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Public Pension Funding Standards in Practice

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Abstract

Public pension funding has recently become a front-burner policy issue in the wake of the financial crisis and given the pending retirement of large numbers of baby boomers. This paper examines the current funding of state and local pensions using a sample of 126 plans, estimating an aggregate funded ratio in 2009 of 78 percent. Projections for 2010-2013 suggest that some continued deterioration is likely. Funded status can vary significantly among plans, so the paper explores the influence of four types of factors: funding discipline, plan governance, plan characteristics, and the fiscal situation of the state. Judging the adequacy of funding requires more than just a snapshot of assets and liabilities, so the paper examines how well plans are meeting their Annual Required Contribution and what factors influence whether they make them. The paper also addresses the controversy over what discount rate to use for valuing liabilities, concluding that using a riskless rate of return could help improve funding discipline but would need to be implemented in a manageable way. Finally, the paper assesses whether plans face a near-term liquidity crisis and finds that most have assets on hand to cover benefits over the next 15-20 years. The bottom line is that, like private investors, public plans have been hit hard by the financial crisis and their full recovery is dependent on the rebound of the economy and the stock market.

Introduction

It is generally agreed that each generation of taxpayers should pay the full cost of the public services it receives. If a worker's compensation includes a defined benefit pension, the cost of the benefit earned in that year should be recognized, and funded, at the time the worker performs that service, not when the pension is paid in retirement. The discipline of making state and local governments pay the annual costs also discourages governments from awarding excessively generous pensions in lieu of current wages.[1] Many states and localities also have some unfunded pension obligations from the past, either because they did not put away money at the time the benefits were earned or because they provided benefits retroactively to some participants. The cost of these unfunded liabilities also needs to be distributed in some equitable fashion.

The question of funding has gained increased urgency for two reasons. First, the collapse of the stock market reduced the value of equities held by state and local plans by about $1 trillion, substantially undermining the funded status of virtually all state and local plans. Second, baby boomers are about to begin retiring in large numbers, which means that benefits are slated to increase sharply.

This paper examines the current funding of state and local pension plans. Section 1 begins by describing the regulatory environment under which the plans operate, and Section 2 describes the actuarial cost methods employed. Section 3 then reports the funding status of the 126 plans in our sample as of 2009 – the first year for which the full impact of the financial meltdown is felt, and Section 4 reports on factors affecting the variability in funded ratios. Judging the adequacy of funding, however, requires more than a snapshot of the ratio of assets to liabilities; the key issue is whether the sponsor has a funding plan and is sticking to it. So Section 5 reports on the extent to which plan sponsors are making their Annual Required Contribution (ARC), tries to identify the factors that lead sponsors to make their ARC payment, and speculates about the future of ARC payments. Section 6 looks at how the funding picture would change if liabilities were valued using the riskless rate rather than the return on assets. Finally, Section 7 addresses the question of liquidity.[2]

The conclusion that emerges is that, despite not having a federal mandate, in the aggregate, state and local plans were making solid progress toward funding until they were thrown severely off course by the bursting of the dot.com bubble and the collapse of asset prices in 2008. Their funded status looks much worse, of course, if assets are valued using the riskless rate. They are not, however, facing a liquidity crisis; on average, plans have enough assets to pay benefits for the next 15-20 years. Most states have responded to the crisis by increasing employee contributions and reducing benefits for new employees. But the picture will not improve significantly until the economy and the stock market recover and states and localities resume paying their full ARC.

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[1] Johnson (1997) found that the relative generosity of pensions among state and local government workers is directly related to the ability to underfund their plans.

[2] This paper is based on a body of research conducted by the Center for Retirement Research at Boston College and supported by the Center for State and Local Government Excellence. See Munnell et al. (2010); Munnell, Aubry, and Quinby (2010); Munnell, Haverstick, Sass, and Aubry (2008);Munnell, Haverstick, Aubry, and Golub-Sass (2008); and Munnell, Haverstick, and Aubry (2008).

1. The Regulatory Environment

Funding is a relatively recent phenomenon in the public sector. Public plans were not in very good shape as recently as the late 1970s. State and local government employment had roughly doubled between the early 1960s and the mid-1970s, resulting in an enormous growth in workers participating in state and local pensions. Nevertheless, primarily for constitutional reasons, public plans were not covered by the Employee Retirement Income Security Act of 1974.[3] ERISA did mandate a study of these plans, and the conclusions of the 1978 *Pension Task Force Report on Public Employee Retirement Systems* were not flattering:

> "In the vast majority of public employee pension systems, plan participants, plan sponsors, and the general public are kept in the dark with regard to a realistic assessment of true pension costs. The high degree of pension cost blindness is due to the lack of actuarial valuations, the use of unrealistic actuarial assumptions, and the general absence of actuarial standards."

Perhaps at least partly in response to the report, states and localities became increasingly aware of the importance of sound funding and began to undertake a variety of approaches to achieve that goal. These funding efforts and a strong stock market produced a marked increase in assets per worker (see Figure 1).

The accounting organizations also played a role. The Governmental Accounting Standards Board (GASB), which came into being in the early 1980s, provided guidance for disclosure of pension information with Statement No. 5 in 1986.[4] One important requirement was that all plans report their benefit obligations and pension fund assets using uniform methods to allow observers to make comparisons across plans. In most cases, this required two sets of books, as the GASB method was very different from the approach most plan actuaries had adopted for establishing funding contributions. What's more, actuaries did not apply it retroactively, which made historical comparisons impossible. As a result, when users needed information about a plan's funded status and funding progress, they generally looked to numbers generated by the plan's own methodology.

GASB Statements No. 25 and 27[5], issued in 1994, contained a key innovation: they allowed sponsors that satisfy certain "parameters" to use the numbers that emerge from the actuary's funding exercise for reporting purposes.[6] Among others, these parameters defined an acceptable

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[3] This legislation for private plans introduced participation and vesting standards to make it easier for workers to establish legal claims to benefits, and funding and fiduciary standards to make sure that the money would be available to pay the legal benefit claims. To further protect participants against the possibility that some plans might terminate with inadequate assets, typically due to the failure of the sponsor, ERISA also established the Pension Benefit Guaranty Corporation.

[4] Statement No. 5 is titled "Disclosure of Pension Information by Public Employee Retirement Systems and State and Local Governmental Employers."

[5] Statement No. 25 is titled "Financial Reporting for Defined Benefit Pension Plans and Note Disclosures for Defined Contribution Plans." Statement No. 27 is titled "Accounting for Pensions by State and Local Governmental Employers." The provisions of GASB 25 and 27 became effective June 15, 1996.

[6] This arrangement is very different from what occurs in the private sector, where the actuary is required to make a number of valuations for different purposes. In the private sector, the actuary must produce: 1) a traditional

amortization period, which was originally up to 40 years and reduced to 30 years in 2006, and an Annual Required Contribution (ARC), which would cover the cost of benefits accruing in the current year and a payment to amortize the plan's unfunded actuarial liability.[7]

For measuring the funded status of a plan, GASB uses the projected benefit obligation (PBO) as the liability concept. The PBO includes pension benefits paid to retired employees, benefits earned to date by active employees based on their current salaries and years of service, *and* the effect of future salary increases on the value of pension rights already earned by active workers. With regard to the discount rate, GASB 25 states that it should be based on "an estimated long-term yield for the plan, with consideration given to the nature and mix of current and planned investments …"

GASB provides the parameters, but plans are not required to follow them. GASB, like its private sector counterpart, the Financial Accounting Standards Board, is an independent organization and has no authority to enforce its recommendations. Many state laws, however, require that public plans comply with GASB standards, and auditors generally require state and local governments to comply with the standards to receive a "clean" audit opinion. And bond raters generally consider whether GASB standards are followed when assessing credit standing.[8] Thus, financial reporting requirements probably have had considerable impact.

2. Determining Pension Costs in the Public Sector

The precise amount of money that state and local plans put aside each year depends on how the actuaries allocate costs to a particular year – that is, it depends on the actuarial cost method adopted. In contrast to the private sector, the public sector relies primarily on the entry-age normal approach for funding and reporting purposes (see Table 1).[9] But 14 percent use the

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actuarial valuation to determine funding, which presents the actuary's best estimate of the plan's liabilities, assets, the annual contribution required to cover benefits accrued that year (the normal cost), and the amortization of any unfunded obligations, all assuming the plan will continue indefinitely; 2) a valuation as stipulated by the accounting profession for reporting purposes that again determines assets, liabilities, and the sponsor's annual pension expense, to be reported on the financial statements of the sponsor and the plan; and 3) a determination of the plan's "current" funding status for compliance purposes to determine minimum and maximum contributions and Pension Benefit Guaranty Corporation insurance premiums. While actuaries attempt to keep assumptions as consistent as possible across these valuations, the discount rates used to value future obligations, a critical variable, can differ considerably (Hustead, 2003).

[7] This amortization period applied to both the plan's "initial" underfunding and any subsequent underfunding created by benefit increases attributed to "past service" or experience losses.

[8] U. S. Government Accountability Office (2008).

[9] Both public and private sector employers had traditionally used the entry-age normal actuarial costing method. The reason for the shift in the private sector is that, in 1985, FASB issued rules requiring sponsors to account for accruing pension liabilities by a uniform method, which was the projected unit credit actuarial cost method. Technically, FASB mandated the projected unit credit method only for reporting purposes, and firms could continue to use any of the six actuarial methods authorized under ERISA for funding. Sponsors, however, appear to have either interpreted the FASB standard as an endorsement of the projected unit credit for funding as well as reporting or simply found it more convenient to use the same method for funding and reporting. As a result, a major shift occurred from entry-age normal to projected unit credit for funding purposes (see Table at bottom of next page).

projected unit credit and 16 percent the aggregate cost or other method. The aggregate cost method allocates unfunded liabilities as future normal costs, so a plan using this method shows no current unfunded liabilities and a 100-percent funded ratio. GASB now requires plans using aggregate cost to also report their funding using entry-age normal and, using this method, the aggregate cost plans turn out to be about average in terms of funding.

