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Andrew G. Biggs  
*American Enterprise Institute*

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

Andrew G. Biggs  
andrew.biggs@aei.org

Resident Scholar, American Enterprise Institute

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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.

This paper first uses a Monte Carlo simulation of current pension assets and projected market returns to calculate the probability that public sector pension assets will be sufficient to fund accrued benefits. The typical public sector pension has only a 16 percent probability of paying full accrued benefits with assets on hand. A larger number of public pension plans have zero probability of paying accrued benefits than have a probability in excess of 50 percent.

But 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 policymakers, 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.

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## 1. Introduction

Most state and local governments provide a defined benefit pension plan for public employees as part of their overall compensation.<sup>1</sup> 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.<sup>2</sup> Around 80 percent of these employees have only a defined benefit pension, with 14 percent having only a defined contribution pension, and 6 percent having both.

The financing of public sector pensions constitutes a significant portion of most state and local budgets, with most governments facing increasing pension obligations due to rising numbers of retirees, increased pensions, and market declines over the past several years. 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 understate the true value of public pension liabilities. A market valuation approach, economists argue, gives a more accurate picture of the risks facing the taxpayers who ultimately must fund these plans. Most of the actuarial profession continues to support current practices, although the Society of Actuaries and the Government Accounting Standards Board are both investigating the merits of financial economics approaches.

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<sup>1</sup> 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.

<sup>2</sup> Alicia H. Munnell and Mauricio Soto. "State and Local Pensions Are Different From Private Pensions." Center for Retirement Research. November 2007.

Accrued public pension liabilities are 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 if these obligations directly threaten the creditworthiness of state governments.<sup>3</sup>

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 risk-adjusted discount rate.

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 implicit put option backing the funds' investments. That is to say, while plan investments may provide the *expectation* of being able 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 assets much as the Pension Benefit Guaranty Corporation has been said to provide a put option

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<sup>3</sup> 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 gross domestic product, 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.

for corporate defined benefit pensions.<sup>4</sup> The value of this option represents the amount that members of the public would be willing to pay in financial markets to eliminate the risk of being called upon to provide additional funds to public sector pensions.

This paper shows, contrary to financial economics evaluations of public pension finances, that under certain conditions the risk and return characteristics of the pension's investment portfolio *do* matter for valuing unfunded public pension liabilities. This arises because the taxpayer guarantee of accrued pension benefits is partially one-sided: while the taxpayer pays the costs if plan assets are insufficient to fund plan liabilities, if pension asset returns exceed the projected level part of that gain is often used to increase benefits rather than improve plan funding.

Contrary to criticisms of market valuation, however, the options pricing method shows that when portfolio characteristics are taken into account, public pension shortfalls tend to be slightly larger than predicted using conventional market evaluation approaches. In instances in which plans are relatively well funded, portfolio effects on plan funding can be large.

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 they wish to settle or start a 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

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<sup>4</sup> See Sharpe, William F. 1976. "Corporate Pension Funding Policy." *Journal of Financial Economics* 3(3): 183-193.

State of Montana, for instance, recently declared that actuaries favorable to market valuation would effectively be disqualified from performing analyses of the state's two public pension programs.<sup>5</sup> Market-based measures of public pensions funding may better inform state governments and taxpayers of the liabilities and risks they face.

## 2. Data Sources

Public sector pension assets and actuarial liabilities are derived from data compiled by the National Association of State Retirement Administrators.<sup>6</sup> Information is contained on 125 mostly state-level programs. In most cases actuarial data is through June 30, 2008, although in some cases figures are from 2007.

Projected rates of return and other plan characteristics are derived from the Center for Retirement Research's (CRR) State and Local Pensions dataset and are current through 2006.<sup>7</sup> Changes in projected rates of return are relatively infrequent, so it is expected that these data remain reasonably current. The CRR dataset covers 107 of 221 state-level defined benefit 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

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<sup>5</sup> Barry B. Burr. "Actuary searches warn against market valuation." *Pensions & Investments*. April 17, 2009.

<sup>6</sup> Keith Brainard. "Public Fund Survey Summary of Findings for FY 2008." National Association of State Retirement Administrators and National Council on Teacher Retirement. October 2009, available online at [http://www.publicfundsurvey.org/publicfundsurvey/pdfs/Summary\\_of\\_Findings\\_FY08.pdf](http://www.publicfundsurvey.org/publicfundsurvey/pdfs/Summary_of_Findings_FY08.pdf)

<sup>7</sup> For details on the Center for Retirement Research's state and local pension data, available online at [http://crr.bc.edu/frequently\\_requested\\_data/state\\_and\\_local\\_pension\\_data\\_4.html](http://crr.bc.edu/frequently_requested_data/state_and_local_pension_data_4.html). Also see Alicia H. Munnell, Jean-Pierre Aubry, and Kelly Haverstick, "The Funding Status of Locally Administered Pension Plans," Center for Retirement Research, December 2008, in particular footnote 2. Available at [http://crr.bc.edu/images/stories/Briefs/slp\\_8.pdf](http://crr.bc.edu/images/stories/Briefs/slp_8.pdf)

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.

### **3. Background on public sector pensions**

State and local pensions work similarly to defined benefit 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 the private sector. 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.<sup>8</sup>

One important difference between public sector and private sector defined benefit 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

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<sup>8</sup> 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.

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 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.<sup>9</sup> The share of investments held in

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<sup>9</sup> Alicia H. Munnell, Kelly Haverstick, Mauricio Soto, and Jean-Pierre Aubry. "What Do We Know About The Universe Of State And Local Plans?" Center for Retirement Research, Boston College. March 2008.

equities has risen from approximately 40 percent in 1990 to around 70 percent as of 2006. Administrative 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.<sup>10</sup>

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.<sup>11</sup> The percentage of plan assets in equities bears virtually no relation to the plan's projected rate of return.<sup>12</sup>

#### **4. 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 Government Accounting Standards Board (GASB), in particular GASB's Statement 27 which recommends that plan obligations be discounted to the present using the long-term expected rate of return on plan assets. In effect, this approach amounts to a “best guess” of how a pension program's finances will evolve over time. 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.

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<sup>10</sup> Munnell, et al. 2008. Comparisons to defined contribution plan administration costs are not straightforward, given differences in how costs are reported and in how individuals choose to allocate investments. However, defined benefit pensions are generally held to have lower overall administrative costs than defined contribution plans. For instance, see “Defined Benefit vs. 401(k) Plans: Investment Returns for 2003-2006.” *Watson Wyatt Insider*. June 2008. Available at <http://www.watsonwyatt.com/us/pubs/Insider/showarticle.asp?ArticleID=19148>

<sup>11</sup> Subtracting assumptions for inflation, projected future real returns average 4.5 percent, ranging from 3.75 to 5 percent.

<sup>12</sup> The adjusted R-squared value for a regression of the nominal projected return on the percentage of plan assets in equities is 0.0124.

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. 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  $\frac{\$10 \text{ billion}}{(1+8.5\%)^{15}} = \$2.94 \text{ billion}$  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 an immutable function of the risk characteristics of the liability. If accrued pension benefits are riskless, economists argue, they should be discounted using a riskless rate of return such as that on U.S. Treasury securities. Discounting the above example at the 3.6 percent yield paid on Treasury bonds with a maturity of 15 years, the \$10 billion liability would have a present value 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 the highest ratio was 122 percent (Washington State Law Enforcement Officers and Fire Fighters Plan 1). 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.<sup>13</sup>

As noted above, public sector pensions tend to hold more stocks 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. It is not clear that pension managers or legislators boost the expected rate of return to obscure measured poor funding ratios. However, a simple OLS regression of plan actuarial funding ratios on projected returns shows  $ProjectedReturn = 8.43\% - 0.56\%FundingRatio$ .<sup>14</sup> 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 also found some evidence of manipulation of projected returns.<sup>15</sup> However, actuarial funding ratios do not bear any relationship to the portfolio allocation to risky assets held by funds.<sup>16</sup> This implies that funding ratios do not affect the allocation of assets so much as the projected return ascribed to that allocation.

