



The Market Value of Public-Sector Pension Deficits

By Andrew G. Biggs

States report that their public-employee pensions are underfunded by a total of \$438 billion, but a more accurate accounting demonstrates that they are actually underfunded by over \$3 trillion. The accounting methods that states currently use to measure their liabilities assume plans can earn high investment without risk. Should plan assets fall short, as is likely, taxpayers are required to make up the difference. But the value of this taxpayer guarantee is not disclosed. As a result, while states recognize that their public-employee pensions are underfunded, the situation is far worse than their accounting demonstrates. Without taking proactive steps now, taxpayers will be made to cover an enormous shortfall when the bills come due.

Nationwide, state public-employee pensions acknowledged a funding shortfall of around \$438 billion as of mid-2008. Given market declines since then, a current figure would likely be higher. But even updated figures would vastly understate the true market cost of pension underfunding. Public-sector pensions use accounting methods that are incompatible with economic theory, the practice of financial markets, and the accounting standards required for private-sector pensions. These methods fail to account for the risk of public-sector pension investments or the fact that, unlike corporate pensions or Social Security benefits, public-pension benefits are effectively guaranteed to be paid. Current pension accounting methods report plans' funding shortfalls assuming that pension investments in stocks, bonds, hedge funds, and private equity will produce forecasted rates of return with certainty. Market-valuation methods account for the uncertainty inherent in such investments by recognizing that risky investments cannot produce a guaranteed return. While many steps must be taken to put

public pensions on a sustainable track, it will be difficult to achieve these steps until the plans incorporate accurate accounting.

Pension Financing

Most state and local governments provide a defined-benefit pension plan for public employees

Key points in this *Outlook*:

- State pension funds are underfunded by over \$3 trillion; this is more than six times the \$438 billion in underfunding the plans themselves report. Pension shortfalls far exceed explicit state debts.
- Current state pension accounting practices are inaccurate and outmoded. Private pension plans would not be allowed to use such methods.
- Market valuation of pension shortfalls more accurately shows the risk to state budgets and taxpayers.
- Pension contributions, benefits, and retirement ages must be reformed, but this will be difficult until states adopt accurate accounting methods.

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as part of overall compensation.¹ 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 in an employer-provided pension plan.² Around 80 percent of public employees have only a defined-benefit pension, 14 percent have only a defined-contribution pension, and 6 percent have both.

Once vested, an employee becomes entitled to a retirement benefit based on a stated percentage of final salary 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. 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.³

Public-sector pensions are financed through a combination of employee and employer contributions and investment earnings. In some cases, contribution rates are set in law, while in other cases, contributions are automatically adjusted based on regular 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 25 percent in bonds, with smaller allocations in real estate, cash, alternate investments such as private equity, or other asset classes. Public-sector pensions tend to allocate around 10 percentage points more of their assets to equities than do private-sector pensions.⁴ The share of public-sector assets held in equities has risen from around 40 percent in 1990 to around 70 percent as of 2006.

Actuarial Valuation of Plan Financing

Public-pension finances are currently analyzed using a method that is referred to here as actuarial valuation. This method involves comparing the value of assets that plans currently hold with the present value of the plan's future benefit liabilities. While a seemingly simple comparison, both "actuarial assets" and "actuarial liabilities" can differ significantly from the values economists and financial markets consider most relevant.

The market value of a plan's assets is simply the amount for which it could be sold at the time the valuation is made. Rather than use this measure, public pensions use a value called "actuarial assets" that involves "smoothing" returns from year to year to reduce measured volatility of

plan funding. Most plans smooth returns over five years, meaning that a particularly high or low return this year will not be fully incorporated into the measure of actuarial assets for another five years. Some plans, such as in Arizona, smooth returns over ten years. While the market value of assets is a preferable figure, in most cases actuarial assets is at least an unbiased measure: it is as likely to understate the market value of plan assets as it is to overstate it.⁵

Public-sector pensions calculate the present value of liabilities by discounting future benefit costs at the interest rate projected for the plan's assets.⁶ In effect, discounting is reverse compounding: it reduces a future benefit amount by a given interest rate for each year between the present and the time it will be paid. For example, a benefit liability of \$1 million one year from now would, at a 5 percent discount rate, have a present value of \$952,380.

