Public Pension Promises: How Big Are They and What Are They Worth?*

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ABSTRACT

We calculate the present value of state employee pension liabilities using discount rates that reflect the risk of the payments from a taxpayer perspective. If benefits have the same default and recovery characteristics as state general obligation debt, the national total of promised liabilities based on current salary and service is $3.20 trillion. If pensions have higher priority than state debt, the value of liabilities is much larger. Using zero-coupon Treasury yields, which are default-free but contain other priced risks, promised liabilities are $4.43 trillion. Liabilities are even larger under broader concepts that account for salary growth and future service.

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Government accounting rules currently obscure the magnitude of public pension liabilities in the United States. In particular, Government Accounting Standards Board (GASB) ruling 25 and Actuarial Standards of Practice (ASOP) item 27 stipulate that public pension liabilities are to be discounted at the expected rate of return on pension assets. This procedure creates a major potential bias in the measurement of public pension liabilities. Discounting liabilities at an expected rate of return on the assets in the plan runs entirely counter to the logic of financial economics: financial streams of payment should be discounted at a rate that reflects their risk (Modigliani and Miller (1958)), and in particular their covariance with priced risks (Treynor (1961), Sharpe (1964), Lintner (1965)). This paper evaluates the economic magnitude of state public pension liabilities by applying financial valuation to the pension liabilities of U.S. states using appropriate discount rates.

From a unique database on 116 state government pension plans built from government reports, we compile information on defined benefit (DB) assets and liabilities as reported by state governments. We then model the prospective stream of payments from state pension promises using each state's stated liability, discount rate, and actuarial cost method, as well as information on benefit formulas, the number and average wage of state employees by age and service, salary growth assumptions by age, mortality assumptions, cost of living adjustments (COLAs), and separation (job-leaving) probabilities by age. We discount these payments at rates that reflect their risk from the perspective of taxpayers.

We begin by focusing only on payments that have already been promised and accrued. In other words, even if the pension plans could be completely frozen, states would still contractually owe these benefits. This quantity is known as an Accumulated Benefit Obligation (ABO) or termination liability. An ABO is not affected by uncertainty about future wages and service, as the cash flows associated with the ABO are based completely on information known today: plan benefit formulas, current salaries, and current years of service.[1] As we explain later, different states use different methods to calculate accrued liabilities. Our model of prospective payments allows us to calculate the ABO for each state.

We first calculate a measure of the taxpayer obligation represented by these accumulated state pension liabilities under the assumption that accrued state pension benefits have the same priority as state general obligation (GO) debt. This assumption implies a discount rate for each payment equal to the state's own zero-coupon bond yield corrected for the tax preference on municipal debt (which we call the "taxable muni rate").

Under this measure, public pension liabilities based on current salary and service are \$3.20 trillion, which is quite close to the \$3.14 trillion obtained by summing the unadjusted liabilities from state government reports. The harmonization of the liabilities to the ABO method actually reduces the liability, since most states use a broader measure, while the application of the appropriate discount rates raises liabilities. Implementing the broader measure used by most states, called Entry Age Normal (EAN), the liability under taxable muni rates is \$3.62 trillion, 15% higher than the stated \$3.14 trillion.

Using taxable muni rates admits the possibility that plan participants, including those already retired and receiving benefits, may not receive the full amount of promised benefits in the future. From the perspective of the taxpayer, assuming that pension liabilities are as risky as state GO debt credits states for their ability to default on pension promises. The use of the taxable muni rate for discounting assumes that these pension defaults would happen in the same states of the world as muni defaults, and that beneficiaries would eventually receive payments proportional to the recovery rates enjoyed by the municipal bond investors.

Crediting state governments by reducing pension liabilities based on GO default premiums leads if anything to an understatement of the liability to the taxpayer. Most importantly, benefits are often given special protections in state constitutions as well as through statutory and common law (Brown and Wilcox (2009)). The priority accorded to public pension cash flows suggests that they should be discounted at rates lower than the state GO bond yield. In most states, a pension default is less likely than a GO debt default. Even if states were to default on pension promises, pension obligations might well have a higher recovery rate than GO debt. Somewhat offsetting this is the possibility that states might receive a bailout from the federal government for these pension promises, in which case taxpayers of a given state might view the pension liabilities as less certain. However, because our focus is on an aggregate liability calculation across 50 states, this issue would affect the distribution of liabilities across states but not the total liability to all U.S. taxpayers.