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<sup>13</sup> U.S. Census Bureau. "2008 Annual Survey of State Government Finances." December 9, 2009. Available at <http://www.census.gov/govs/state/>

<sup>14</sup>  $p=0.007$ ; adjusted- $R^2 = 0.056$ .

<sup>15</sup> See Leslie E. Papke and J. Fred Giertz. "Public Pension Plans: Myths and Realities for State Budgets." *National Tax Journal*. Vol. LX, No.2, June 2007. Available online at [http://ntj.tax.org/wwtax%5Cnjrec.nsf/3C2F5DD2698ECEEE8525732C00036923/\\$FILE/Article%2007-Giertz%28F%29.pdf](http://ntj.tax.org/wwtax%5Cnjrec.nsf/3C2F5DD2698ECEEE8525732C00036923/$FILE/Article%2007-Giertz%28F%29.pdf)

<sup>16</sup> A regression of actuarial funding ratios on the percentage of assets held in bonds (held to be the non-risky asset) produced an  $R^2$  of 0.005;  $p=0.46$ .

## 5. 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 are assumed to be infinitely lived and have the power to tax. In a 2006 white paper, GASB 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.<sup>17</sup>

There is at least a plausible argument that can be made to this effect. Arrow and Lind 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.<sup>18</sup>

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 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

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<sup>17</sup> Government Accounting Standards Board. "Why Governmental Accounting And Financial Reporting Is—And Should Be—Different." White paper released 2006. Available at [http://www.gasb.org/white\\_paper\\_mar\\_2006.html](http://www.gasb.org/white_paper_mar_2006.html)

<sup>18</sup> Arrow, Kenneth J. and R.C. Lind. "Uncertainty and the Evaluation of Public Investment Decisions", *American Economic Review*, Vol. 60, 1970.

likely to weaken at the same time that governments' capacity to support them is at their weakest.

Financial 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."<sup>19</sup> 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.<sup>20</sup>

Before illustrating a method for valuing public pension shortfalls using financial instruments known as options, we first present simulations of the risk of pension funding shortfalls.

## 6. Market Volatility and the "Expected Return"

Actuarial valuation methods project the average long-term rate of return that is expected to be received by a program's portfolio of assets. Based on this return, the

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<sup>19</sup> Congressional Budget Office. "Estimating the Value of Subsidies for Federal Loans and Loan Guarantees." August 2004. This article contains an extensive discussion of the treatment of risk of government programs, extending beyond federal loan guarantees. See also [Budget of the United States Government, Fiscal Year 2004: Analytical Perspectives](#), "Railroad Retirement Board Investments," p. 471; and Congressional Budget Office, "[Evaluating and Accounting for Federal Investment in Corporate Stocks and Other Private Securities](#)," January, 2003.

<sup>20</sup> For background, see Deborah Lucas and Marvin Phaup. "The Cost of Risk to the Government and Its Implications for Federal Budgeting." Forthcoming in *Measuring and Managing Federal Financial Risk*, published by National Bureau of Economic Research.

plan's ability to fund accrued benefits is calculated. However, in almost no cases is the volatility of returns considered. This section presents an initial attempt to do so, and shows that even if a plan is "fully funded" by current actuarial standards, market volatility for the typical plan portfolio implies a probability that current plan assets will be insufficient to meet accrued benefit obligations.

To simulate the solvency of public pension plans requires first translating a single figure provided in plan financial reports – the present value of accrued plan liabilities – into a series of annual benefit obligations. As plans do not provide annual liability data, an estimation method is employed. Figure 2 is derived from Medel and Straub for a pension that does not pay annual cost of living adjustments.<sup>21</sup> Because many plans pay inflation adjustments, based on differing terms and often contingent upon legislative action, funding levels or investment returns, this pattern of cash flows will not match each public pension exactly. Nevertheless, it has been modified into a simple tool for translating the present value of plan liabilities into approximate annual cash requirements.

The ability of plan assets to meet liabilities is tested through a Monte Carlo simulation where annual returns are randomly generated based on projected plan returns and a standard deviation of returns consistent with the mean return. The mean rate of return equals the return projected by the plan itself. The standard deviation of annual returns must be inferred, as plans generally do not release information regarding the assumed level of risk of their chosen portfolio. This estimation is based on projections from Wilshire and follows a process detailed in the Appendix.

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<sup>21</sup> Aaron Meder and Renato Staub. "Linking Pension Liabilities to Assets." *UBS Global Asset Management Working Paper*. 2006. Available online at <http://www.soa.org/library/journals/actuarial-practice-forum/2007/october/apf-2007-10-meder-staub.pdf>

Future employee contributions are not modeled as these are principally intended to fund their own benefits rather than previously accrued obligations. That is to say, new contributions also imply new liabilities so one should not be simulated without the other. Plans that are incapable of paying accrued benefits with current assets as measured here may nevertheless be able to meet near-term benefit obligations by diverting employee contributions from investments to the payment of current costs. Doing so, however, delays the financial problem but not reduce it.

Each year, plan assets are compounded by the return generated by the random process; meanwhile, annual benefit costs are deducted from the balance of assets. This process is repeated 1,000 times for each plan and the probability of plan assets being sufficient to pay accrued liabilities is measured. This process is undertaken for each of the 125 plans for which data is available.

If a plan that is fully funded by actuarial standards receives the projected return in every future year, by construction assets will be sufficient to meet liabilities. However, market returns can vary significantly from year to year, with no guarantee that the long-term average will be realized.

For individual plans, probabilities of current assets being sufficient to fund current liabilities are rounded to the nearest decimal (Figure 3). There is a very wide distribution of probabilities, with a maximum of 62 percent (the Washington State LEOFF Plan 1) and several plans with the minimum probability of zero percent (See Table 1). The mean probability of current public pension assets being sufficient to fund current accrued liabilities is 16 percent. More plans have a zero probability of solvency (7) than have a probability of solvency greater than 50 percent (6).

Part of the 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, the major role is played by market volatility. Even if a plan is fully funded based on actuarial accounting and the long-term average return is accurately projected, there nevertheless will be less than a 50 percent probability of the plan being solvent. This result is driven by the simple fact that the median (or typical) return is lower than the mean (or average) return. Based on the results of individual plan simulations, a fully funded plan with an actuarial funding ratio of 100 percent would have a probability of paying full accrued benefits of only around 35 percent.

One aspect of these Monte Carlo simulations might appear to support actuarial accounting's focus on pension assets' expected return: all other things being equal, a plan that invests in higher-returning assets is more likely to be able to meet accrued liabilities than one investing in assets with lower expected returns. But this single measure masks the fact that with a riskier portfolio, losses that *do* occur will be larger. In effect, a riskier portfolio amounts to doubling down on pension financing: there is a higher probability of the plan being solvent, but also a higher probability of large losses.

Monte Carlo simulations cannot place a single value on a range of possible outcomes. As will be shown below, however, market pricing mechanisms are capable of doing so. But to properly incorporate market risk into measures of plan funding, however, requires information regarding who bears that risk. The following section summarizes the legal protections afforded to accrued public pension benefits.

## 7. Legal protections for accrued public pension benefits

Donald Kohn, Vice Chairman of the Federal Reserve Board, states that “For all intents and purposes, accrued benefits have turned out to be riskless obligations.”<sup>22</sup> 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.<sup>23</sup> 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.<sup>24</sup> Rauh and Novy-Mark assume public pension benefits to have a probability of default similar to that of U.S Treasury bonds,<sup>25</sup> 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

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<sup>22</sup> Donald L. Kohn. Statement at the National Conference on Public Employee Retirement Systems Annual Conference. New Orleans, Louisiana, May 20, 2008. Available at <http://www.federalreserve.gov/newsevents/speech/kohn20080520a.htm>

<sup>23</sup> For details by state see Morrison & Foerster, LLP, and Greenebaum Doll & McDonald, PLLC. 2007. “Index by States.” Available at <http://finance.ky.gov/NR/rdonlyres/275A2978-5DDE-4138-A7F5-AF02D17D7F97/0/Statebystatememo10.pdf>

<sup>24</sup> Jeffrey R. Brown and David W. Wilcox. “Discounting State and Local Pension Liabilities.” *American Economic Review*, vol. 99 (May 2009), pp. 538-42.