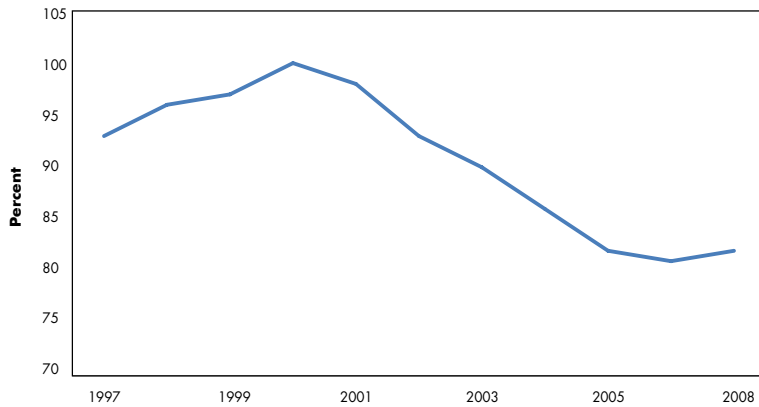
Rates of return on plan assets are either projected by plan managers or established in statute. State pensions on average project future nominal returns of 8 percent; the lowest projected return for a state pension is 7 percent and the highest is 8.5 percent.

Using actuarial assets and actuarial liabilities, pensions calculate two principal measures: first, the funding ratio, which is assets divided by liabilities; and second, the unfunded liability, which is assets minus liabilities. A plan would be considered "fully funded" if it had a funding ratio equal to 100 percent and zero unfunded liabilities. Even using actuarial methods, public-sector pension funding has fallen over much of the past decade, as figure 1 illustrates.

In 2008, the median public-sector pension had a funding ratio of 83 percent and an unfunded liability of \$1.9 billion. Even this decline may be understated due to the use of smoothed investment returns by which reported asset values only slowly reflect recent market declines. For instance, if a pension fund declined by 20 percent in 2009, a plan that smoothed returns over five years would not fully report that loss until 2013. Total actuarially measured unfunded public-sector pension liabilities nationwide as of 2008 were \$438 billion. For comparison, total

On average, public-sector pension plans have only a 16 percent probability of being able to cover accrued benefit liabilities with current assets.

FIGURE 1
MEDIAN FUNDING RATIO FOR STATE PENSION PROGRAMS



SOURCE: Pew Center on the States, “The Trillion Dollar Gap: Underfunded State Retirement Systems and the Roads to Reform” (Washington, DC: Pew Charitable Trusts, February 2010), available at www.pewcenteronthestates.org/report_detail.aspx?id=56695 (accessed March 25, 2010); and Pew Center on the States, “Promises with a Price: Public Sector Retirement Benefits” (Washington, DC: Pew Charitable Trusts, 2005), available at www.pewtrusts.org/uploadedfiles/wwwpewtrustsorg/reports/state_policy/pension_report.pdf (accessed March 25, 2010).

explicit state government debt as of fiscal year 2008 was \$1.01 trillion.⁷

Critiques of Actuarial Accounting

Discounting liabilities at the plan’s projected rate of return has intuitive appeal, but financial economists and the practice of financial markets object to using an interest rate derived from risky investments to discount the value of a riskless liability. As University of Illinois finance professor Jeffrey R. Brown and Federal Reserve economist David W. Wilcox write, “Finance theory is unambiguous that the discount rate used to value future pension obligations should reflect the riskiness of the liabilities.”⁸

The following example illustrates the problems with discounting liabilities using the expected interest rate on a risky portfolio: imagine a pension that owes a lump-sum liability of \$10 million to be paid fifteen years from now. If we discount that liability by the 8 percent return typically projected for pension assets, it has a present value of \$3.15 million. A public pension would consider that liability fully funded if it held at least \$3.15 million in assets. The practical problem is that those assets are risky while the liability is certain. A simple simulation of market returns shows that, even if we assume that the average long-term return is

accurately predicted at 8 percent, volatility from year to year means that \$3.15 million in assets today would have only around a 40 percent chance of reaching the goal of \$10 million in fifteen years. The remaining 60 percent of the time the plan’s investments would fall short.