Both the entry-age normal and projected unit credit generate conventional funded ratios. A numerical example may help clarify a key difference between the costing methods. Suppose a plan sponsor needs to contribute $15,000 for a particular employee who will retire in five years, and that the sponsor fully funds the cost specified by either method. Under projected unit credit, the sponsor recognizes and funds, say, $1,000 in the first year, $2,000 in the second year, $3,000 in the third year, $4,000 in the fourth year, and $5,000 in the fifth year. Under entry-age normal, the actuary would level the contributions over the five-year period so that the sponsor would recognize and pay a normal cost of $3,000 per year. Had the sponsor used entry-age normal, after three years, the plan would have an actuarial accumulated liability of $9,000 and assets of $9,000 (see Figure 2). Had the sponsor used projected unit credit, the plan would have a cumulative liability of $6,000 and assets of $6,000.

In other words, up to the point of retirement, the entry-age method recognizes a larger accumulated pension obligation for active employees and requires a larger contribution than the projected unit credit. Thus, given comparable funded ratios, plans using the entry-age normal method have recognized more liabilities and accumulated more assets than those using the projected unit credit, which is the dominant costing method in the private sector.[10]

3. Funding Levels in the Public Sector

GASB requires plan sponsors to report the funded status of their plans at least every two years; most do so annually. These reported numbers for our sample of 126 plans over the period 1994-2008 and our estimates for 2009 are presented in Figure 3. From the mid-1990s to 2000, funding improved markedly in response to GASB guidelines and a rising stock market. In 2000, assets amounted to 104 percent of liabilities. With the bursting of the high-tech bubble at the turn of the century, funding levels dropped as years of low asset values replaced the higher values from

Table. *Percent of Large Private Pension Plans Using Alternative Actuarial Methods, 1976–2006*

Actuarial cost method	1976	1986	1996	2006
Projected unit credit	0	28	54	74
Entry-age normal	57	40	31	19
Other	43	32	15	7

Source: Watson Wyatt Worldwide. *Survey of Actuarial Assumptions and Funding: Pension Plans with 1,000 or More Participants,* 1986, 1992, 1998, 2003, 2006.

[10] In addition, the private sector's shift in actuarial methods reduced pension expense (and thereby contributions) during the 1980s and 1990s when the baby boom generation (those born between 1946 and 1964) were young workers (age 20 to 50) and shifted pension expense (and contributions) for this very large cohort to later in their careers. Now that the baby boomers are approaching retirement, funding requirements will be higher than they would have been under the entry-age normal cost method. The public sector, in contrast, faces a steady contribution rate.

the 1990s. Funding then stabilized with the run-up of stock prices, which peaked in 2007. But the collapse of asset values in 2008 has once again led to declining funded ratios.

The magnitude of that decline depends on the accuracy of our 2009 estimates. Of the 126 plans in our sample, 72 had reported their 2009 funding levels by mid-July 2010. For those plans without valuations, we projected assets on a plan-by-plan basis using the detailed process described in the valuations.[11] Applying our methodology retrospectively produced numbers for previous years that perfectly match published asset values in half the cases and that came within 1 percent in the other half.[12] We projected liabilities based on the average rate of growth over the past four years. We then sent our proposed projections to the plan administrators and made any suggested alterations.[13] This process resulted in a complete set of plan funded ratios for fiscal year 2009. Based on those numbers, the aggregate funded ratio dropped from 84 percent in 2008 to 78 percent in 2009.

Projections for 2010-2013

While funded ratios for 2009 were the lowest they have been in 15 years, reported numbers are likely to decline further over 2010-2013 as gains in the years leading up to 2007 are phased out and losses from the market collapse phased in. The precise pattern of future funding will depend, of course, on what happens to the stock market. To address such uncertainty, projections were made using three sets of assumptions for the Dow Jones Wilshire 5000 Index between now and 2013 (see Figure 4). All projections assume 3-percent inflation. The pessimistic projection assumes negligible economic growth, rising unemployment, profits growing at only 3 percent annually, falling price-earnings ratios, and the stock market remaining at its current level of roughly 12,000. The most likely projection assumes an economic expansion sufficient to reduce unemployment slightly, profits growing at 7 percent annually, and stock prices rising about 6 percent annually to produce a Wilshire 5000 of 15,000 by 2013. The optimistic projection assumes a stronger economic expansion that reduces unemployment significantly and allows profits and stock prices to grow nearly 11 percent annually, so the Wilshire 5000 reaches 18,000 by 2013. The optimistic projection is designed to exceed the central projection to the same extent that the central exceeds the pessimistic.

In order to estimate the actuarial level of assets for 2010-2013, we replicate the smoothing method of each plan in our data set as detailed in the plan's actuarial valuation, based on each of the assumptions regarding the Wilshire 5000.[14] Because, historically, contribution payments

[11] For those plans without published 2009 actuarial valuations, we took the percent change in actuarial assets between 2008 and 2009, calculated according to the plan's own methodology, and applied that change to its published 2008 GASB level of actuarial assets.

[12] We are less proud of our calculations for the following six plans: Louisiana SERS and TRS, Tennessee State and Teachers, Tennessee Political Subdivisions, Minneapolis ERF, and Denver Employees. In these cases, our estimates fall within a 10-percent confidence interval. However, these are relatively small plans and have a negligible effect on aggregate funding levels.

[13] A few plans declined to comment for various reasons. Connecticut SERS' valuation schedule does not include a 2009 report, and CalPERS and Colorado PERA do not yet have 2009 numbers. Connecticut Teachers, which also did not have 2009 numbers, emphasized that it did not want our numbers interpreted as official in any way.

[14] Projections assume that plans retain their most recently reported investment return assumption and method for calculating actuarial assets.

hold relatively steady for each plan, we estimate future contributions based on an average of the prior three years plus a modest 5-percent per-year increase (the average increase between 1990-2007). Benefit payments, which also show little variation over time, are estimated in the same manner as contributions.

The results are shown in Figure 5. Certainly, the more distant the year, the more uncertain is the projection. In all likelihood, assuming any changes to benefits or contributions would have no material effect, 2010 actuarial reports will show assets equal to about 77 percent of promised benefits. What happens thereafter depends increasingly on the future performance of the stock market. Under the most likely scenario, the funded ratio will continue to decline as the strong stock market experienced in 2005, 2006, 2007, and much of 2008 is slowly phased out of the calculation. By 2013, the ratio of assets to liabilities is projected to equal 73 percent. The comparable 2013 ratio for the optimistic scenario is 76 percent and for the pessimistic scenario 66 percent.

Unfunded Liabilities

The unfunded liabilities for the "most likely" scenario implied by these funded ratios are shown in Figure 6. In 2009 dollars, they will rise from $726 billion to about $1.0 trillion over the next four years.

4. Why Does Funding Vary?

In 2009, as in earlier years, funding levels vary substantially. Figure 7 shows the distribution of funding for our sample of plans. Fifty-seven percent of plans had funding below the 80-percent level. Although many of the poorly funded plans are relatively small, several large plans, such as those in Illinois (SERS, Teachers, and Universities) and Connecticut (SERS), had funding levels below 60 percent.

Factors That Might Affect Funded Status

In order to ascertain why some governments have fairly well-funded plans and others do not, we estimate a simple ordinary least squares (OLS) regression that includes four categories of factors that could affect the funding status: funding discipline, the governance of the plan, the characteristics of the plan, and the fiscal health of the state.[15]

Funding discipline: The funded status of pension plans depends on how much money the government and its employees are required to contribute and whether the government has been making its annual required contribution.

- *Actuarial cost method.* The choice of actuarial cost method may be related to the funded status of the plan. As noted earlier, up to the point of retirement, the entry-age normal (EAN) method recognizes a larger accumulated pension obligation for active employees than the projected unit credit (PUC) method. Given comparable funded ratios, plans

[15] One might think that asset allocation might be important, but the variable "percent in equities" was never statistically significant in any of the equations estimated for our analysis.

using the EAN method would have accumulated more assets than those using the PUC method. Therefore, the EAN method is a more stringent funding program. Of course, if plans start with no initial unfunded liability and are following their funding schedules, the choice of cost method should not matter – both would have a ratio of assets to liabilities of 100 percent. But our hypothesis is that sponsors that opted for the currently cheaper funding regime – namely, the projected unit credit – may be less committed to funding their plans and therefore will have lower reported funded ratios.

- *Making contributions*. The other consideration, regardless of the actuarial method selected, is whether sponsors are actually making the required contributions. GASB 27 defines the ARC as the employer's share of the normal cost (the portion not covered by employee contributions) and any payment required to amortize an unfunded liability. Sponsors are required to report the percent of the ARC paid.[16] Sponsors that make the annual required contribution should have plans that are better funded than those that do not.

Governance. Several studies have explored the effect of governance on the funding status of public pension plans.[17] Based on this earlier research, two variables that might have an effect on the funding status of pension plans are the presence of employees and/or retirees on the board that governs the plan and the existence of an investment council.

- *Employees/retirees on the board*. Pension boards can influence a plan's actuarial method and its investment policy. If a lot of current workers and retirees are on the board and they are more interested in benefit expansion or greater cost-of-living adjustments than in funding benefit promises, the plan is likely to have accumulated fewer assets. Also, to the extent that plan beneficiaries are not financial experts, plan assets may not be well invested. In the following analysis, board composition is represented by the percent of board seats occupied by retirees and employees. Although earlier studies have shown mixed results, we expected the effect of the number of retirees and employees to be negative.[18]

- *Investment council*. The hypothesis with respect to an investment council is just the opposite. If a plan has a dedicated investment board or hires financial advisors in making its investment decision, the plan should have greater returns, more assets, and a higher funded ratio.[19] The variable included is a dummy variable indicating if the plan has a separate investment council that directly makes investment decisions.