The second main measure we present is a measure that attempts to view the liability as default free. Given the protections that state constitutions provide to accrued public pension promises, beneficiaries face a negligible probability of default on benefits they have already earned. Thus, using a default-free yield curve would be appropriate to measure the liability if we were doing so from the perspective of beneficiaries. If taxpayers are the ultimate underwriters of the default-free promise, then this calculation also values the liability from their perspective. The approximation we employ for the default-free curve is the Treasury zero-coupon yield curve. Under the Treasury-discounting measure of liabilities, total liabilities are $4.43 trillion.

There are important caveats to note about using the Treasury yield curve as a measure of risk in a default-free pension liability. Although the Treasury yield curve is generally viewed as default-free, it reflects other risks that may not be present in the pension liability. State employee pensions typically contain COLAs. If inflation risk is priced (Fisher (1975), Barro (1976), Benninga and Protopapadakis (1985)), then an appropriate default-free pension discount rate would involve a downward adjustment of nominal yields to remove the inflation risk premium. This adjustment would further increase the present value of ABO liabilities. However, a countervailing factor is the fact that Treasuries trade at a premium due to their liquidity (Woodford (1990), Duffie and Singleton (1997), Longstaff (2004), Krishnamurthy and Vissing-Jorgensen (2008)). Pension obligations are nowhere near as liquid as Treasuries. Therefore, a liquidity price premium should ideally be removed from Treasury rates before using them to discount default-free but illiquid obligations. Given the lack of consensus over the relative size of the liquidity price premium and inflation yield premium, we use unadjusted Treasury rates to calculate our default-free liability measures. However, we note that due to these risks priced into the Treasury curve, default-free public pension obligations are not equivalent to Treasuries.

States set aside assets in pension funds that are dedicated to providing the retirement benefit cash flows associated with these liabilities. As of June 2009, the states had approximately $1.94 trillion in assets in the plans we study. The difference between assets and liabilities is therefore $1.26 trillion under taxable muni discounting and $2.49 trillion under Treasury discounting. As of January 2011, Treasury yields were slightly lower than they were in June 2009, and hence the difference between assets and liabilities is now slightly larger. In this paper, we do not address the question of optimal funding levels, which is entirely separate from the valuation question.

The calculations above use the ABO, a very narrow measure of liabilities in that it considers the accrued liability to be only what is implied by current salary and years of service. In a typical plan, a worker accrues the right to an annual benefit upon retirement that equals a flat percentage of his final (or late-career) salary times his years of service with the employer. If salary increases with years of service for a given worker, the worker's ABO grows convexly with years of service. Thus, the ABO delays a large share of recognized liabilities until late in the employee's life. The newly accrued liability under the ABO rises dramatically as a fraction of the worker's salary as he approaches retirement.

There is substantial debate as to whether the ABO is the most meaningful liability measure or whether more of the liability owing to future salary growth and years of service should be recognized up front (Treynor (1976), Bulow (1982), Bodie (1990)). A broader measure than the ABO is the Projected Benefit Obligation (PBO), which takes projected future salary increases into account, but not future years of service, in calculating today's liability. An even broader concept is the Projected Value of Benefits (PVB), which discounts a full projection of what current employees are expected to be owed if their salary grows and they retire according to actuarial assumptions.

The fact that states cannot freeze pension accruals as easily as companies may argue for considering a liability measure broader than the ABO in the state pension context. If states had no ability to limit future pension accruals, the ABO would appear to be an excessively narrow measure. However, Bulow (1982) explains that the broader measures only make sense if the implicit labor contracts involve overpaying old workers at the expense of young ones. If labor markets are competitive, there should be no misalignments between the marginal product of labor and total compensation.[2]

The actuarial methods used by states are not classified as ABO or PBO. Most states report accrued actuarial liabilities under the so-called Entry Age Normal (EAN) method, in which new service liabilities accrue as a fixed percentage of a given worker's salary throughout his or her career. The EAN is therefore a measure between the PBO and the PVB. Discounting EAN liabilities at the taxable muni rate yields a liability of $3.53 trillion, or 10% above state-reported numbers. Discounting EAN liabilities at the Treasury rate yields a liability of $5.28 trillion, or 68% above state-reported numbers.