Alternatively, if the plan discounted the \$10 million liability at a safe interest rate—say, at 3.6 percent, equivalent to the yield on U.S. Treasury bonds with a maturity of fifteen years—the plan could be virtually certain of being able to pay its debt. However, the upfront cost would be larger: to be fully funded, the plan would presently need to have \$5.88 million in assets instead of \$3.15 million. Proponents of actuarial accounting deem these higher funding requirements unnecessary.

By contrast, economists argue for a market-valuation approach, which views government assets and liabilities from the perspective of government stakeholders, including taxpayers, bondholders, public employees, and beneficiaries of government programs. This approach—

which mirrors the corporate-finance view of businesses as pass-through entities for shareholders—discounts public-pension liabilities the way the market would, with a low interest rate that reflects the fact that such benefits are virtually guaranteed to be paid.⁹ Studies examining public-sector pension plans from a market-valuation approach find that pension-funding shortfalls far exceed those that the plans report having.¹⁰

Public-Pension Investment Risk

While public-sector pensions publish lengthy reports on many aspects of their administration and financing, most financial disclosures omit important details regarding the amount of risk inherent in plan investments and how that risk affects the plan’s ability to meet future obligations. This section simulates the probability that plans will be able to meet their obligations, given the level and volatility of the assets they currently hold.

For each plan, I estimate payments of currently accrued benefits extending over the next sixty-five years. Then, using a “Monte Carlo” simulation of asset returns, I produce one thousand possible paths of future asset levels extending over the same period, with asset returns matching the average rate projected by plans but allowed to vary annually

based upon the implied risk of the portfolio. I then calculate the percentage of the one thousand outcomes in which a plan's current assets are sufficient to meet its liabilities.

On average, public-sector pension plans have only a 16 percent probability of being able to cover accrued benefit liabilities with current assets. The maximum probability is 62 percent (Law Enforcement Officers and Fire Fighters Plan 1 from Washington State), while several plans share the minimum probability of zero percent. Worryingly, more plans have a zero probability of solvency (seven) than have a probability of solvency greater than 50 percent (six).

Part of the high probability of funding shortfalls is driven by the fact that, even by actuarial-accounting measures, the typical public-sector pension has assets equal to only 83 percent of accrued liabilities. However, market volatility plays the major role in determining asset values; even a plan that is fully funded by actuarial standards would have only around a 40 percent chance of having sufficient assets to fund liabilities. This alone illustrates the absurdity of public-pension accounting standards. Public employees and retirees can take comfort in strong legal protections for their retirement benefits, but these protections are financed at taxpayers' expense.

Legal Status of Public-Pension Benefits

Public-sector pension benefits receive significantly greater protection against reductions than Social Security or private-pension benefits. In most states, public-employee pension benefits are guaranteed by law, legal precedent, or the state constitution.¹¹ In practice, as Brown and Wilcox note, public-pension benefits have not been reduced even when governments face severe fiscal distress. New York City's financial crisis in the 1970s forced it to cut jobs, freeze employee wages, and impose losses on its bondholders, yet New York 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.¹²

As Donald L. Kohn, vice chairman of the Federal Reserve Board, states, "For all intents and purposes, accrued benefits have turned out to be riskless obligations."¹³ Joshua D. Rauh

and Robert Novy-Marx assume public-pension benefits to have a probability of default similar to that of U.S. Treasury bonds,¹⁴ making an accrued public-pension benefit

one of the most secure assets in the world. In short, once earned there is a near-zero probability that benefits will not be paid in full.