<sup>25</sup> Novy-Marx, Robert and Rauh, Joshua D. “The Liabilities and Risks of State-Sponsored Pension Plans.” *Journal of Economic Perspectives* 23(4). 191-210.

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.

## 8. 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.<sup>26</sup> Public sector pensions effectively provide such a put option via their legal ability to call upon taxpayers for additional funds as needed.

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<sup>26</sup> 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 dominant method for pricing options is known as Black-Scholes, initially developed by Fischer Black and Myron Scholes and extended by Robert Merton.<sup>27</sup> 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.
- 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.

The Black-Scholes price of a call option is equal to

$$C_0 = S_0N(d_1) - Xe^{-rt}N(d_2)$$

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  $d$ ;

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<sup>27</sup> Fischer Black and Myron Scholes. "The Pricing of Options and Corporate Liabilities." *The Journal of Political Economy*, Vol.81, No.3. (May-June 1973), pp.637-654. Merton, Robert C. (1973). "Theory of Rational Option Pricing." *Bell Journal of Economics and Management Science* 4 (1): 141-183.

$X$  = 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

$$P = C_0 + PV(X) - S_0 = C + Xe^{-rt} - S_0$$

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

Applying the Black-Schole options pricing formula to public sector pensions requires a number of assumptions and simplifications.

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. However, 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.<sup>28</sup> 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

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<sup>28</sup> 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.

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.<sup>29</sup>

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. That said, the current market value is the more appropriate measure.

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. Waring finds that the mid-point of a public pension's stream of future benefit payments 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.<sup>30</sup> To calculate this figure, we compound the present value 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

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<sup>29</sup> Barry W. Poulson and Arthur P. Hall. "State Pension Funds Fall Off a Cliff." American Legislative Exchange Council. January 2010. Available online at [http://www.alec.org/AM/Template.cfm?Section=State\\_Pension\\_Funds\\_Fall\\_Off\\_a\\_Cliff](http://www.alec.org/AM/Template.cfm?Section=State_Pension_Funds_Fall_Off_a_Cliff)

<sup>30</sup> See M. Barton Waring. "Liability-relative investing." *Journal of Portfolio Management* 30(4). Here I follow Robert Novy-Marx and Joshua D. Rauh. "The Intergenerational Transfer of Public Pension Promises." (September 2, 2008). Chicago GSB Research Paper No. 08-13. Available online at [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=1156477](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1156477)

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. The standard deviation of annual returns is approximated using the method used in the Monte Carlo simulation, outlined in the Appendix.

Finally, these calculations use the yield on U.S. Treasury debt as the riskless interest rate.<sup>31</sup> 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 those needed to pay accrued benefits might be returned to the plan; in another, surplus assets might be used to 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

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<sup>31</sup> 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.

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 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 are paid as contingent Cost of Living Adjustments (COLAs), while in others they are paid via a so-called “13<sup>th</sup> check.”<sup>32</sup> Aronson, Dearden and Munley, 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.<sup>33</sup> 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.

For this analysis we assume that all excess assets as of the 15<sup>th</sup> year are used to increase plan benefits, which is an unrealistic simplification of actual plan rules. In practice, however, this assumption does not significantly alter the results. Because most plans are underfunded, 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

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<sup>32</sup> Some cases of potential benefit increases are discussed in Keith Brainard. “Redefining Traditional Plans: Variations and Developments in Public Employee Retirement Plan Design.” In Olivia S. Mitchell and Gary W. Anderson, Editors. *The Future of Public Employee Retirement Systems*. Oxford University Press. October 2009.

<sup>33</sup> Aronson, J. Richard, James A. Dearden, Vincent G. Munley. “Public Employee Defined Benefit Pension Systems: The Impact of Explicit Surplus Sharing Contracts and Stakeholder Influence on Investment Strategies.” *Public Choice*. Volume 140, Numbers 1-2 / July, 2009.

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<sup>34</sup>—the most recent available—the plan holds \$10.995 billion in assets. These assets are invested in a mix of 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 present value 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 future value 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.

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<sup>34</sup> Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2008, State Employees' Retirement System of Illinois, <http://www.state.il.us/srs/PDFILES/oldAnnuals/SERS08.pdf>

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.<sup>35</sup> 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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<sup>35</sup> In practice, options could be purchased on an annual basis, ensuring that assets met projected goals for the year.

## 9. 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 equaled \$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 3).

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.<sup>36</sup> And, 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 4 shows the market value of unfunded pension liabilities by state.

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<sup>36</sup> 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. Joshua Rauh and Robert Novy-Marx. "The Liabilities and Risks of State-Sponsored Pension Plans." *Journal of Economic Perspectives* 23(4), 191-210.

While the absolute value of state pension liabilities is of interest, a dollar figure alone cannot give any 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.

In only two of 50 states are accumulated public pension liabilities smaller than explicit government debt (Figure 5). 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 787 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 gross domestic product (GDP)<sup>37</sup> better shows the states' ability to service and/or retire public pension liabilities in conjunction with other state responsibilities (Figure 6). There is a wide dispersion by state of the ratio of unfunded pension liabilities to gross domestic product (Table 3). 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.

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 7). If states were independent entities these debt levels would, on average, be sustainable given reasonable

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<sup>37</sup> Source for state gross domestic product: Bureau of Economic Analysis. June 2, 2009.

rates of economic growth. However, these state obligations will be coupled with rising federal debt levels, which the Congressional Budget Office projects could reach 87 percent of GDP by 2020.<sup>38</sup> It is questionable whether and how these total debt burdens are sustainable.

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 pre-funded 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 have speculated regarding an eventual federal bailout of state public sector pension funds<sup>39</sup> and such a step is not unimaginable given the scale of funding shortfalls. 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, Alaska, Illinois, or other poorly funded states.

## **10. 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

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<sup>38</sup> Congressional Budget Office. “Long Term Budget Outlook.” June 2010.

<sup>39</sup> Steven Brull. “The Big Public Pension Squeeze.” *Institutional Investor Magazine*. June 10, 2009.

valuation is the Illinois SERS, while under conventional actuarial it is the Indiana Teachers plan. These differences illustrate the ability of an options pricing approach to account for the effects of portfolio allocation on plan funding levels.

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 essentially free money: that is, the Indiana Teachers plan could costlessly improve its actuarial valuation simply by stating that it expects the same 8.5 percent return on its portfolio that Illinois SERS projects, or at the least increasing the allocation of stocks in its portfolio. 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 generally 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 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. 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.

## **11. 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 present value of plan liabilities. This method follows the established precept in financial economics that, as Kohn puts it, “The only appropriate way to calculate the present value of a very-low-risk liability is to use a very-low-risk discount rate.”<sup>40</sup>

Risk-adjusted discounting can be utilized using existing pension data by first compounding the reported present value of plan liabilities forward at the expected rate of

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<sup>40</sup> Donald L. Kohn. Statement at the National Conference on Public Employee Retirement Systems Annual Conference. New Orleans, Louisiana, May 20, 2008. Available at <http://www.federalreserve.gov/newsevents/speech/kohn20080520a.htm>

return, then discounting back to the present using a risk-adjusted return.<sup>41</sup> 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.