To calculate present values under different assumptions, we implement calibrations to translate the stated EAN or PUC liability measures into an ABO for each state pension plan. In addition to the ABO measures, we also calculate the present value of PBO, EAN, and PVB liabilities. These broader measures have the additional complication that their evolution depends on the path of future government wages, which may be correlated with pricing factors such as stock market returns over long horizons. If this is the case, the streams of payments in the broader liability measures (at least those above and beyond the ABO) should be discounted at higher rates to reflect this systematic risk. Acknowledging that government wages and the stock market may be correlated at long horizons that are not observed, we see little evidence of this sort of correlation in the data. However, in order to be conservative, we calculate the broader measures under discount rates that reflect high correlations between government worker salaries and the stock market.

We emphasize that considerations about the accrual method affect only the liability for active workers, whom we calculate to be responsible for only around one-half of the total liability. The rest of the liability comes mostly from retired workers, as well as workers who have left the job but have not yet begun to collect benefits (which we call separated workers).[3] The accrual standards differ only in their treatment of uncertainty about future wages and years of service. Therefore, for annuitants (i.e., retirees) and former employees entitled to future benefits, the liabilities are the same under the different actuarial standards.

Our valuation methodology uses the entire yield curve. It does not rely on a single average measure of public pension liability duration. It can therefore handle tilts in the yield curve as well as parallel shifts in yield. Our model of the stream of promised pension payments nonetheless lends new insight into the duration and convexity of state public pension liabilities overall and of their constituent components (active, separated, and retired workers). Measurements of the duration and convexity of the liabilities facilitate understanding of the impact of changes in market-based rates on the present value of liabilities. The effective average duration over the range of discount rates we consider is roughly 13 years, somewhat shorter than the 15-year duration typically assumed for public pension liabilities (Barclays Global Investors (2004), Waring (2004a, 2004b)). However, our analysis shows that there is a great deal of convexity in the promised pension payments, as well as large differences in duration between liabilities associated with by active, separated and retired workers.

Our calculations refer to liabilities that have already been accrued under these different measures. They ignore the question of whether states have sufficient tax revenues to fund the flow of newly accrued liabilities. They also ignore other post-retirement employee benefits (OPEBs), including state-provided retiree healthcare, which total $587 billion in present value according to recent disclosures (Pew Charitable Trust (2010)). Furthermore, we focus only on state pension plans, not local city and county plans, whose size is about 20% of state plans.[4] Our calculations are therefore certain to understate total liabilities related to pension and other retirement benefits offered by U.S. state and local governments. We note that the liabilities of state employee pension systems are larger than the liabilities faced by the federal government through exposure to corporate pension plans. Total ABO liabilities of all DB plans covered by the Pension Benefit Guaranty Corporation (PBGC) were $1.6 trillion at the latest estimate in 2003 (Congressional Budget Office (2005)).

Questions of risk and liability discounting similar to those we address have arisen in the measurement of Social Security liabilities (Geanakoplos and Zeldes (2009, 2010), Geanakoplos, Mitchell, and Zeldes (1999), Blocker, Kotlikoff, and Ross (2008)). Geanakoplos and Zeldes (2010) derive a market value of Social Security promises by considering a system of personal accounts that could be structured to exactly replicate promised Social Security payments under the current system. Our approach to valuing public pension liabilities is similar in that we price the promised cash flow streams from state employee pensions. However, since Social Security is wage-indexed, even the Social Security ABO depends on future labor earnings, whereas for state employee pensions the ABO does not depend on future wage growth.

The paper proceeds as follows. Section I takes state disclosures of liabilities as given and, as a starting point for our analysis, calculates aggregate U.S. state pension plan liabilities on this reporting basis. Section II outlines the different liability concepts: that is, ABO, PBO, EAN, and PVB, in increasing order of broadness. In Section III we implement calibrations to translate among different liability measures for a given discount rate. We calculate what liabilities would be under the different accrual concepts, but still under state-chosen discount rates. Section IV calculates the value of ABO pension liabilities under appropriate discount rates. Section V discusses the duration and convexity of outstanding state pension promises as implied by our calibration. Section VI considers broader liability measures. We also analyze the effects of correlations between government wages and the stock market on these measures. Section VII concludes.

I. State Pension Liabilities Under Current Reporting

In a typical DB pension plan, an employer pledges an annual pension payment of an amount that is a function of the employee's final salary and years of employment. Most states have at least one DB plan for teachers and another for general state employees. Some states have one combined plan for all state employees. Many have a number of smaller plans.