Options Pricing

If public-sector pension assets prove insufficient to fund a plan's promised benefits, taxpayers are legally obliged to make up the difference. In this way, taxpayers act as an implicit "put option" backing pension investments. A put option is a financial instrument that gives the holder the right to sell an underlying asset for a given

price at a given time, effectively acting as insurance against market downturns. This taxpayer guarantee would be particularly painful to honor, as it would generally be needed during financial and economic slumps in which employment has fallen and individuals' asset holdings have declined in value.

Actuarial-accounting methods do not disclose the price of this taxpayer-provided option and therefore omit a significant contingent liability the public faces. Using the Black-Scholes options-pricing formula, however, we can calculate the cost of this risk and show the true funding status of public-sector pensions.¹⁵ Pension shortfalls calculated using this market-valuation method represent the amount taxpayers would be willing to pay today to eliminate the chance of much larger payments in the future. Given market volatility, the chance of extremely large future deficits is significant.

The cost of a put option depends upon the minimum value for which the underlying asset can be sold (the strike price), the volatility of the asset's returns (expressed as the standard deviation of annual returns),¹⁶ the rate of interest that can be earned without taking any risk (usually the yield on U.S. Treasury securities), and the time over which the option spans. As a rule, higher strike prices, riskier underlying assets, lower risk-free interest rates, and longer time periods make the option more expensive.

For example, as of June 30, 2008, the Illinois State Employees' Retirement System (SERS) held \$11 billion in assets, invested in a mix of stocks, bonds, and real estate.¹⁷ The actuarial measure of its liabilities was \$23.84 billion,

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 borrowing of \$1.01 trillion.

producing an actuarial funding ratio of 46 percent and an unfunded liability of \$12.85 billion. Despite an assumed 8.5 percent average annual return, the state's portfolio is risky and each year's return will vary; often the return will be much less than the assumed rate.¹⁸ As a result, it has a very good chance of falling short.

How much would it cost to truly *guarantee* that SERS will have sufficient assets to pay all the benefits the plan has promised? I adjust the published actuarial deficits to approximate the nominal dollar value the plan's assets must reach in the future to fund accrued benefits¹⁹ and then calculate the price of a put option that would guarantee SERS the ability to sell their assets for no less than this value.²⁰

The cost of such an option for Illinois SERS would be \$36.25 billion. This option, in combination with SERS current assets of \$11 billion would guarantee that SERS benefits could be paid without recourse to additional taxes on the public for a total cost of \$47.25 billion. Since SERS holds the assets but not the put option, it should be considered only 23 percent funded, with an unfunded liability of \$36.25 billion.²¹ This shortfall is equal to about \$3,000 for every Illinois resident.

Pension Underfunding Nationally

This section uses the options-pricing technique outlined above to calculate the market value of public-pension liabilities across the country. As stated earlier, the median funding ratio using actuarial accounting methods was 83 percent, with a maximum value of 122 percent and a minimum of 45 percent, and aggregate unfunded liabilities using actuarial methods equaled \$438 billion.

When the cost of the taxpayer guarantee of full benefit payment is included, the median plan funding ratio is just 45 percent. The maximum funding ratio falls to 63 percent, while the lowest funding ratio declines to only 23 percent. 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 borrowing of \$1.01 trillion.²² And, if anything, these pension liabilities are more binding than explicit state debt.

As the state with the largest population, California has the largest absolute public-pension funding shortfall at

\$454 billion. It is followed by New York with \$284 billion and Illinois with \$208 billion. While the absolute value of

state-pension liabilities is of interest, a dollar figure alone does not indicate whether these shortfalls are financially sustainable. Comparisons to states' explicit government debt and to state gross domestic product (GDP) help indicate the scale of public-pension shortfalls.

On average, public-sector pension debt is around three times that of explicit state borrowing. In only two of fifty states are accumulated pension liabilities smaller than explicit government debt. Massachusetts has the lowest ratio of pension debt to explicit debt at 84 percent while Nevada has the high-

est, with unfunded pension liabilities equal to 787 percent of explicit government debt.

The ability to service government debt depends upon the size of the state's economy. Comparing unfunded pension liabilities to state GDP²³ better shows the state's ability to fund public-pension costs in conjunction with other state responsibilities. As figure 2 shows, there is a wide disparity by state of the ratio of unfunded pension liabilities to GDP.