While it is generally true, as Rauh and Novy-Marx argue, “The way the liabilities are funded is irrelevant to their value,” the partially one-sided characteristics of pension financing imply that under certain conditions the risk of the funding vehicle also matters. Funding values would be precisely equivalent 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 need pay plan liabilities, the plan *sold* a call option giving up the right to any assets in excess of the necessary level. While this would miss the fact that, in many plans, higher than expected returns can in part be used to increase benefits, in practice the effects of this assumption are extremely small.

The options pricing method introduced here is designed 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 National Association of State Retirement Administrators (NASRA), argues that “Actuaries should want their work product ... to reflect reality.”

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<sup>41</sup> 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  $\left(\frac{1+r_e}{1+r_r}\right)^{15}$ .

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 rate of investment return, that does not necessarily produce a more realistic reading of the plan's funding condition.<sup>42</sup>

Advocates of the standard market valuation approach would argue that this is a misunderstanding of their position. Nevertheless, the options pricing approach is designed to explicitly account for the risk and return characteristics of the pension's investment portfolio and use available financial instruments to hedge the risk of that portfolio. While financial markets do not currently provide put or call options with durations extending beyond several years, a pension could easily purchase options to ensure that projected returns are met on an annual basis. There is nothing in practice – *except* for the bias inherent to actuarial accounting methods – that prevents plan managers from today purchasing put options to protect the public against the possibility of market downturns.

Second, the options pricing method more explicitly rebuts the actuarial method's assumption that stocks grow safer the longer they are held. Since government entities are

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<sup>42</sup> “What's The Debate About? Should public pension plans disclose a market value of liability?” Symposium. *The Actuary Magazine*—December 2008/January 2009 Volume 5 Issue 6. Moderated by Andy Peterson. Available online at <http://www.soa.org/library/newsletters/the-actuary-magazine/2008/december/act-2008-vol5-iss6-peterson.aspx>

held to be permanent, 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.” Samuelson shows that while the probability of a loss declines over time, the *magnitude* of the loss, should it occur, increases.<sup>43</sup> Similarly, Bodie shows that the cost of guaranteeing against low stock returns rises as the holding period grows larger.<sup>44</sup> 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.

## 12. Discussion and Conclusions

Babbell, Gold and Merrill 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.”<sup>45</sup> 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 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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<sup>43</sup> 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.,  $\frac{\sigma}{\sqrt{t}}$ . See Paul A. Samuelson. “Risk and Uncertainty: A Fallacy of Large Numbers.” *The Collected Scientific Papers of Paul A. Samuelson*, ed. Joseph E. Stiglitz. MIT Press, 1966.

<sup>44</sup> Zvi Bodie. “On the Risk of Stocks in the Long Run.” *Financial Analysts Journal*. May-June 1995.

<sup>45</sup> David F. Babbell, Jeremy Gold, and Craig B. Merrill. “Fair Value of Liabilities: The Financial Economics Perspective.” *North American Actuarial Journal*. January 2002, Vol. 6, No. 1.

are large and damaging to policymakers' willingness and ability to address public pension financing.

In the private sector, a defined benefit plan is considered "safe" if its assets equal 80 percent or more of liabilities and "critical" if 65 percent or less.<sup>46</sup> 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 like 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,<sup>47</sup> although the chair of New

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<sup>46</sup> Life and Health Insurance News.com (2009). "The Big Pension Freeze." May 19. <http://www.lifeandhealthinsurancenews.com/News/2009/4/Pages/The-Big-Pension-Freeze.aspx>

<sup>47</sup> For instance, see "NYC Story." *Life & Pensions Magazine*. March 2006. Available online at [http://www.pensionfinance.org/papers/Bob\\_North.pdf](http://www.pensionfinance.org/papers/Bob_North.pdf)

Jersey's pension investment council recently cited market valuation of pension shortfalls as evidence for the poor state of funding.<sup>48</sup>

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. However, higher contributions rates may help initiate discussions between public sector workers and public sector retirees, mediated by public employee unions representing both.

A second option is to utilize leverage based on other retiree benefits, in particular health coverage. These steps could include increased premiums or co-payments, a higher age of eligibility or elimination of retiree health coverage outright.<sup>49</sup> 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.

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<sup>48</sup> Francesco Guerrera and Nicole Bullock. "U.S. public pensions face \$2,000bn deficit." *Financial Times*. January 4 2010. Available online at <http://www.ft.com/cms/s/0/bd1c2552-f966-11de-8085-00144feab49a.html>

<sup>49</sup> In about three quarters of states Medicare is already the primary insurer of retired public sector employees. See Center for State & Local Government Excellence. "At a Crossroads: The Financing and Future of Health Benefits for State and Local Government Retirees." July 2009.

Finally, policymakers 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 gradually 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.

It is important that state governments and taxpayers have predictable and affordable commitments to public sector pensions. This paper restricted itself to the single topic of the market valuation of public pension financing: whether it should be done and what methods might be utilized. While a number of other issues relating to pension valuation are important, including the smoothing of market returns from year-to-year and the methods by which plan managers choose investments and estimate returns, market valuation is one of the major questions facing public sector plans and, potentially, state and local government finances as a whole.

## **Appendix: Estimating the risk of public pension investments**

Public sector pensions do not publish the estimated risk of their portfolios. This is a significant oversight, since plan managers must possess estimates of the risk of portfolio subcomponents, and of the correlations in returns between subcomponents, to construct the overall investment portfolio. While investment risk is effectively ignored under the actuarial approach for measuring plan financing, it is of crucial importance for stochastic simulations – and of greater importance than estimated returns for market valuations.

To complete the options exercise, a portfolio risk estimate is essential. This estimate is expressed through the standard deviation of annual returns. Projections of annual asset returns, standard deviations of annual returns and correlations between returns of different asset types are taken from Wilshire estimates.<sup>50</sup> Five asset classes are used: equities; bonds; real estate; cash; and alternative investments, which include private equity, hedge funds and the like. For any given combination of such assets a projected mean return and standard deviation of annual returns can be calculated.

Calculations are based on portfolio allocations derived from the CRR public pension dataset. This data is based on 2006 survey responses from plan managers. In a small number of cases figures contained in the dataset have been adjusted based on consultation with current plan financial reports.<sup>51</sup>

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<sup>50</sup> Steven J. Foresti, Michael E. Rush, and Alexander C. Browning, “2009 Mid-Year Asset Class Assumptions Update,” Wilshire Consulting, July 20, 2009.

<sup>51</sup> The CRR dataset contains a portfolio item listed as “other.” When this proportion is below 10 percent it is ignored and asset allocations are adjusted to equal 100 percent in the absence of “other” assets. When the proportion of “other” assets is above 10 percent, plan financial reports were consulted and the percentage of assets marked as “other” was allocated to other asset types. In most such cases, assets marked as “other”