While the U.S. corporate sector has moved away from DB plans and towards defined contribution (DC) arrangements such as 401(k) plans, the public sector has seen very limited movement in this direction. A March 2008 Bureau of Labor Statistics (BLS) survey indicates that 80% of state and local government workers are enrolled in a DB plan, with less than 20% enrolled in a DC plan (Bureau of Labor Statistics (2008)). The Government Accounting Office (GAO) reported in late 2007 that only Alaska and Michigan offered new employees in their "primary pension plan" a DC arrangement but not a

DB arrangement, while Indiana and Oregon offered a hybrid plan; all other states offered only DB plans to new employees in their primary plan (Government Accounting Office (2007)).[5] Finally, according to data from the Pensions and Investments (P&I) survey of the 1,000 largest pension plans, 32 states reported nonzero DC assets in a state-sponsored pension plan in 2008. However, the total magnitude of DC assets was $83 billion compared to $2.30 trillion in DB assets.

We collect data on the largest DB pension funds sponsored by U.S. state governments. To assemble the list of plans, we begin with data from the Census of Governments, published by the U.S. Census Bureau (2007). The starting point is all plans with more than $1 billion of assets, including only those plans sponsored by state governments themselves.

The Census of Governments does not contain measures of pension liabilities. We therefore examine the most recent Comprehensive Annual Financial Report (CAFR) for each pension plan and collect total actuarial liabilities for each pension plan, along with the discount rate used by state actuaries to calculate these liabilities. In some cases, the Census of Governments had aggregated plans that we find to have separate CAFRs, or separate disclosures within a CAFR. Disaggregating as much as possible, we identify 116 individual state plans at the end of 2008.The statement of liabilities in the CAFRs is an accrued actuarial liability (AAL). In calculating an AAL, state actuaries must begin with a projection of the expected streams of payments that will be made to current and former employees. Since benefits typically depend on an employee's ultimate years of service and his salary late in his career, some of those expected benefits will not yet have been earned or "accrued" by the worker. Actuaries therefore have to determine the allocation of the present value of liabilities to past, current, and future years. The flow measure of accruing benefits is called the Normal Cost, which is the share of the present value of future benefits assigned to a given year. The AAL is the portion of the present value of benefits that is not going to be reflected in future normal costs.

In Section II below we will consider the subtlety of which pension promises are recognized in the stated liability. For now, we point out that this consideration matters only for the part of liabilities attributed to the current workforce, since all benefit promises to retired and otherwise separated workers have already been made based on the past work of those former employees.

The actuaries also need to choose a discount rate with which to discount the future payments from these accrued benefits. The discount rates used by the state plans to calculate these liabilities had a mean of 7.97% with a standard deviation of 0.31% and a median of 8.00%. The modal discount rate was also 8.00% with 54 entities using this rate. The minimum rate was 7.00% and the maximum was 8.5%.[6]

We begin with the AAL figures as reported, and then consider how different AAL methods and discount rates might affect them. The latest fiscal year for which all 116 plans have reported liabilities is 2007, while 111 plans have reported liabilities for 2008 and 54 have reported liabilities for 2009. A simple sum of stated liabilities over all 116 plans yields \$2.80 trillion as of 2007, while a raw sum of latest reports regardless of reporting date yields a total of \$3.03 trillion. Using the weighted-average growth rate of the reported plans to extrapolate for missing data and harmonizing all plans to a June reporting date yields a total June 2009 liability of \$3.14 trillion on a stated basis. Reported liabilities grew at a 6.0% annual rate from 2007 to 2008, and at a 6.0% annual rate from 2008 to 2009. See the Internet Appendix for details.[7]

For comparison to other studies, we also estimate total assets in these plans as of June 2009. As also shown in the Internet Appendix, the raw sum of the latest reports regardless of reporting date yields a total of \$1.96 trillion in assets. The reporting date for 82 of the 116 plans was in fact June 2009. Harmonizing the remaining 34 plans to a June 2009 date reveals an estimated \$1.94 trillion in aggregate assets in these 116 funds at that date.