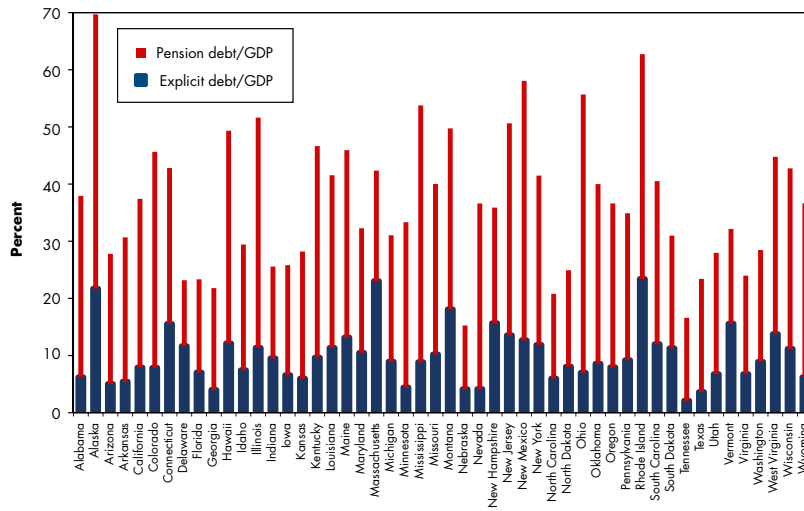
The median pension debt-to-GDP ratio is 27 percent. Nebraska has the lowest pension debt-to-GDP ratio at 11 percent, while Ohio has the highest at 49 percent. Ten percent of states have a pension debt-to-GDP ratio below 16 percent while 10 percent have a ratio above 38 percent.

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. Combined with rising federal borrowing, it is highly questionable whether these total debt burdens are sustainable.²⁴

Some have speculated regarding an eventual federal bailout of state public-sector pension funds. Such a step is not unimaginable given the scale of funding shortfalls.²⁵ However, the significant disparities in unfunded liabilities between states imply that political consensus may be hard to obtain. Relatively well-prepared states such as Nebraska and Delaware may resist their residents' taxes being transferred to public-sector pensions in Ohio, Illinois, or other poorly funded states.

There is no reason
public-sector
employees should
receive retirement
benefits that are
either larger or
more secure than
those received by
private-sector workers.

FIGURE 2
EXPLICIT DEBT AND UNFUNDED PENSION LIABILITIES AS PERCENT OF STATE GDP



Source: Author's calculations.

Conclusion

Public-sector pensions around the country face very significant funding shortfalls that will put state budgets under pressure for years to come. Pension accounting methods that showed the true market value of these liabilities might have prevented these shortfalls from being accumulated in the first place by encouraging higher contributions by employees and government, more modest retirement benefits, and retirement ages more in line with the private sector. But, given the guarantees afforded to vested public-pension benefits, painful choices are inevitable. Since taxpayers are liable for trillions of dollars in public-pension liabilities, however, a number of steps should be undertaken now.

First, pensions must disclose greater detail regarding investment risk. These details should include the volatility of their investments and the covariances of returns between different elements of their portfolios. This is basic information that investment managers use; the public deserves to see it as well. Actuarial firms contracted by pensions should calculate the probability that plan assets will be sufficient to meet obligations, such as is currently done for Social Security by the plan's actuaries and by the Congressional Budget Office. These simulations would show the absurdity of actuarial methods, which call "fully funded" a plan that has a less-than-even chance of being solvent in practice.

Second, pension plans should reform their accounting methods to include the market value of plan liabilities.

Current accounting methods not only underestimate funding shortfalls, they offer a seemingly painless way to solve them: invest in riskier assets. New Jersey, for instance, faces an actuarially measured \$32 billion pension shortfall; however, if it were to shift its investments such that it could project a 10.5 percent average return rather than the current 8.5 percent, its pension books would seemingly be balanced. This, of course, is an illusion: higher-returning assets come with higher risks. But current pension accounting ignores risk, opening the possibility for lawmakers desperate to put off a seeming crisis to take dangerous steps. Market-pricing methods, such as the options-pricing approach

described in this *Outlook*, are not as subject to gaming as actuarial accounting. Market valuation would show that a shift to riskier investments would increase costs, not reduce them.