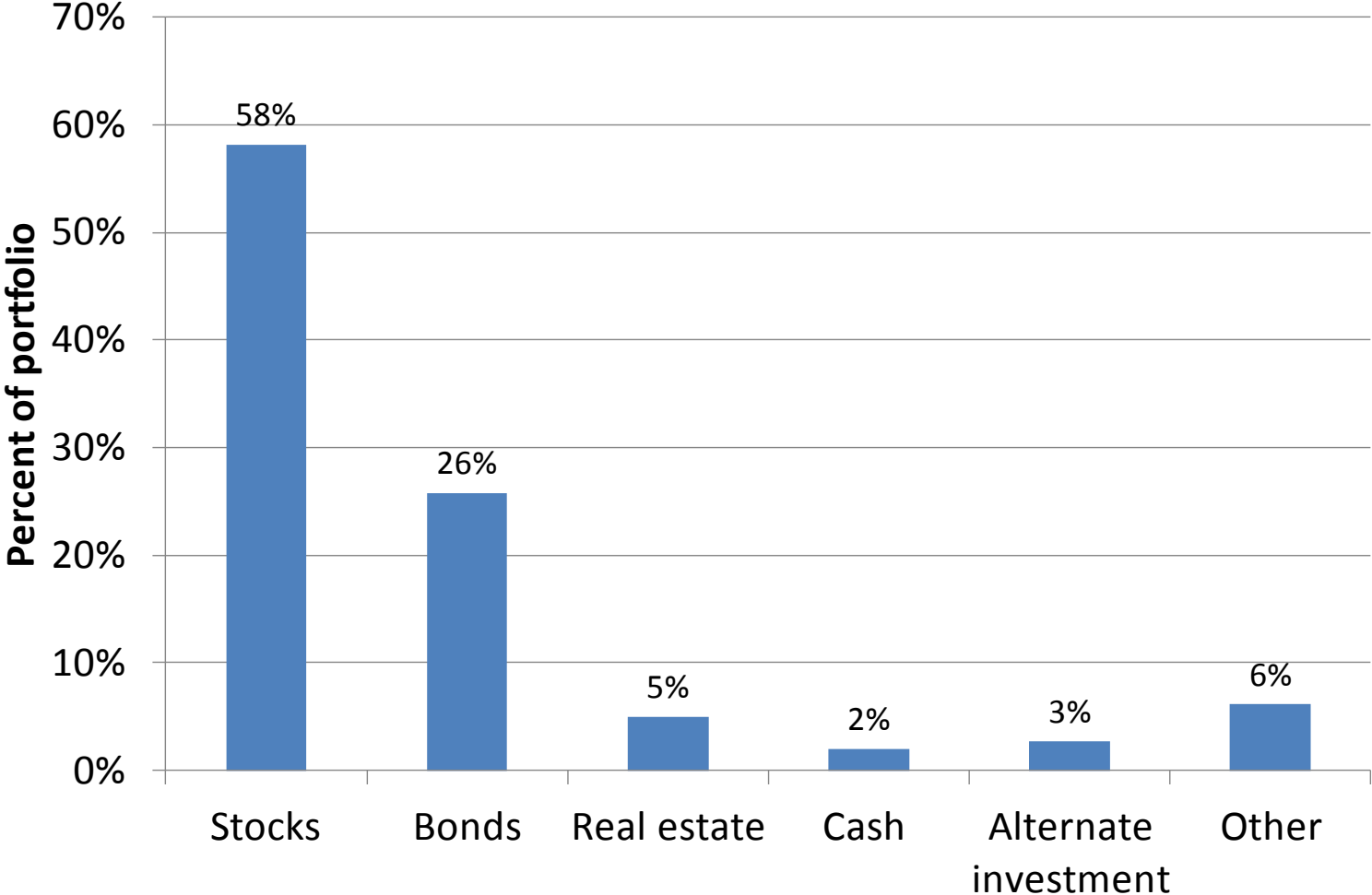
This calculation produces both a projected mean return and a standard deviation of annual returns. The mean return may differ from the plan's own projected return, but the sources of such differences are unclear due to the lack of disclosure by the plans themselves. The average estimated return in this exercise was 8.3 percent, versus an average return projected by plans of 8.0 percent. The maximum amount by which the estimated returns exceed plan's own projections is 3.7 percent; the maximum understatement is 2.5 percent.

This is an imperfect process and better disclosure of data by plans themselves would be superior. Nevertheless, given the crucial role that investment risk plays in options pricing techniques, such approximations are necessary.

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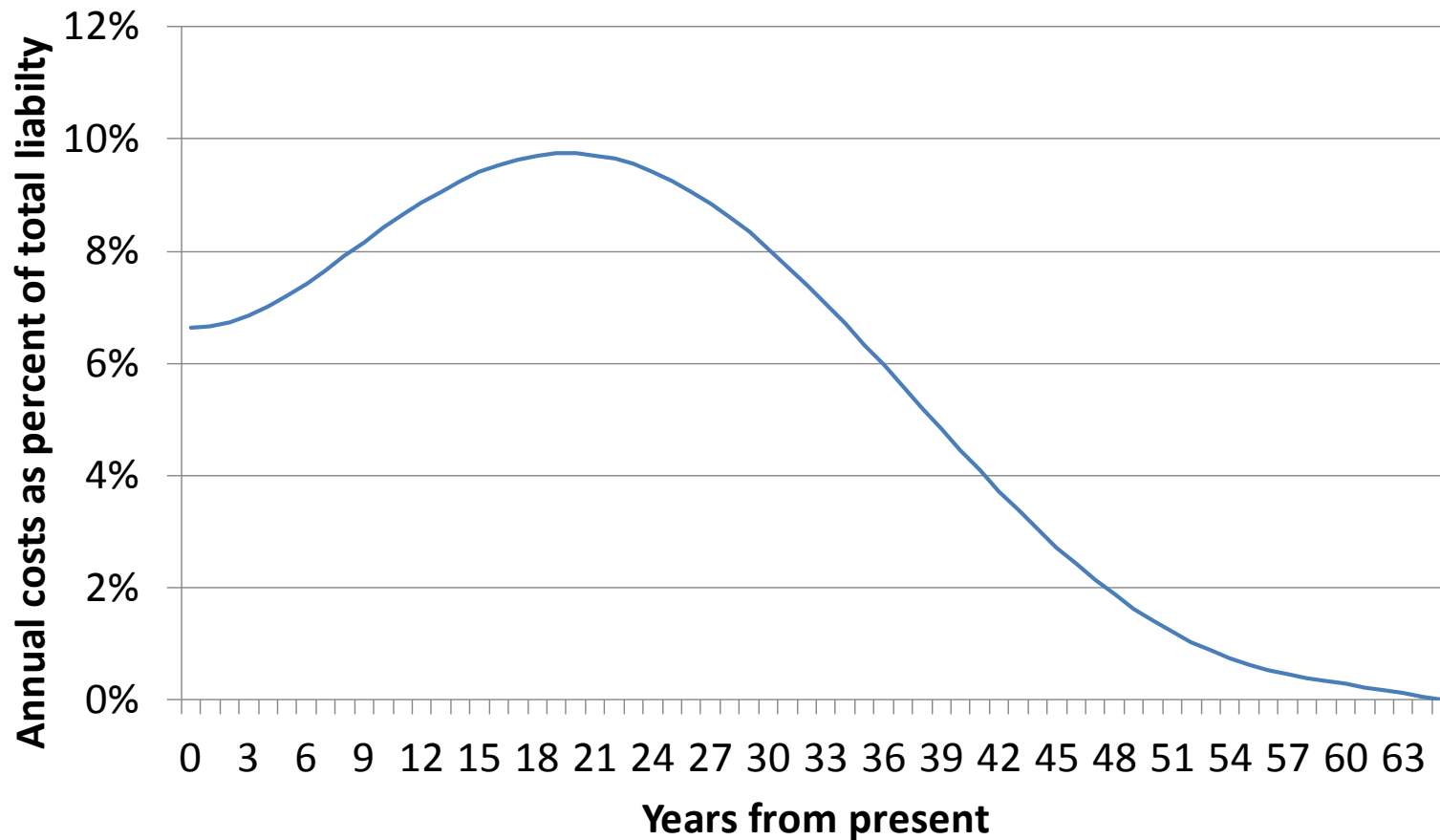
consisted of private equity which should properly have been credited to the "alternative investments" category. The effects of these adjustments, both on individual plan funding reports and on aggregate funding, should be small.

**Figure 1: Average state pension portfolio allocations**



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

**Figure 2. Projected annual accrued benefit costs as percent of total accrued liability**



Source: Author's calculations based on Meder and Staub 2006, Chart 2.