Plan characteristics. Three characteristics of the plan would be expected to affect the funded ratio: when the plan started, plan size, and the generosity of benefits.

[16] This variable used is the percentage of the ARC paid in 2008.
[17] See Carmichael and Palacios (2003); Mitchell and Hsin (1997); Schneider and Damanpour (2002); and Yang and Mitchell (2005).
[18] Romano (1993); Coronado, Engen, and Knight (2003); Munnell and Sundén (2001); Harper (2008); Yang and Mitchell (2005); and Hess (2005).
[19] Previous studies have directly included a measure of the rate of return on investments (see Yang and Mitchell, 2005).

- *Age of system.* Older plans are likely to have promised benefits over a longer period of time without putting aside funds to cover the promises, thereby creating a large unfunded liability. Therefore, the older the plan, the higher the expected funded ratio.

- *Plan size*. Other studies have shown that plan size and funding levels are closely related. Possible reasons for this pattern may be more sophisticated asset management, better discipline because not funding could have a huge impact on taxpayers in the future, or the effect of being more in the political spotlight than smaller plans. In any event, a dummy variable is included for plans in the top third in terms of assets, and its impact is expected to be positive.

- *Benefit levels*. Some previous studies have found a negative relationship between the level of benefits and funded ratios.[20] Teachers have longer tenures than general government employees and higher earnings (due to higher education levels), and these factors translate into larger pension liabilities.[21] Thus, the equation includes information on whether or not teachers are included in a plan, and the coefficient is expected to have a negative effect on funding.

Fiscal situation: The final factor that may influence funding is the fiscal health of the state. The notion here is that if a state is having fiscal problems, it may meet current non-pension obligations by not making the annual contribution to the pension plan.[22] Thus, plans in states facing fiscal distress are less likely to be well funded. The measure of fiscal distress in the following analysis is the ratio of a state's debt to its gross state product (GSP).[23]

Our regression was used to estimate the impact of each of the variables discussed above on the 2008 funded ratios for the 126 plans in our sample.[24] The results of the regression are shown in Table 2. All of the variables except employees on the board have the expected effect on the funded status of the pension plan, and all effects were statistically significant.

In terms of funding discipline, if the sponsor makes the ARC payment, the funded ratio is 7.6 percentage points higher than in situations where the full ARC is not paid. On the negative side, plans using the projected unit credit costing method have a funded ratio 13.1 percentage points lower than other plans, which rely primarily on entry-age normal.

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[20] See Johnson (1997); and Yang and Mitchell (2005).

[21] Weller, Price, and Margolis (2006).[22]The U.S. GAO (1993, 1985) provides examples of states that closed budget gaps by reducing the pension contribution, while Chaney, Copley, and Stone (2002) and Bohn and Inman (1996) consider the general effects of balanced budget requirements in states. Since almost all states have some type of balanced budget requirement, this variable was not included in our analysis.

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[23] The concept of the debt to GSP is similar to the leverage variable used in Davis, Grob, and de Haan (2007) for private employers. This variable is for 2005, as the debt for the District of Columbia in 2006 was not available at the time of the analysis.

[24] The 17 plans in our sample that use either the frozen initial liability or the aggregate cost method of funding were included using their entry-age normal funded ratios, reported according to GASB 50.

With regard to governance, having employees and/or retirees on the board does not appear to affect the level of funding, while having a separate investment council improves the funded status by 5.0 percentage points.

The characteristics of plans also have the expected effects. The older the system, the lower is the funded level. The largest third of plans do appear to have a scale advantage with an average funded ratio that is 7.3 percentage points higher than small and medium plans. And plans that include teachers have an average funded ratio that is 4.2 percentage points lower than plans that do not cover teachers.

Finally, the regression confirms that the fiscal health of the state plays an important role. States with high levels of debt to GSP are less well funded than those with lower levels. As discussed above, this fiscal ratio varies substantially (from 1.6 to 17.5 percent), and the results show that a 10-percentage-point change in the ratio reduces funding levels by about 6.5 percentage points.

5. Making the ARC Payment

As noted in the introduction, an assessment of the funding situation requires more than a snapshot. The real question is whether sponsors have a plan and stick to it. One important component of any plan is making the ARC. Figure 8 shows that, in 2008, state and local governments paid 100 percent of the ARC for only 60 percent of the plans in our sample. Employers that contribute less than the full ARC could still be setting aside enough money to cover currently accruing benefits. They could even be reducing the plan's unfunded liability from previous years, albeit at a slower pace than the actuary would like. Not making the full ARC payment, nevertheless, indicates a failure to follow GASB's suggested funding plan. The question is why such a large percentage of plan sponsors are not making the full ARC.

Experts we spoke with suggested that a major reason that some sponsors do not pay the full ARC is that they face legal limitations on how much they can contribute. Indeed, a careful review of the annual reports found that 50 percent of the 40 percent of sponsors that did not pay 100 percent of the ARC were legally constrained (see Figure 9).[25]

For example, Oklahoma PERS made only 75 percent of its ARC in 2009. The reason is that the employer contribution rate is determined by statute and is smaller than the rate recommended by the plan's actuaries. In the case of Oklahoma, the state legislature is aware of the inadequacy of the statutory contribution rate and has been steadily increasing the legislated rate in an attempt to catch up to the actuarially required contribution level.[26] In fact, most states where funding is legally constrained appear aware of this problem and are in the process of gradually increasing their contribution rates.

The question is why the unconstrained plan sponsors failed to make the full contribution.

[25] Other entities also faced legal limitations, but they were not binding at this time.
[26] See Oklahoma Public Employees Retirement System (2009).

Factors That Might Affect Making the ARC

Four types of factors might account for whether or not an unconstrained plan sponsor makes the full ARC payment: the discipline of the sponsor; the priorities of those involved in governance of the plan; the plan characteristics; and the fiscal health of the state.[27]

Funding discipline. As discussed above, the use of the PUC actuarial cost method may signal that sponsors are less committed to funding their plans and therefore less likely to make the full annual required contribution.

Governance: employees/retirees on the board. As discussed above, the composition of the board may be important. One view is that boards with a lot of workers and retirees could be more interested in benefit expansion or greater cost-of-living adjustments than in funding benefit promises, which could lead to lower contributions. An alternative view is that workers and retirees have more of a stake in the plan's success than outside board members and, therefore, their presence on a board would tend to have a positive impact on a plan's funding status. Earlier studies have shown mixed results.[28] In the following analysis, board composition is represented by the percent of board seats occupied by employees and retirees.

Characteristics of the plan: Two characteristics of the plan would be expected to affect the likelihood that the sponsor paid 100 percent of the ARC: whether employees are covered by Social Security and the magnitude of the ARC.

- *Social Security coverage*. Government employers might feel an increased responsibility to fund the plan if plan benefits represent their employees' only source of retirement income. Thus, a greater percentage of plan participants without Social Security coverage would increase the likelihood that a sponsor would pay 100 percent of the ARC.

- *ARC as a percent of payroll.* The notion is that the higher the ARC as a percent of payroll, the more costly to make the full payment and therefore the less likelihood of making 100 percent of the ARC.

Fiscal pressure. The final factor that may influence the funding of a public pension plan is the fiscal health of the state. As before, states having fiscal problems may meet current non-pension obligations by not making the annual contribution to the pension plan. The measure of fiscal distress, as in the previous analysis, is the ratio of a state's debt to its GSP.

A probit regression was used to estimate the impact of each of the variables discussed above on the probability that the sponsor would make 100 percent of the ARC. Plans that were constrained by legal funding limitations were excluded from the analysis, which reduced the sample size from 126 to 101. The results of the regression are shown in Table 3. All variables

[27] One reviewer suggested that the diversion of employer contributions to cover health care costs may explain why some states have failed to pay 100 percent of their ARC.
[28] Romano (1993); Coronado, Engen, and Knight (2003); Munnell and Sundén (2001); Harper (2008); Yang and Mitchell (2005); and Hess (2005).

enter with their expected signs and have statistically significant coefficients with the exception of the ARC as a percent of payroll. Plans using the projected unit credit costing method are a whopping 37 percentage points less likely to make their ARC payment. Similarly, a one-standard-deviation increase in either the state's debt-to-GSP ratio or in the seats held by employees/retirees decreases the probability of paying the ARC by 11-12 percentage points. In contrast, a one-standard-deviation increase in the percent of employees not covered by Social Security increases the likelihood of a plan paying its ARC by 10 percentage points.

Trends in ARC payments

The previous analysis suggests, albeit mildly, that the probability of making 100 percent of the ARC payment is inversely related to the magnitude of the ARC. If this cross-sectional relationship holds over time, then the upward trend in the ARC as a percent of payroll for the 126 plans in our sample suggests that fewer and fewer plans will make the full ARC payment. As shown in Figure 10, the ARC increased from 6.3 percent of payrolls in 2001 to 12.1 percent in 2009. The increase was driven at least in part from the collapse of the dot-com bubble, which reduced asset values and increased the unfunded liabilities of the plans. The ARC as a percent of payroll increased steadily after 2002 as years of low equity values replaced earlier years of high equity values in the smoothing process. The ARC had more or less stabilized in 2008 and may well have started to decline if the funds had not been hit by another market meltdown. Instead, the ARC as a percent of payroll was higher in 2009 than 2008, and is likely to grow over the next five years.

At the same time that the ARC as a percent of payroll increased, the percent of ARC paid declined from 100 percent in 2001 to 83 percent in 2006 (see Figure 11). It had started to rebound in 2007 and 2008, but fell back in 2009. Without a recovery in the economy and the stock market, the percent of ARC paid is likely to decline further.

6. Valuing Liabilities

The entire discussion of funded status and ARC payments has been based on the liabilities reported in the plans' Comprehensive Annual Financial Reports (CAFRs) and Actuarial Valuations. To calculate these liabilities, GASB recommends discounting the stream of future benefits by a rate based on the estimated long-term yield of plan assets – roughly 8 percent. Most economists contend, however, that the discount rate should reflect the risk associated with the liabilities and, given that benefits are guaranteed under most state laws, the appropriate discount factor is a riskless rate.