Once more accurate accounting methods are in place, lawmakers can consider the policy options open to them. These will differ from state to state based on the legal protections afforded to pension benefits. While nearly all states effectively guarantee accrued benefits, some may allow for changes in the rules by which future benefits are accrued. Others allow changes only for newly hired employees. Employee-contribution rates should be increased and eligibility for retirement delayed. Where possible, the rate at which future benefits are accrued should be reduced. For instance, most plans currently pay 2 percent of final salary per year of service; while accrued benefits should be honored, future benefits could be earned at a lower rate. In addition, states should no longer put off their own pension contributions. Each state must do the maximum to restore its plans to solvency. Even the best-funded states face significant challenges.

For newly hired employees, public-sector pensions should shift to a defined-contribution basis to make them more comparable to plans offered in the private sector. Under a defined-contribution plan, the employer's liability is limited to the matching contributions made to employees' accounts each year. Employees can be sure their employer has met its obligations, and taxpayers can be assured they face no contingent liability in the future. There is no reason

public-sector employees should receive retirement benefits that are either larger or more secure than those received by private-sector workers. State governments must compete with the private sector for employees while ensuring that taxpayer funds are not wasted. Putting public-sector pensions on a common platform with the private sector will make comparisons easier for both potential employees and taxpayers.

None of this will be easy to accomplish. Pension policies and accounting rules are set by state lawmakers, few of whom see it in their interest to highlight looming funding shortfalls. Likewise, the actuarial profession has largely resisted efforts to include the market valuation of plan funding alongside traditional measures, although both the Society of Actuaries and the Government Accounting Standards Board are examining the issues and may alter their views in coming years. Meeting public-sector pension obligations and reforming pension policy will not be easy. Accurate accounting is an important first step.

The author wishes to thank AEI research assistant Adam Paul for his help in producing this Outlook.

Notes

1. Defined-benefit plans base retirement benefits upon a formula derived from the employee's earnings and years of service; any investment risk is borne by the plan sponsor.

2. Alicia H. Munnell and Mauricio Soto, "State and Local Pensions Are Different from Private Pensions," *Issue in Brief: State and Local Pension Plans*, no. 1 (Boston: Center for Retirement Research, Boston College, November 2007), available at http://crr.bc.edu/briefs/state_and_local_pensions_are_different_from_private_plans.html (accessed March 25, 2010).

3. For individuals who spend 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. For information on the Government Pension Offset and Windfall Elimination Provision, see Social Security Administration, "Information for Government Employees," available at www.ssa.gov/gpo-wep (accessed March 31, 2010).

4. Alicia H. Munnell, Kelly Haverstick, Mauricio Soto, and Jean-Pierre Aubry, "What Do We Know about the Universe of State and Local Plans?" *Issue in Brief: State and Local Pension Plans*, no. 4 (Boston: Center for Retirement Research, Boston College, March 2008), available at http://crr.bc.edu/briefs/what_do_we_know_about_the_universe_of_state_and_local_plans_4.html (accessed March 25, 2010).

5. Some states limit the degree to which the actuarial value of assets can differ from the market value. While overall a good step, states such as Kansas allow the actuarial value of assets to overstate the market value by a greater amount than the actuarial value is allowed to understate the market value. This skews reported asset values upward over time.

6. The present value (PV) of a dollar amount paid in the future (FV) equals the future value divided by one plus the interest (or discount) rate (r) compounded by the number of years (n) until the liability must be paid. Expressed mathematically, $PV = \frac{FV}{(1+r)^n}$.

7. U.S. Census Bureau, "2008 Annual Survey of State Government Finances," December 9, 2009, available at www.census.gov/govs/state (accessed March 25, 2010).