<b>Table 1; Distribution of probabilities of plan assets being sufficient to fund accrued liabilities</b>	
Percentile	Probability
Min	0%
10 <sup>th</sup>	3%
25 <sup>th</sup>	7%
50 <sup>th</sup>	16%
75 <sup>th</sup>	27%
90 <sup>th</sup>	43%
Max	62%
Source: Author's calculations	

<b>Table 3: Distribution of unfunded pension liabilities relative to state gross domestic product</b>	
Percentile	Pension liability/ GDP
Min	12%
10 <sup>th</sup>	16%
25 <sup>th</sup>	19%
50 <sup>th</sup>	28%
75 <sup>th</sup>	32%
90 <sup>th</sup>	39%
Max	54%
Source: Author's calculations; state GDP from Bureau of Economic Analysis.	

**Table 2 on following pages.**

**Table 2. Market valued funding ratios and unfunded liabilities**

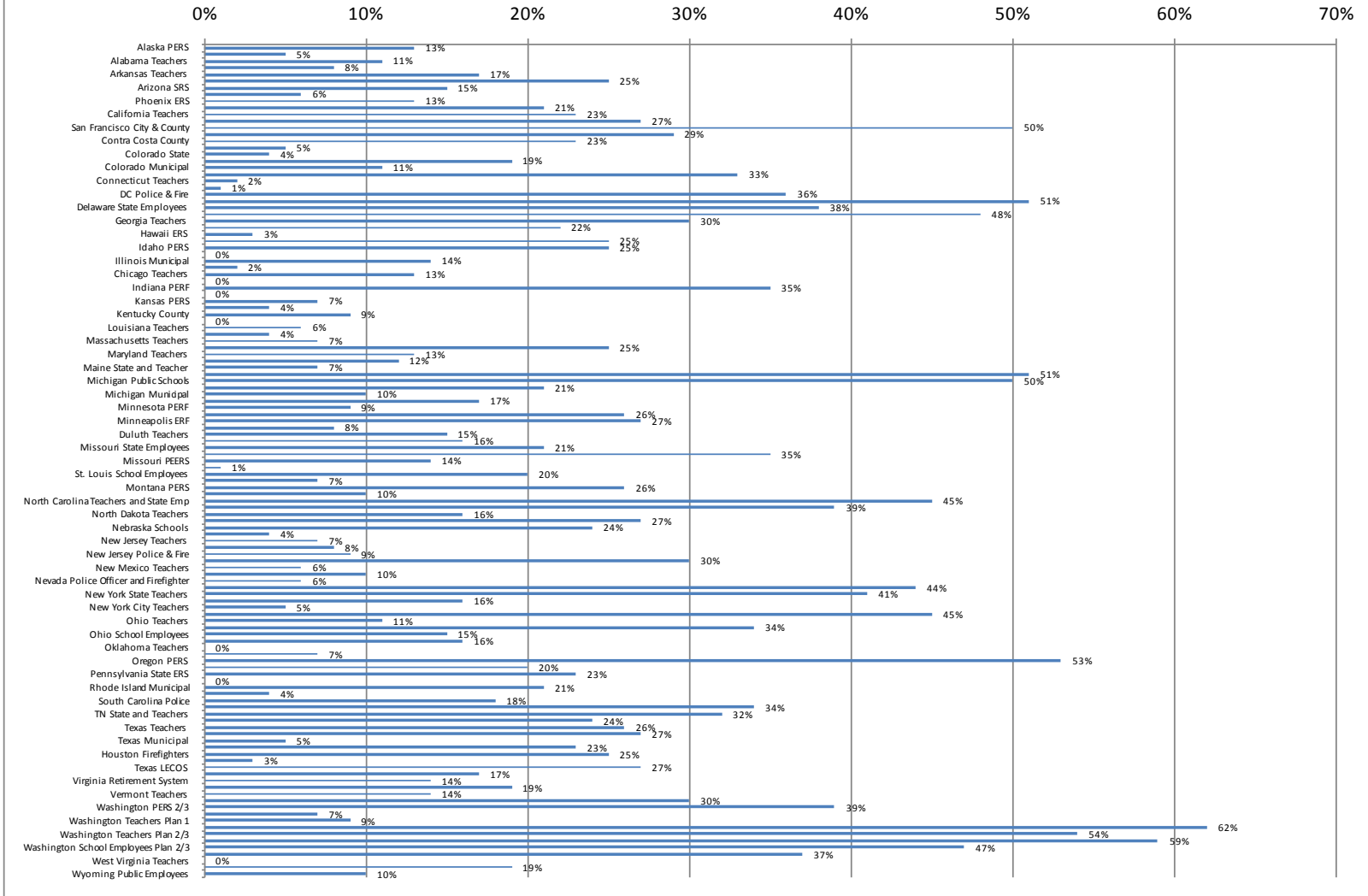
Plan	Funding ratio	Unfunded liability	Plan	Funding ratio	Unfunded liability
Alaska PERS	46%	\$ 8,050,237	Missouri DOT and Highway Patrol	31%	\$ 4,003,514
Alaska Teachers	37%	\$ 6,380,078	St. Louis School Employees	48%	\$ 1,086,775
Alabama Teachers	42%	\$ 29,111,963	Mississippi PERS	39%	\$ 32,225,716
Alabama ERS	41%	\$ 14,432,917	Montana PERS	48%	\$ 4,390,299
Arkansas Teachers	45%	\$ 13,616,284	Montana Teachers	43%	\$ 4,243,003
Arkansas PERS	48%	\$ 6,410,030	North Carolina Teachers and State Employees	60%	\$ 36,576,881
Arizona SRS	44%	\$ 35,386,811	North Carolina Local Government	58%	\$ 12,321,531
Arizona Public Safety Personnel	35%	\$ 9,617,279	North Dakota Teachers	44%	\$ 2,441,111
Phoenix ERS	40%	\$ 2,900,971	North Dakota PERS	49%	\$ 1,657,941
California PERF	48%	\$ 233,543,336	Nebraska Schools	48%	\$ 7,438,589
California Teachers	47%	\$ 164,947,238	New Hampshire Retirement System	34%	\$ 10,233,796
LA County ERS	53%	\$ 32,755,300	New Jersey Teachers	38%	\$ 60,832,717
San Francisco City & County	58%	\$ 11,008,846	New Jersey PERS	38%	\$ 47,885,415
San Diego County	50%	\$ 8,191,004	New Jersey Police & Fire	39%	\$ 36,151,554
Contra Costa County	45%	\$ 6,162,321	New Mexico PERF	50%	\$ 13,057,695
Colorado School	35%	\$ 39,875,871	New Mexico Teachers	38%	\$ 14,817,485
Colorado State	34%	\$ 26,803,823	Nevada Regular Employees	42%	\$ 26,065,679
Denver Schools	45%	\$ 3,585,376	Nevada Police Officer and Firefighter	38%	\$ 7,463,667
Colorado Municipal	38%	\$ 4,708,149	NY State & Local ERS	56%	\$ 97,060,712
Denver Employees	52%	\$ 1,802,717	New York State Teachers	55%	\$ 68,393,049
Connecticut Teachers	32%	\$ 25,338,342	New York City ERS	44%	\$ 48,427,183
Connecticut SERS	27%	\$ 23,176,899	New York City Teachers	38%	\$ 55,214,745
DC Police & Fire	58%	\$ 2,141,724	NY State & Local Police & Fire	56%	\$ 16,896,343
DC Teachers	62%	\$ 893,004	Ohio Teachers	42%	\$ 93,770,630