Just what rate best represents the riskless rate is a subject of debate. Researchers have laid out some general characteristics.[29] The rate should reflect as little risk as the liabilities themselves, be based on fully taxable securities (because pension fund returns are not subject to tax), and not have a premium for liquidity (because most pension fund liabilities are long term and do not

[29] Brown and Wilcox (2009).

require liquidity).[30] Among the interest rates quoted in financial markets, those on Treasury securities come the closest to reflecting the yield that investors require for getting a specific sum of money in the future free of risk. Currently, the yield on 30-year Treasury bonds, about 4 percent, is likely less than the riskless rate due to the valuable liquidity they offer investors.[31] Therefore, we would suggest increasing the current rate by about 1 percentage point and using a number of about 5 percent for 2009.[32]

Some debate also surrounds the appropriate liability concept to use. The use of the PBO seems appropriate for pension plans in the public sector. Benefits promised under a public plan are accorded a higher degree of protection than those under a private sector plan, because under the laws of most states, the sponsor cannot close down the plan for current participants.[33] That is, whereas ERISA protects benefits earned *to date*, employees hired under a public plan have the right to earn benefits as long as their employment continues.[34] Since public plan sponsors cannot halt accruals under most state laws as can private sector sponsors, the PBO, which includes the effect of future salary increases on the value of pension rights already earned by active workers, seems like the correct measure of liability.[35]

Figure 12 shows what liabilities would look like under alternative liability concepts and interest rates. In 2009, the aggregate liability for our sample of 126 state and local plans was $3.4 billion, calculated under the guidance provided by GASB 25 – a PBO concept and a typical discount rate of 8 percent. Assets in 2009 for these sample plans were $2.7 trillion, yielding an unfunded liability of $0.7 trillion. Using a riskless discount rate of 5 percent raises public sector PBO liabilities to $5.4 trillion, which yields an unfunded liability of $2.7 trillion.

But, in reality, what would such a change mean? Under current circumstances, states and localities are not in any position to double or triple their contributions. Therefore, implementation of any change would have to wait until the economy and markets recover. Moreover, changing the discount rate would have to be considered by the community of actuaries, accountants, and sponsors in the context of other changes, such as perhaps extending

[30] Novy-Marx and Rauh (2009) employ a state-specific taxable municipal bond rate based on the zero-coupon municipal bond curve. Their rationale is that states are equally likely to default on their pension obligations as on their other debt.

[31] The 30-year Treasury constant maturity series was discontinued on February 18, 2002, and reintroduced on February 9, 2006.

[32] A 5-percent rate is also consistent, for example, with a riskless real rate of 2.5 percent and an inflation rate of 2.5 percent.

[33] NCPERS (2010).

[34] Steffen (2001). Assuming that employers are constitutionally barred from changing all benefit provisions slightly overstates the riskless nature of public liabilities, since some states and localities can alter the cost-of-living adjustment (COLA) that they grant beneficiaries from year to year. However, a survey of the 126 plans in the CRR PPD shows that plans offering ad hoc COLAs account for only 20 percent of aggregate accrued liability. Discounting ad hoc COLAs at 8 percent, rather than the risk-free rate, does not significantly alter the percent increase in liabilities.

[35] This assessment differs from that of Brown and Wilcox (2009), Novy-Marx and Rauh (2009), and Bulow (1982), who argue that the ABO is the preferred concept because it puts pension accruals on the same basis as wages and salaries.

the amortization period from 30 to 40 years.[36] That is, an increase in the measure of the unfunded liability need not automatically translate into an immediate and intolerable increase in annual amortization payments for states and localities.

One change that probably could not wait pertains to the normal cost. Reducing the discount rate from about 8 percent to 5 percent would raise the present value of benefits and increase the employer's normal cost from about 7 to about 15 percent of payroll (assuming the employer paid this full increment).[37] Since payrolls account for about 28 percent of state and local budgets, in ordinary times, the increase would be significant but manageable. Higher normal cost payments will ensure that adequate reserves are put aside for today's workers.

7. Immediacy of the Problem

One of the attractive features of defined benefit plans is that they can pool investment risk across individuals and spread risk over time. Two financial crises within a ten-year period seriously stress any defined benefit system, however, so an important question is for how long state and local plans will be able to meet their commitments. In other words, are the plans going to run out of money? And, if so, when?

The simplest place to start is the ratio of plan assets to benefits, which shows for how many years plans could – with no further investment returns, no additional contributions, and no growth in benefits – continue to pay benefits. Figure 13 reveals that, in 2001, assets were 23 times annual benefit payments, suggesting that with money on hand state and local plans in the aggregate could continue to pay benefits for 23 years. In the wake of the bursting of the dot.com bubble, this ratio dropped for the next four years to 19, and was headed back up until the financial crisis of 2008. The ratio now stands at 13. Moreover, plans are distributed around that average ratio (see Figure 14). One plan – Kentucky ERS – has a ratio of 5, and 33 plans – including large plans such as Illinois SERS, New Jersey PERS, and New York City ERS – have ratios between 6 and 10.

While the simple ratio is useful for describing trends over time, in fact plan sponsors will continue to make contributions, hopefully plans will earn returns on their assets, and benefit payments will grow as the baby boom retires. Given realistic assumptions then, how long before plans run out of money?

The answer to this question depends on how the exercise is structured. Rauh (2009) adopts a termination approach, essentially putting benefits earned to date into one plan with the existing assets and creating a new plan where all accruing benefits are covered by future normal cost contributions. The question is then for how many years can the existing assets cover benefits promised to date. Since these plans are underfunded, without additional contributions they

[36] Increasing the amortization period raises its own set of issues. For example, payments made roughly 40 years or more in the future add little to the present value of the payment stream. Moreover, such a long amortization period might not be viewed as a credible funding strategy by bond rating agencies and others.

[37] As discussed above, actuaries use a number of actuarial cost methods to allocate the portion of future benefit payments to each year for funding purposes, but this exercise simply calculates the present value of the additional lifetime benefit accrued to the current workforce by one more year of service.

ultimately run out of money. The exhaustion date depends on the investment returns. We have replicated Rauh's exercise (using a combination of Rauh's and our actuarial assumptions) and find that the exhaustion dates for current assets are 2022 with returns of 6 percent; 2025 with returns of 8 percent; and 2029 with returns of 10 percent (see Table 4).

The alternative approach is to treat the plans as ongoing entities. This approach requires a projection of actual benefit payments for current and future employees and the assumption that plan sponsors can use future normal cost contributions to cover benefit payments. Under the ongoing scenario, the exhaustion dates are 2025 with returns of 6 percent; 2029 with returns of 8 percent, and 2035 with returns of 10 percent. Of course, using normal costs to cover benefits rather than accumulating payments in anticipation of future payments will worsen the funded status of plans. But if the issue is strictly one of plans running out of money, then using normal costs to cover future benefits must be considered.

Under either the termination approach or the ongoing approach, plans are distributed around the average exhaustion dates. Assuming the 8-percent return, we estimated exhaustion dates for each of the 126 plans in our sample, and the results are shown in Figure 15. As expected, the ongoing scenario shows far fewer plans exhausting their assets in the next ten years, suggesting that plans have more breathing room than the termination approach suggests.

Conclusion

Public pension funding has recently become a front-burner policy issue in the wake of the second financial crisis in a decade. Notably, before the 2008 crisis hit, state and local plans were generally on a path toward full funding. However, the collapse of the stock market has reduced the aggregate funded ratio below 80 percent with some continued decline likely over the next few years. And the funded ratio looks much worse if liabilities are valued using the riskless rate of return instead of the expected return on plan assets. Not surprisingly, the individual plans in the worst shape tend to be less disciplined in their funding approach, have less access to investment professionals and economies of scale, provide higher benefit levels, and/or are in states with relatively poor fiscal health.

Yet the picture is not as bleak as it first appears. First, most plans have made great strides in improving their funding discipline and management in recent decades, meaning that they have a solid foundation in place. Second, even after the worst market crash in decades, state and local plans do not face an immediate liquidity crisis; most plans will be able to cover benefit payments for the next 15-20 years. Third, states have already begun responding to their shortfalls by increasing employee contributions and reducing benefits for new employees. Finally, once plans have regained their footing, any change in the measurement of liabilities could be handled so that increased pension contributions are manageable. Just as with private investors, though, the future outlook of public pensions is closely tied to the recovery of the economy and the stock market.