8. Jeffrey R. Brown and David W. Wilcox, "Discounting State and Local Pension Liabilities," *American Economic Review* 99 (May 2009): 538–42.

9. For background on the financial-economics approach, see Joint American Academy of Actuaries–Society of Actuaries Task Force on Financial Economics and the Actuarial Model, "Pension Actuary's Guide to Financial Economics," Society of Actuaries and American Academy of Actuaries, 2006, available at www.actuary.org/pdf/pension/finguide.pdf (accessed March 26, 2010).

10. For instance, see Robert Novy-Marx and Joshua D. Rauh, "The Liabilities and Risks of State-Sponsored Pension Plans," *Journal of Economic Perspectives* 23, no. 4 (Fall 2009): 191–210.

11. For details by state, see Morrison and Foerster LLP and Greenebaum Doll and McDonald PLLC, "Index by States: Extent of Protection of Pension Interests," September 25, 2007, available at <http://finance.ky.gov/NR/rdonlyres/275A2978-5DDE-4138-A7F5-AF02D17D7F97/0/Statebystatememo10.pdf> (accessed March 26, 2010).

12. Jeffrey R. Brown and David W. Wilcox, "Discounting State and Local Pension Liabilities."

13. Donald L. Kohn, "The Economic Outlook" (statement, National Conference on Public Employee Retirement Systems Annual Conference, New Orleans, May 20, 2008), available at www.federalreserve.gov/newsevents/speech/kohn20080520a.htm (accessed March 26, 2010).

14. Robert Novy-Marx and Joshua D. Rauh, "The Liabilities and Risks of State-Sponsored Pension Plans."

15. The Black-Scholes formula was introduced by Fischer Black and Myron Scholes and further developed by Robert Merton. It is commonly used in financial markets to calculate the price of options and other related financial instruments. Merton and Scholes received the 1997 Nobel Prize in economics for their work; Black would also have received the prize but was ineligible due to his death.

16. Roughly speaking, around two-thirds of annual returns will be within one standard deviation plus or minus the average return; 95 percent will be within two standard deviations of the mean.

17. State Employees' Retirement System of Illinois, *A Pension Trust Fund of the State of Illinois: Comprehensive Annual Financial Report*

for the Fiscal Year Ended June 30, 2008 (Springfield, IL, June 30, 2008), available at www.state.il.us/srs/PDFILES/oldAnnuals/SERS08.pdf (accessed March 29, 2010).

18. Author's calculations predict that Illinois SERS has a portfolio standard deviation of 11.4 percent. Thus, negative returns are possible within one standard deviation from the mean.

19. Future benefit obligations must be approximated because plans do not release such information. Following Rauh and Novy-Marx, future values are calculated by compounding the present value of actuarial liabilities forward fifteen years at the plan's 8.5 percent projected rate of return. This produces a nominal dollar amount occurring fifteen years in the future. Fifteen years is chosen because the midpoint of future benefit payments occurs fifteen years ahead for most pensions. If a plan's assets are sufficient to meet this cost, it is taken to be fully funded.

20. Option prices are calculated assuming a riskless interest rate of 3.6 percent; this matches the fifteen-year yield on U.S. Treasury securities as of late November 2009.

21. These funding figures almost precisely match those calculated using a risk-adjusted discount rate, as discussed in a preceding section, showing the comparability between the two.

22. 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. Robert Novy-Marx and Joshua D. Rauh, "The Liabilities and Risks of State-Sponsored Pension Plans."

23. For state gross domestic product (GDP), see Bureau of Economic Analysis, "GDP by State," news release, June 2, 2009, available at www.bea.gov/newsreleases/regional/gdp_state/gsp_newsrelease.htm (accessed March 31, 2010).

24. Congressional Budget Office, *Long Term Budget Outlook*, 111th Cong., 1st sess. (Washington, DC, June 2009), available at <http://cbo.gov/doc.cfm?index=10297> (accessed March 29, 2010).

25. Steven Brull, "The Big Public Pension Squeeze," *Institutional Investor Magazine*, June 10, 2009.