Delaware State Employees	54%	\$ 5,688,663	Ohio PERS	51%	\$ 64,405,880
Florida RS	57%	\$ 98,505,110	Ohio School Employees	44%	\$ 14,342,118
Georgia Teachers	54%	\$ 45,177,962	Ohio Police & Fire	42%	\$ 15,274,853
Georgia ERS	51%	\$ 13,564,822	Oklahoma Teachers	27%	\$ 24,682,475
Hawaii ERS	36%	\$ 18,533,398	Oklahoma PERS	42%	\$ 8,964,897
Iowa PERS	51%	\$ 21,266,226	Oregon PERS	58%	\$ 42,203,565
Idaho PERS	51%	\$ 10,022,613	Pennsylvania School Employees	43%	\$ 75,841,353
Illinois Teachers	28%	\$ 97,660,583	Pennsylvania State ERS	44%	\$ 38,303,543
Illinois Municipal	47%	\$ 23,711,290	Rhode Island ERS	29%	\$ 13,918,497
Illinois Universities	30%	\$ 34,836,038	Rhode Island Municipal	47%	\$ 1,087,343
Chicago Teachers	43%	\$ 15,611,551	South Carolina RS	42%	\$ 33,102,372
Illinois SERS	23%	\$ 36,250,750	South Carolina Police	50%	\$ 3,166,538
Indiana PERF	57%	\$ 9,772,242	South Dakota PERS	53%	\$ 5,982,103
Indiana Teachers	26%	\$ 23,984,413	TN State and Teachers	51%	\$ 25,172,217
Kansas PERS	38%	\$ 21,827,991	TN Political Subdivisions	48%	\$ 5,373,882
Kentucky Teachers	39%	\$ 23,623,659	Texas Teachers	48%	\$ 118,359,305
Kentucky County	43%	\$ 9,999,298	Texas ERS	49%	\$ 24,258,117
Kentucky ERS	30%	\$ 13,393,425	Texas Municipal	46%	\$ 17,981,171
Louisiana Teachers	37%	\$ 26,929,309	Texas County & District	47%	\$ 16,514,425
Louisiana SERS	35%	\$ 16,868,589	Houston Firefighters	48%	\$ 2,799,275
Massachusetts Teachers	38%	\$ 36,653,317	City of Austin ERS	36%	\$ 2,685,697
Massachusetts SERS	46%	\$ 23,822,957	Texas LECOS	49%	\$ 808,348
Maryland Teachers	44%	\$ 30,083,495	Utah Noncontributory	45%	\$ 18,626,024
Maryland PERS	43%	\$ 18,115,763	Virginia Retirement System	47%	\$ 53,783,973
Maine State and Teacher	41%	\$ 11,815,963	Fairfax County Schools	47%	\$ 2,173,151
Maine Local	59%	\$ 1,411,326	Vermont Teachers	42%	\$ 2,223,024
Michigan Public Schools	47%	\$ 50,485,669	Vermont State Employees	50%	\$ 1,379,728

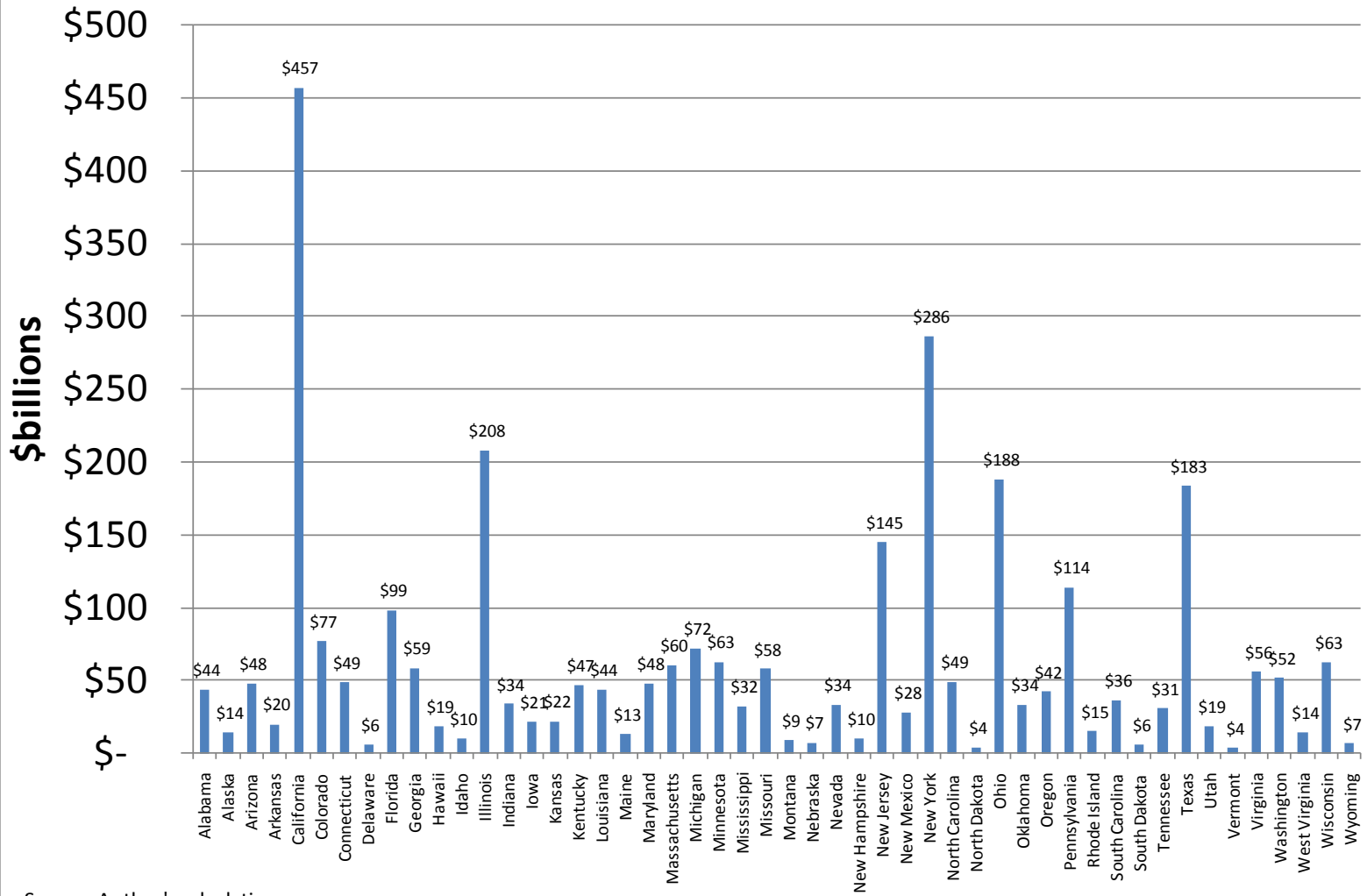
Michigan SERS	46%	\$ 13,290,401	Washington PERS 2/3	54%	\$ 12,913,141
Michigan Municipal	42%	\$ 8,411,128	Washington PERS 1	38%	\$ 15,804,162
Minnesota Teachers	41%	\$ 26,126,326	Washington Teachers Plan 1	41%	\$ 11,853,097
Minnesota PERF	37%	\$ 22,219,455	Washington LEOFF Plan 1	63%	\$ 3,156,316
Minnesota State Employees	45%	\$ 11,008,549	Washington Teachers Plan 2/3	59%	\$ 3,720,025
Minneapolis ERF	49%	\$ 1,575,351	Washington LEOFF Plan 2	62%	\$ 2,683,403
St. Paul Teachers	42%	\$ 1,500,369	Washington School Employees Plan 2/3	56%	\$ 1,677,759
Duluth Teachers	44%	\$ 379,706	Wisconsin Retirement System	54%	\$ 62,691,675
Missouri Teachers	45%	\$ 35,686,962	West Virginia Teachers	29%	\$ 10,139,294
Missouri State Employees	43%	\$ 10,406,075	West Virginia PERS	48%	\$ 4,239,620
Missouri Local	55%	\$ 3,245,199	Wyoming Public Employees	42%	\$ 6,628,204
Missouri PEERS	44%	\$ 3,418,397	<b>Total</b>	<b>46%</b>	<b>\$ 3,061,058,582</b>

