very-low-risk liability is to use a very-low-risk discount rate.”

More recently, the CBO examined market valuation relative to traditional actuarial standards. The CBO concluded that “By accounting for the different risks associated with investment returns and benefit payments, the fair-value approach provides a more complete and transparent measure of the costs of pension obligations.”\textsuperscript{40}

Risk-adjusted discounting can be utilized using existing pension data by first compounding the reported PV of plan liabilities forward at the expected rate of return, then discounting back to the present using a risk-adjusted return.\textsuperscript{41} Using the risk-adjusted measure of plan liabilities, plan funding ratios and unfunded liabilities can then be calculated. These values will be very close to those calculated using the options pricing method outlined above and there is no question of their adequacy for policy purposes. In fact, funding values would be identical between the two methods if the options pricing approach assumed that, in addition to purchasing a put option guaranteeing the right to sell assets for no less than needed to pay plan liabilities, the plan sold a call option giving up the right to any assets in excess of the necessary level.

The options pricing method introduced here is designed as a pedagogical device to address several criticisms regarding the standard method based upon risk-adjusted discount rates. First, some critics consider the standard method esoteric or unrealistic. For instance, Keith Brainard, the research director of the NASRA, argues that “Actuaries should want their work product . . . to reflect reality.”

The application of market valuation would in the short term lead to lower funding levels, which (proponents believe) is a more realistic reflection of funding levels, but they would be lower based on the use of a lower investment return assumption. The investment return assumptions used by most public pension plans are based on reasonable expectations of future returns that also are consistent with the historic returns that public pension plans have experienced. While there may indeed be a lower figure as a result of applying a risk-free


\textsuperscript{40} Congressional Budget Office. “The Underfunding of State and Local Pension Plans.” May, 2011.

\textsuperscript{41} If $r_e$ is the expected return on plan assets, $r_r$ is the riskless return and we assume the center of mass of future plan liabilities lies 15 years in the future, the risk-adjusted present value of plan liabilities can be calculated by multiplying reported liabilities by $(1 + r_e r_r)^{15}$. 

Biggs / Calculating the Market Price of Public Sector Pension Liabilities
rate of investment return, that does not necessarily produce a more realistic reading of the plan’s funding condition (2008).

This is a misunderstanding of the market valuation position. The options pricing approach may make this misunderstanding clearer as it explicitly accounts for the risk and return characteristics of the pension’s investment portfolio.

Second, the options pricing method helps explain the flaw in the actuarial method’s assumption that stocks grow safer the longer they are held. Since government entities are infinitely lived, it is argued, they can count on the long-term average market return and ignore shorter term fluctuations. This argument relies on a popular but ultimately incorrect view of the risk of stocks. It is often argued that stock market risk declines over time, such that entities with long time horizons can take advantage of “time diversification.” Samuelson42 shows that while the probability of a loss declines over time, the magnitude of the loss, should it occur, increases.43 Similarly, Bodie44 shows that the cost of guaranteeing against low stock returns rises as the holding period grows larger. The options pricing method makes this point quite explicitly: in financial markets, the price of a put option increases with the time period until which it can be exercised.

The options pricing approach is not presented as a correction to the standard market valuation method of discounting plan liabilities at a risk-adjusted interest rate. Rather, the different structure of the argument in the options pricing method may make market valuation easier for noneconomists to understand.

**DISCUSSION AND CONCLUSIONS**

Babbell et al.45 state, “It is important . . . that the final form of fair value accounting does not deviate from well-established valuation principles that are tested by the entire world capital markets on a daily basis.” Public sector pension accounting, which fails entirely to account for the cost of market risk, clearly does not meet this test.

At a time when pensions invested mostly in bonds or annuity contracts, the effects of discounting future obligations at the expected rate of return on assets would be small. But today, when public sector plans have moved aggressively into stocks and into even higher risk assets such as real estate, private equity, and other “alternative investments,” the effects of discounting a riskless liability at an interest rate derived from highly risky investments

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43. The standard deviation of an investment over longer periods equals the single-year standard deviation divided by the square root of the holding period; i.e., \( \frac{\sigma}{\sqrt{t}} \).
are large and damaging to policymakers’ willingness and ability to address public pension financing.

In the private sector, a DB plan is considered “safe” if its assets equal 80 percent or more of liabilities and “critical” if 65 percent or less. On a market valuation basis, there is not a single public sector pension in our sample that does not qualify as “critical.”

Given the legal protections applied to accrued public pension benefits, which far surpass those of private pensions or federal programs such as Social Security, there is no plausible policy by which this problem can simply be made to go away. The decisions that led to this funding state were no doubt facilitated by opaque accounting methods that policymakers only poorly understand. Nevertheless, the result remains that public sector pension obligations are large and binding and will impose significant future burdens on Americans in terms of higher taxes, lower government services, and a poorer economic environment.

That said, policymakers should act to ensure that pension shortfalls do not become worse. The first step is to ensure accurate accounting of public pension financing. Market valuation of pension shortfalls should regularly be included in actuarial valuations and financial reports, with clear explanations of the meaning of such figures. To date, only New York City publishes market valuation of their pension funding, in the process generating public and professional discussion, although the chair of New Jersey’s pension investment council recently cited market valuation of pension shortfalls as evidence for the poor state of funding (Guerrera and Bullock, 2010).

In many states, public pension contribution rates from employees and state agencies are automatically recalculated based upon changes in actuarial projections. Shifting to a market valuation method would in these cases increase contributions and better ensure plan solvency in the future. In other states legislation would be required.

While contribution increases would better protect future taxpayers, they nevertheless institutionalize a generational inequity even among public employees. Current and near retirees, who have significant accrued benefits, would be favored at the expense of younger employees who would pay higher pension contributions throughout their working careers. However, higher contributions rates may help initiate discussions between public sector workers and public sector retirees, perhaps mediated by public employee unions.

A second option is to utilize leverage based on other retiree benefits, in particular health coverage. These steps could include increased premiums or copayments, a higher age of

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eligibility or elimination of retiree health coverage outright.49 These alternatives are highly limited, however, based on the fact that many states already are considering steps to contain the already large and rapidly increasing cost of retiree health coverage, meaning that marginal savings to offset pension costs may be slight.

Finally, policy makers should consider shifting public sector pensions to a defined contribution model, which would give public sector employees retirement programs on par with other Americans. While the 401(k) system of defined contribution accounts has a number of well-known shortcomings, these are rapidly being addressed through policies such as automatic enrollment and auto-investment in so-called life-cycle portfolios. Moreover, the federal government’s Thrift Savings Plan, a simplified, low-cost defined contribution program, has been considered a success by many.

How governments account for their obligations matters because accounting conventions influence the size of the obligations they undertake and because, ultimately, it is citizens themselves who bear the costs and risks of these obligations. Given the size of public sector pension benefits promised and the degree to which state budgets depend upon income generated by risky pension investments, it is important for policy makers and the public to have an accurate view of pension obligations. Market valuation of pension liabilities is an important step in that direction.

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