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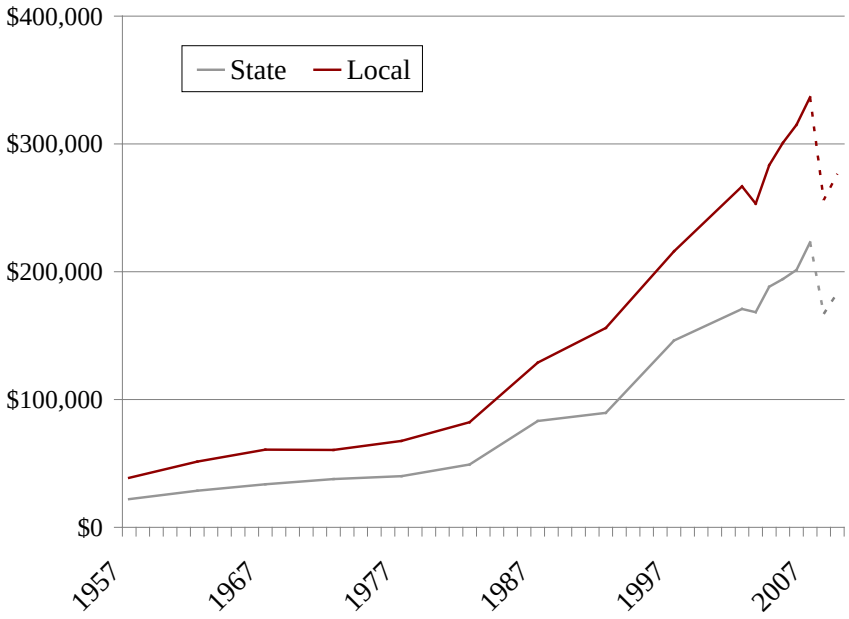
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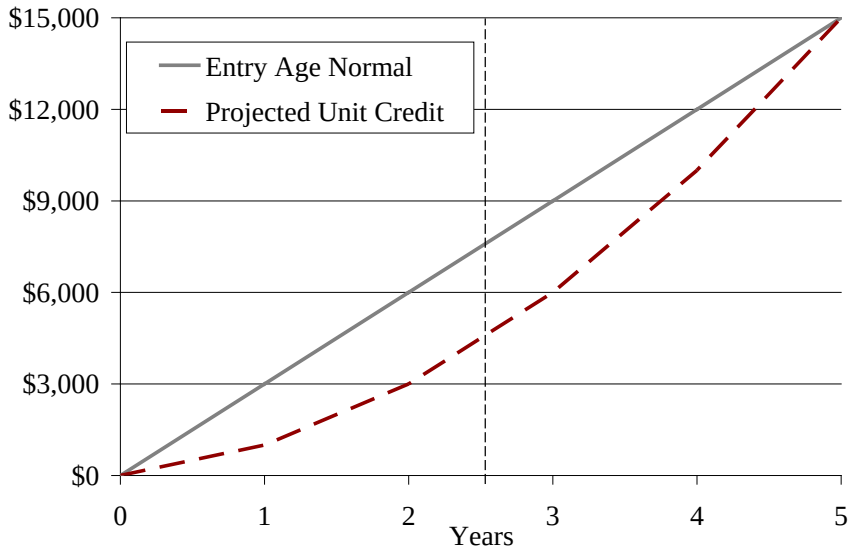
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Figure 1. *Assets per Active Worker by Level of Administration, Fiscal Years 1957-2009 (2009 Dollars)*



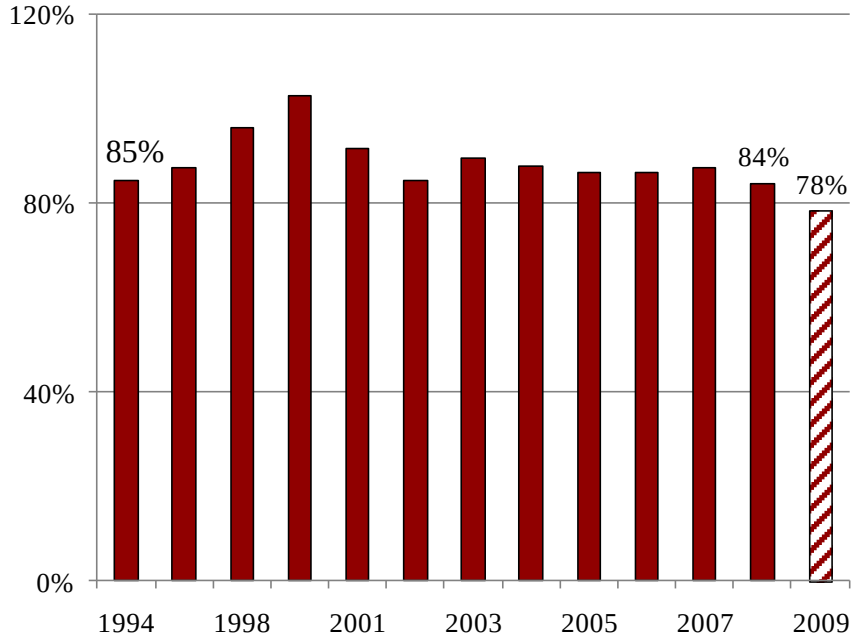
Note: Assets are at market value beginning in 2002 and book value prior to 2002. Data for the period 1957-2002 is reported in five-year intervals, whereas 2003-2009 is reported on a yearly basis.
Sources: Authors' calculations from the U.S. Census Bureau (1957-2006), *Employee-Retirement Systems of State and Local Governments*; the U.S. Board of Governors of the Federal Reserve System, *Flow of Funds* (2007-2009); and the Center for Retirement Research at Boston College, Public Pension Database (PPD) (2008-2009).

Figure 2. *Accrued Liability by Method, by Year*



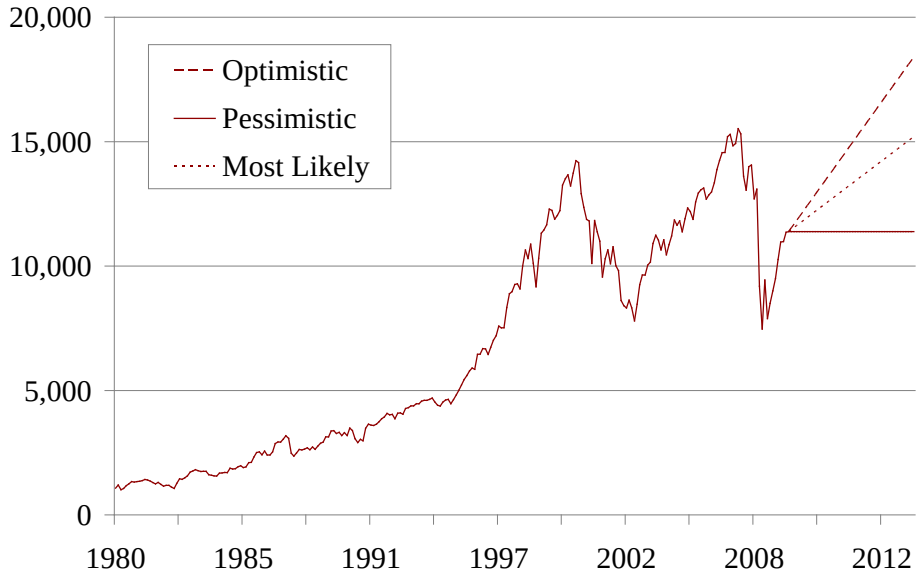
Source: Authors' illustration.

Figure 3. *State and Local Funded Ratios, 1994-2009*



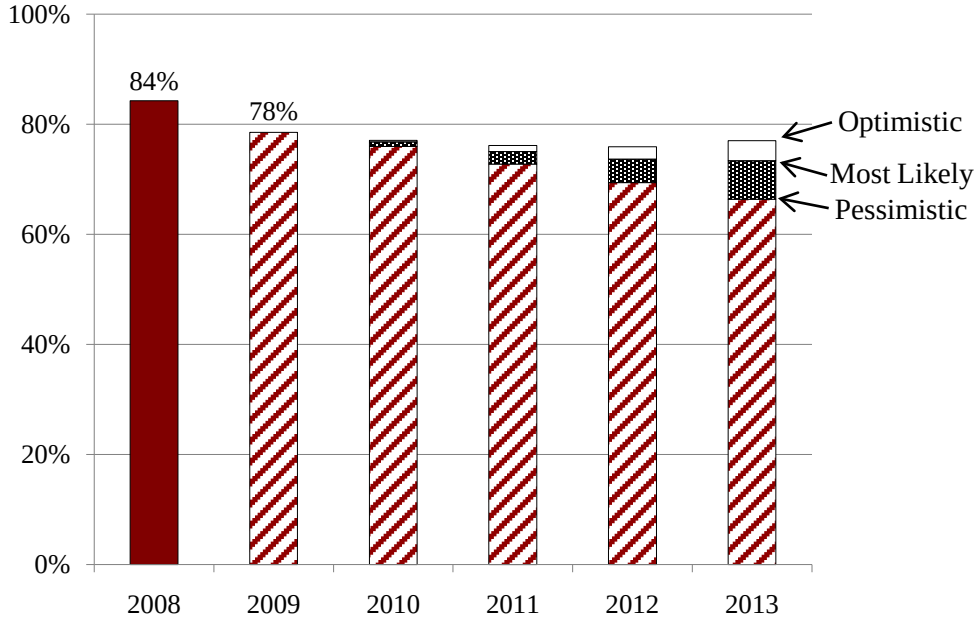
Note: 2009 is authors' estimate.
Sources: CRR PPD (2001-2009); and Zorn (1994-2000).

Figure 4. *Dow Jones Wilshire 5000 Index, 1980-2010, and Projections for 2013*



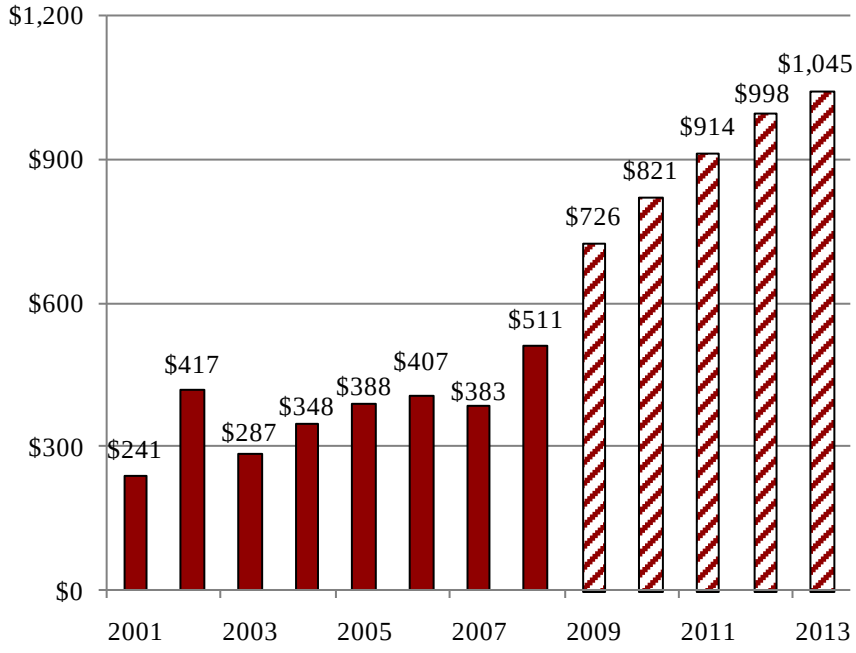
Sources: Wilshire Associates (2010) and authors' projections.