Source: Author's calculations

**Figure 3. Probability of assets being sufficient to fund accrued liabilities**

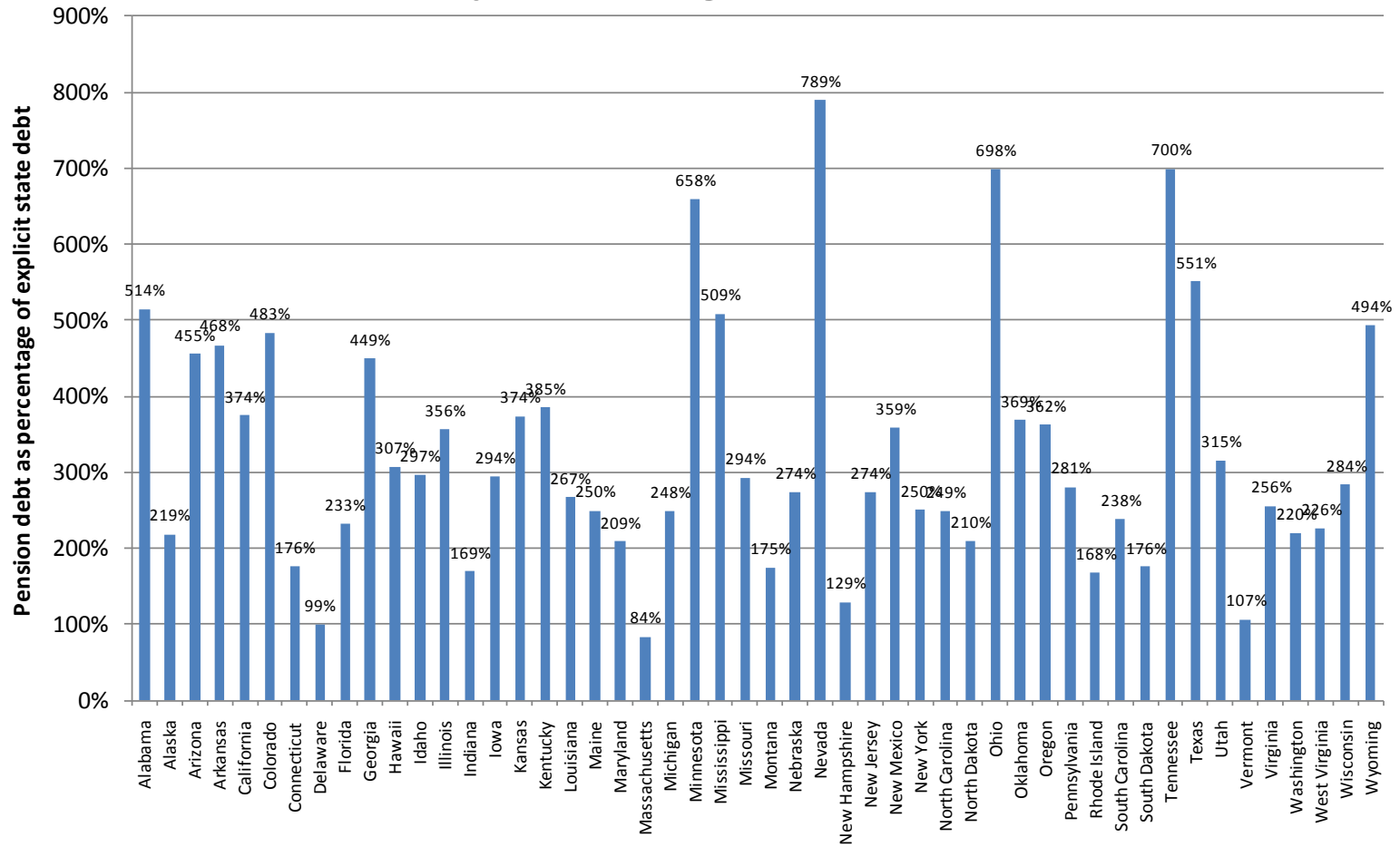


**Figure 4. Market valued unfunded pension liabilities by state**



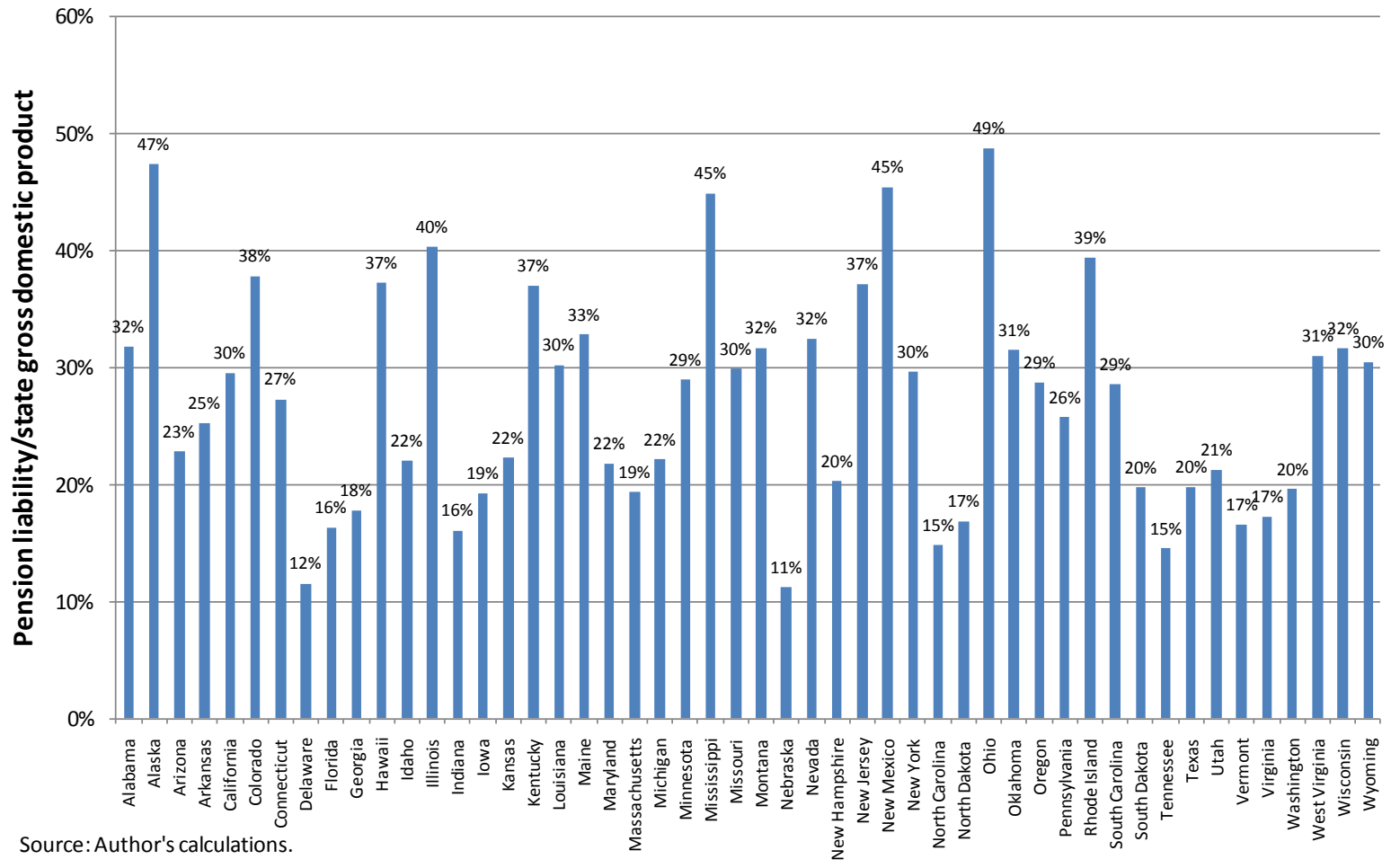
Source: Author's calculations

**Figure 5. Ratio of unfunded public pension liabilities to explicit state government debt**



Source: Author's calculations.

### Figure 6: Unfunded public pension liabilities as percent of state GDP



Source: Author's calculations.

**Figure 7. Explicit debt and unfunded pension liabilities as percent of state GDP**