Figure 5. *Projected State and Local Funded Ratios under Three Scenarios, 2008-2013*



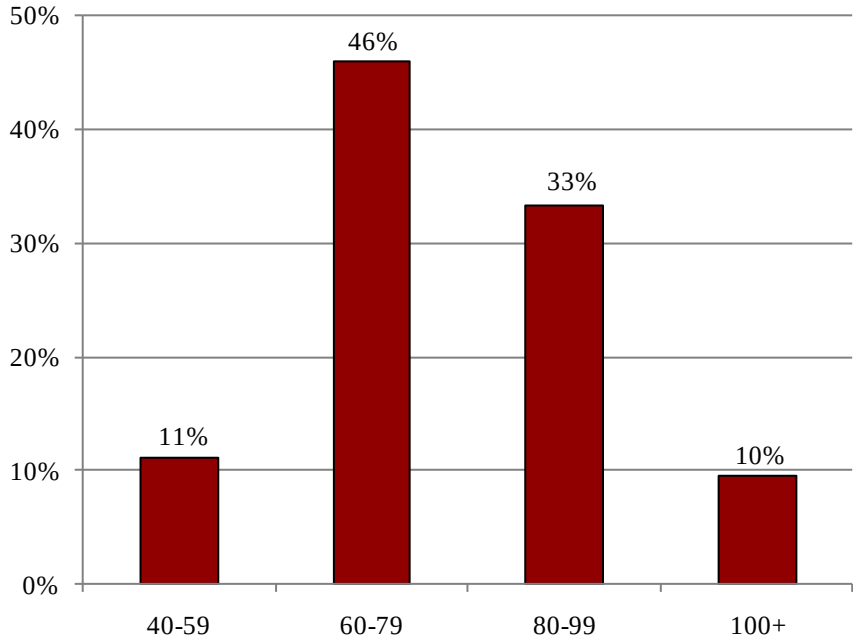
Source: CRR PPD and authors' estimates for 2009-2013.

Figure 6. *Unfunded Actuarial Accrued Liability, 2001-2013, Billions of 2009 Dollars*



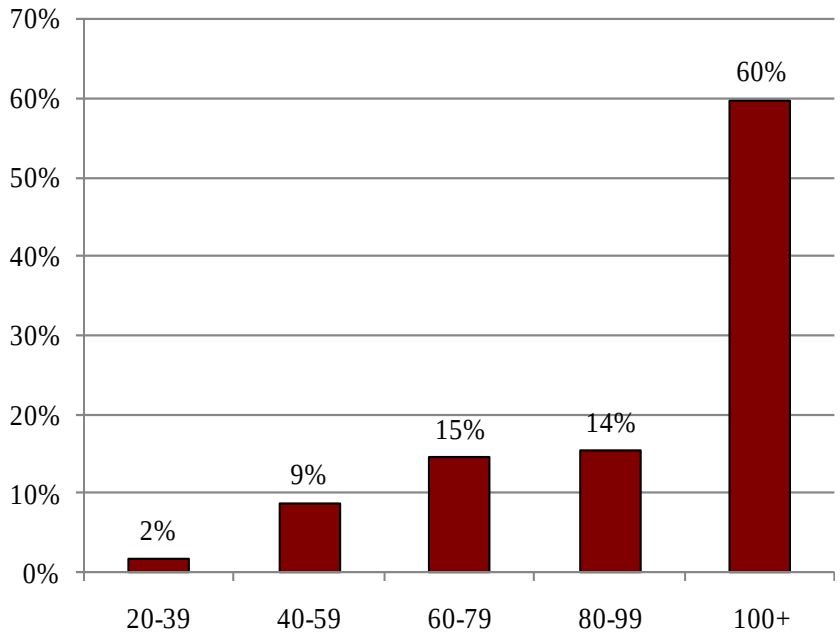
Note: 2009-2013 are authors' estimates.
Source: CRR PPD.

Figure 7. *Distribution of Funded Ratios for Public Plans, 2009*



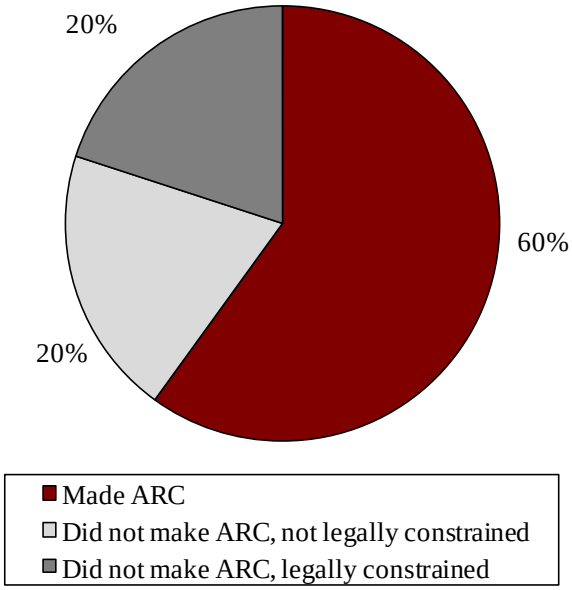
Source: Authors' calculations based on CRR PPD.

Figure 8. *Distribution of State and Local Plans, by Percentage of ARC Paid, 2008*



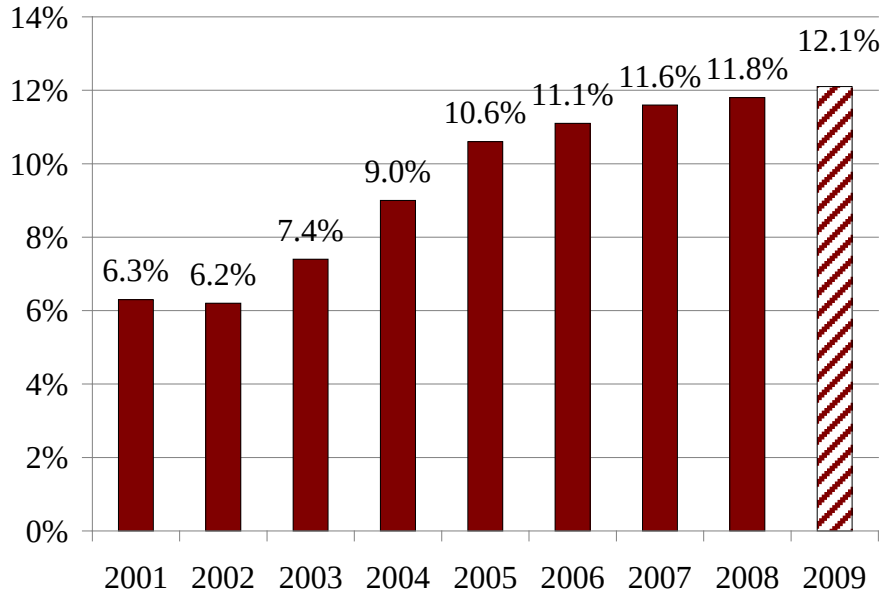
Note: Plans that used the aggregate cost method were coded with 100 percent of ARC paid.
Source: CRR PPD (2008).

Figure 9. *Distribution of Plans by ARC Payment and Legal Constraint, 2008*



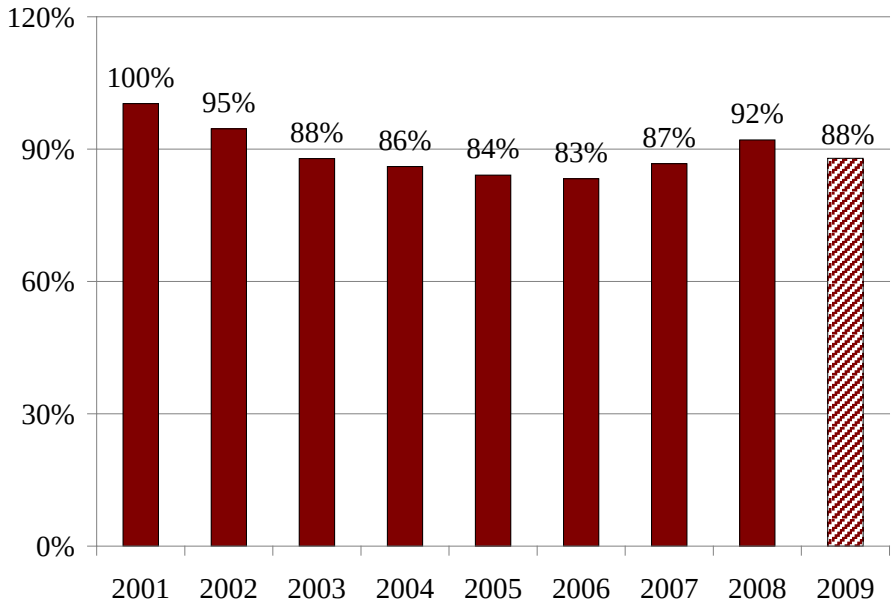
Note: Values do not sum to 100 percent due to rounding.
Sources: Authors' calculations from CRR PPD (2008).

Figure 10. *ARC as a Percent of Payroll, 2001-2009*



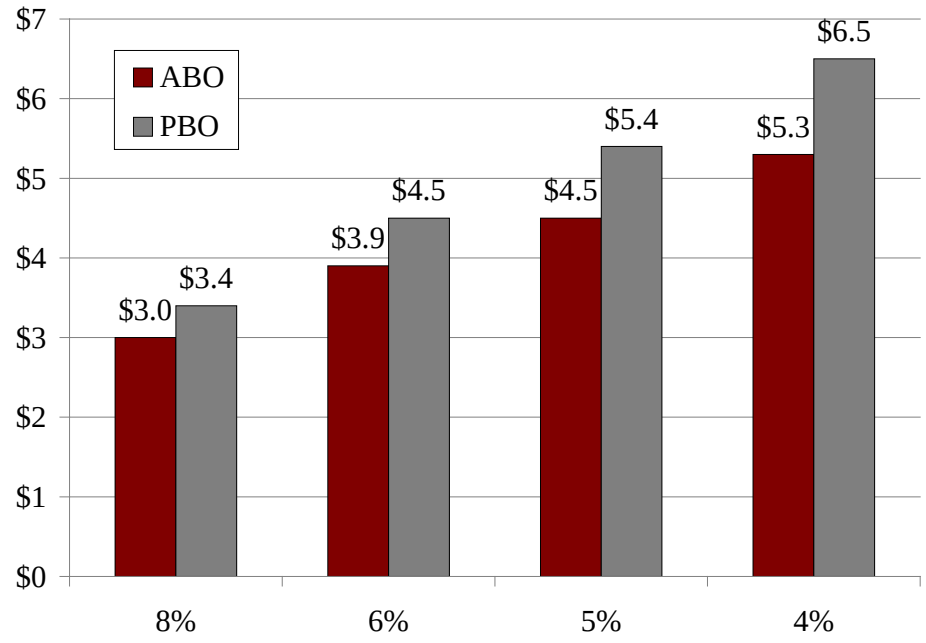
Source: CRR PPD (2001-2009).

Figure 11. *Percent of Annual Required Contributions Paid, 2001-2009*



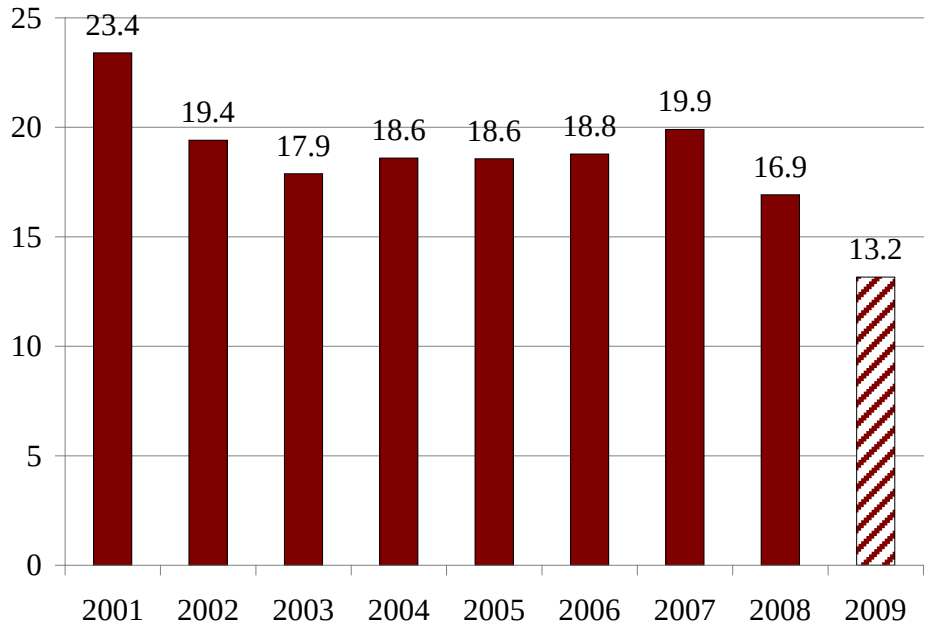
Source: CRR PPD (2001-2009).

Figure 12. *Aggregate State and Local Pension Liability under Alternative Discount Rate Assumptions, 2009, in Trillions*



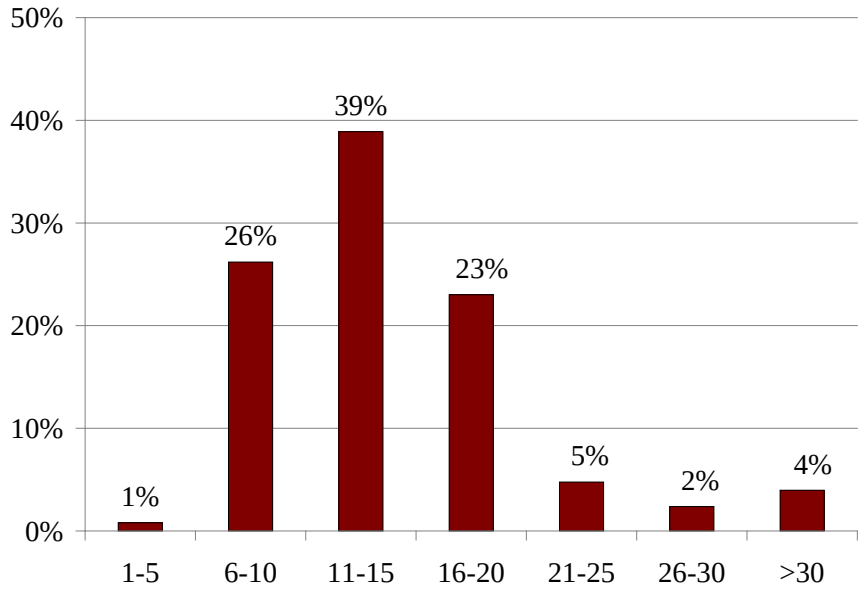
Source: Authors' calculations from CRR PPD.

Figure 13. *Market Assets over Annual Benefit Payments, 2001-2009*



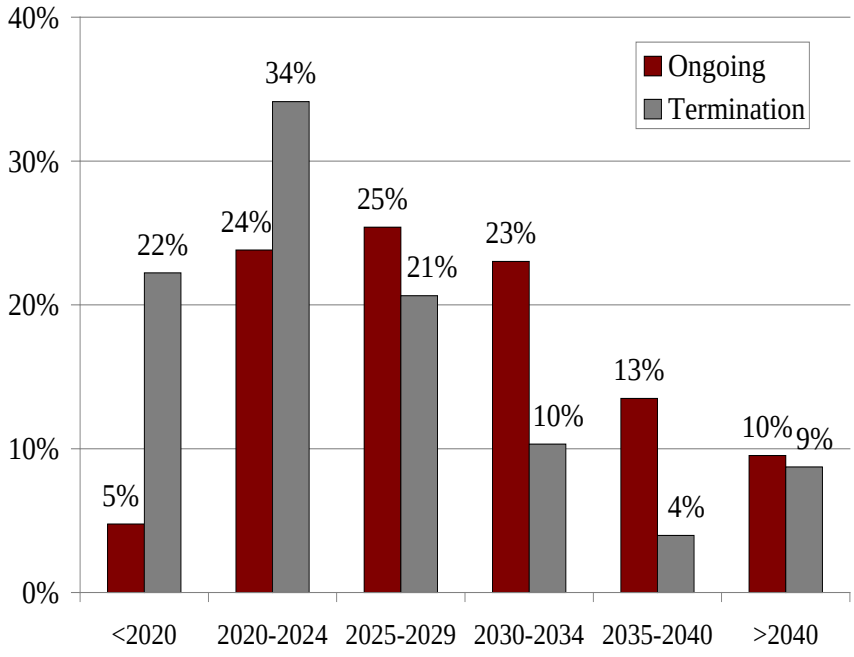
Source: Authors' calculations from CRR PPD (2001-2009).

Figure 14. *Distribution of Plans by Market Assets over Annual Benefit Payments, 2009*



Source: Authors' estimates from CRR PPD (2001-2009).

Figure 15. *Percent of State and Local Plans Becoming Insolvent by Year under a "Termination" and an "Ongoing" Framework*



Note: "Ongoing" assumes that plans pay the normal cost in future years and these monies are available to cover benefit payments for current and future employees. "Termination" assumes that plans make future contributions exactly sufficient to cover the cost of future accruals. Benefit payments under an ABO concept are paid solely out of existing assets and returns on those assets.
Source: Authors' estimates based on CRR PPD and Rauh (2009).

Table 1. *Percent of Large Private Sector and Public Sector Plans Using Alternative Actuarial Methods, 2006*

Actuarial cost method	Private sector	Public sector
Projected unit credit	74	14
Entry-age normal	19	70
Other	7	16

Source: Watson Wyatt Worldwide, *Survey of Actuarial Assumptions and Funding: Pension Plans with 1,000 or More Participants* and National Association of State Retirement Administrators, *Public Fund Survey*. 2006.

Table 2. *Regression Results on the Funded Ratio of State and Local Pension Plans, 2008*

Variable	Coefficient
Made the ARC	7.64**
	(1.74)
Use PUC method	-13.05**
	(2.68)
Employees/retirees on board	0.04
	(0.07)
Separate investment council	5.03*
	(2.86)
Age of system	- 0.18*
	(0.10)
Large plan	7.29**
	(2.38)
Teachers in plan	-4.21*
	(2.32)
State debt to GSP	-0.65**
	(0.28)
Constant	91.33
	(6.01)
R-squared	0.316
Number of observations	126

Notes: Robust standard errors are in parentheses. Coefficients are significant at the 5-percent level (**) or 10-percent level (*).
Source: Authors' calculations from CRR PPD.

Table 3. *Regression Results for State and Local Pension Plans Making 100 Percent of the ARC, 2008*

Variable	Marginal effect
Use PUC method	-0.371**
	(.158)
Employees/retirees on board	-0.397**
	(0.194)
Not covered by Social Security	0.384**
	(0.161)
ARC as a percent of payroll	-0.540
	(0.416)
State debt to GSP	-2.851**
	(1.265)
Pseudo R-squared	0.1986
Number of observations	101

Notes: Robust standard errors are in parentheses. The marginal effects are significant at the 5-percent level (**). For continuous variables, the marginal effect is for a one-unit change from the mean. For dummy variables, the marginal effect is for a change from 0 to 1.
Source: Authors' calculations from CRR PPD.

Table 4. *Exhaustion Date for State and Local Pension Plans under an Ongoing and Termination Framework by Rate of Return Earned on Pension Assets*

Rate of return	Framework	
	Ongoing	Termination
6 percent	2025	2022
8 percent	2029	2025
10 percent	2035	2029

Note: "Ongoing" assumes that plans pay the normal cost in future years and these monies are available to cover benefit payments for current and future employees. "Termination" assumes that plans make future contributions exactly sufficient to cover the cost of future accruals. Benefit payments as calculated under an ABO concept are paid solely out of existing assets and returns on those assets.
Source: Authors' estimates based on CRR PPD and Rauh (2009).

Appendix A

We use two models to project the benefits that state and local pension plans will pay in the future. The first model calculates the PBO and ABO for currently active and retired workers. The second, which extends the first to include future benefit payments to new hires, estimates the dates when plans become insolvent.

PBO and ABO

We use the first model to convert the PBO liability reported in plans' annual reports to an ABO liability and to change the discount rate assumption. A plan's current pension obligation is the flow of expected future benefit payments to currently active employees and retirees, discounted to the present. The ABO is a termination liability, which assumes that workers will accrue no future benefits. The PBO recognizes accruals due to future salary growth, but does not allow credits for future years of service.

We collected demographic information about active employees from the Actuarial Valuation reports of the ten largest plans. These starting assumptions, which are reported in Appendix B,[38] include the proportion of the active work force in each birth cohort, starting salary and average accrued tenure by age, a vector of salary growth by age, as well as separation and mortality probabilities by age. An active member of a plan will either continue working, separate, or die. At time t, the number of individuals, by birth cohort *i*, remaining in the plan is

$$pop_{i,t} = pop_{i,t-1} * \left(1 - mort_{i,t-1}\right) * \left(1 - sep_{i,t-1}\right)$$

and the number of individuals who separate is equal to

$$separates_{i,t} = pop_{i,t-1} * \left(1 - mort_{i,t-1}\right) * sep_{i,t-1}$$

where $pop_{i,t}$, $mort_{i,t}$, and $sep_{i,t}$ are the number of members, mortality rate, and separation probabilities respectively for cohort *i* at time *t*.
When an individual separates, his, accrued tenure, highest three-year average salary, and separation date are stored. Those who separate are also assigned a survival probability from their date of separation until retirement age. The starting pension benefit, *S*, for person *n* of birth cohort *i* who separates from the plan at time *t* is given by

$$S_{i,n} = a * tenure_{i,n} * W_{i,n} * P(t)$$

where *a* is the plan's accrual rate, $tenure_{i,n}$ is the accrued years of service at the time of separation is and $P(t)$ is the probability of living from time *t* until retirement. To calculate the ABO, $W_{i,n}$ is the average of the 3 highest annual wages received by person *n* as of the date that the ABO is reported. To calculate the PBO, $W_{i,n}$ is replaced by $W_{i,n}'$, the average of the 3 highest annual wages to be received by person *n* over his projected years of active employment.

[38] Our base assumptions are very similar to those used by Novy-Marx and Rauh (2009).

These projections of future wages increase employees' current wages at the rate of growth of future wages reported by their plans.

Benefits for individuals who work until retirement age are computed in a similar manner. The starting benefit for an individual, *m*, at the time of retirement is

$$R_{i,m} = a * tenure_{i,m} * W_{i,m}$$

where *a* is the plan's accrual rate and $tenure_{i,m}$ is the accrued years of service at the time of retirement. As before, to calculate the ABO, $W_{i,m}$ is the average of the 3 highest annual wages received by person *m* as of the reporting date. To calculate the PBO, $W_{i,m}$ is replaced by $W_{i,m}'$, the average of the 3 highest annual wages to be received by person *n* over his projected years of active employment.

The benefits paid to birth cohort *i* reaching retirement at time *t* are equal to

$$Benefits_{i,t} = \sum_{n=1}^{N} S_{i,n} + \sum_{m=1}^{M} R_{i,m}$$

In each subsequent year, the expected value of the cohort's total benefit is equal to the previous year's payment multiplied by the plan specific cost of living adjustment and the survival probability of living to the next year. Total future payments to active workers made by the pension plan in a given year is then equal to

$$B_t = \sum_i Benefits_{i,t} * 1(i \geq retirement\ age\ at\ time\ t) * 1(i \leq maximum\ living\ age\ at\ time\ t)$$

where 1(.) is the indicator function that takes the value of 0 if false, and 1 if true.

Current retirees are treated differently than active employees. The CRR *Public Pension Database* (PPD) records the total benefits paid to retired employees in 2009 and the proportion of those benefits paid to retirees of different ages. We assume that the aggregate yearly level of benefits received by each age group in 2009 is that group's aggregate expected yearly benefit for all future years.

This methodology produces two streams of nominal pension benefits that will be paid to current retirees and to employees who have not yet retired. The "PBO stream" reflects the effects of future increases in wages for active employees; the "ABO stream" does not. The PBO stream for each plan is normalized so that its present value, discounted at its reported investment return rate, equals the plan's PBO as reported for 2009 in the CRR PPD:

$$PBO_t = b_t * L^R$$

where L^R is each plan's reported liability, and b_t is a year-specific scaling factor equal to:

$$b_t = \left(B_t/(1+d^{t-t'})\right)/\left(\sum_t \left(B_t/(1+d^{t-t'})\right)\right)$$

with d as the plan's reported discount rate, and t' as the valuation date. The ABO stream is also normalized by taking the percent difference between the nominal ABO and PBO benefit streams in each year, and applying that difference to the normalized PBO stream.

$$ABO_t = z_t * PBO_t$$

$$z_t = B_{t,ABO}/B_{t,PBO}$$

To calculate the consequences of changing the discount rate on a plan's PBO and ABO, we discount its normalized PBO and ABO streams using the alternative discount rates or yield curves.

$$L_R{}' = \sum_t \left(PBO_t * \left(\left((1+d')/(1+d)\right)\text{^}(t-t')\right)\right)$$

Where $L_R{}'$ is the new liability calculated under the normalized PBO stream and different discount rate (d').

Solvency

The second model estimates the dates when plans will become insolvent by projecting its future pension payments to current retirees, current employees, and employees who will be hired in the future. Accordingly, this model adds new hires to the equation for the plan's work force.

$$pop_{i,t} = pop_{i,t-1} * \left(1 - mort_{i,t-1}\right) * \left(1 - sep_{i,t-1}\right) + \left(pop_{i,t-1} - \left(pop_{i,t-1} * \left(1 - mort_{i,t-1}\right) * \left(1 - sep_{i,t-1}\right)\right)\right)$$

The total work force remains constant over time as new hires replace employees who separate, retire, or die. The distribution of the ages of new hires reflects that reported in the Actuarial Valuations of the ten largest plans.

Under this model, benefits in year *T* for workers who separated before the normal retirement age are as follows

$$Sep_t = \sum_{t<T} \sum_{i=1}^{M} \sum_{n=1}^{N} S_{i,n,t}$$

where $S_{i,n,t}$ is the initial retirement benefit as defined in the first model for employees who separated before they were eligible for retirement in each year before year *T*. Initial benefits paid to those who work until the normal retirement age in year *T* is

$$R_t = \sum_i \sum_m R_{i,m}$$

where $R_{i,m}$ is calculated as in the first model.

In year *T*, a plan's total benefit payment is equal to the previous year's payment multiplied by the plan specific cost of living adjustment and the survival probability of living to the next year plus the benefits paid to new retirees, Sep_t and R_t:

$$B_t = B_{T-1} * (1 + cola_T) + Sep_t + R_t$$

A plan's assets increase each year as a result of new contributions and the return to the assets less the total benefits paid by the plan. When calculating their actuarial assets, plans implicitly assume that the flow of contributions and benefits into the plan occurs periodically throughout the year. Simplifying this assumption, we assume that plans receive contributions and pay benefits at two points during the year. We follow the continuous asset growth formula

$$Assets_{t+1} = \left(\left(Assets_t * e^{\frac{r}{2}}\right) + \left(\frac{(C_t - B_t)}{2} * e^{\frac{r}{2}}\right)\right) + \frac{(C_t - B_t)}{2}$$

where *r* is the assumed rate of return on plan assets, C_t is the normal contribution in a given year *t*, and B_t is the benefit payment owed in year *t*.

Appendix B

This section outlines the actuarial and demographic assumptions used in our two models of public pension benefit projections. While many of the values are based off of the tables reported in Novy-Marx and Rauh (2009), some come from our own investigation of the 2009 Actuarial Valuations of the ten largest plans in the CRR PPD.

A. Values for active members from Novy-Marx and Rauh (2009)

Age	Average tenure	Percent of workforce	Average salary (thousands)	Salary growth	Separation and retirement
Under 25	2	3.3	26.35	1.100	0.198
25-29	3	12.9	32.27	1.100	0.091
30-34	5	13.1	33.19	1.080	0.068
35-39	8	13.1	41.56	1.070	0.060
40-44	10	12.0	37.17	1.061	0.049
45-49	12	12.6	42.86	1.056	0.047
50-54	16	14.7	48.82	1.050	0.047
55-59	19	13.0	48.22	1.047	0.214
60-64	17	4.4	46.14	1.042	0.233
65-69	17	0.7	46.74	1.040	0.261

B. Values from the 2009 Actuarial Valuations of the ten largest plans in the CRR PPD

Age	Percent of total benefits paid in 2009
50-59	0.13
60-69	0.46
70-79	0.27
80-89	0.14

Aggregate 2009 values (dollars in thousands)	
Liability	3,386,240,092
Benefit payments	168,577,222
Market assets	2,149,631,887
Payroll	60,4076,666

Note: we assume the average retirement age at 60, the workforce at 13,065,313, and use the RP-2000 mortality table adopted by most of the plans in the CRR PPD.