Taking the pension liability calculations from the state plans as reported, there is an aggregate difference between liabilities and assets of \$1.20 trillion (= \$3.14 trillion in liabilities – \$1.94 trillion in assets). Similar "as-reported" calculations have also been performed by the Pew Charitable Trust (2010), National Association of State Retirement Administrators (2003-2009), Merrill Lynch Research (2007), Munnell, Aubry, and Muldoon (2008), and Munnell et al. (2008). The Pew Charitable Trust (2010) report finds a \$1 trillion difference. Studies referring to earlier years find a difference between assets and liabilities closer to $0.3 trillion, due to the fact that asset values were approximately $1 trillion higher before the market decline of 2008.

The studies referenced in the above paragraph are typical of the many popular studies on pension liabilities that have come out of the private sector. These studies simply add up liabilities taken verbatim from the reports and stop there. In the following sections, we show that these calculations based on liabilities taken verbatim from the reports understate the value of public pension liabilities.

II. Liability Concepts for State Pension Promises

One issue that arises in calculating the present value of pension liabilities is the question of how and to what extent pension benefits owed in the future should be recognized today ((Treynor (1976), Bulow (1982), Bodie (1990)). In this section we discuss several accrual methods for active workers. In Section III we provide stylized examples of these various liability concepts, and we present calculations of actual state pension liabilities under the different methods.

A. The Accumulated Benefit Obligation (ABO)

In a typical plan, an active worker accrues the right to an annual benefit upon retirement that equals a flat percentage of his final (or late-career) salary times his years of service with the employer. For example, suppose the benefit factor is 2% and Alice has worked for 10 years and has an average wage in the last several years of work equal to $40,000. Alice will be entitled to a pension of $8,000 (= 2%*10*$40,000) per annum when she retires, plus any COLAs her plan offers. Suppose that Bob has worked for 20 years and has an average wage in the last several years of work equal to $60,000. He is entitled to a benefit when he retires of $24,000 (= 2%*20*$60,000) plus any COLAs. COLAs vary by state and by plan but typically index the annual payment to a fixed rate of inflation (e.g. 3%) or to the Consumer Price Index (see Peng (2009)). Note that for a given worker, both the years of service and the salary grow with each year of work, so that the nominal benefit the worker expects to receive increases convexly with the worker's age.

Consider a plan in which both Alice and Bob are just days before reaching their retirement age of 65. In this plan, it seems clear that the sponsor's financial liability is the present value of one annuity that will pay Alice $8,000 until she dies, and one that will pay Bob $24,000 until he dies, both adjusted for the COLAs specified by the plan. To value this, one only needs mortality tables that project how long Alice and Bob will live starting at 65 years of age, inflation assumptions, and appropriate discount rates.

Now consider instead a plan in which Alice and Bob are both 45 years old and both have quit the workforce. In actuarial terms, they are called separated workers. What is the present value of this promise? The liability is again a present value of Alice's annuity of $8,000 and Bob's annuity of $24,000, but the annuities do not need to begin for 20 years. Setting aside the important matter of selecting the discount rate, the state's liability here is still clear. It is the expected value of these annuities discounted by 20 years (the amount of time before Alice and Bob reach the retirement age). Again, the state only needs mortality tables and inflation assumptions, although here the tables need to start at the latest at 45 years of age and the inflation assumptions need to run further into the future.

Now instead consider a plan in which Alice and Bob are both 45 years old and both are working. Here the sponsor's financial liability is not as obvious. If the state views the liability as though Alice and Bob were going to stop working today, it is behaving as though it could stop the benefit accrual to Alice and Bob at any time by freezing (terminating) the pension plan. This method is the ABO measure, or termination liability. Under a termination liability, the sponsor does not worry about the fact that as Alice and Bob get older, their ABO liability grows convexly with additional years of service. Calculating an ABO is relatively simple, as beyond the mortality tables, one needs only the benefit formula, the current wages of the employees by years of service, and inflation assumptions. To calculate a plan's total ABO, one simply adds up the ABOs represented by each individual employee. This adding up requires the distribution of plan employees by age and service (an "age-service matrix"), as well as average wages of state employees by age and service.

If workers receive their marginal product in total compensation (wages plus pension benefits), then the ABO is the appropriate measure to use, since it captures the benefits that employees have actually earned (Bulow (1982), Brown and Wilcox (2009)). The ABO is also narrow in that it does not recognize any future wage increases or future service that employees are expected to provide, even though such wage increases and service are to some extent predictable. Moreover, the ABO obligation is also independent of wage risk, which simplifies the valuation. Our main estimates of state pension liabilities therefore employ this accrual method, as it represents a conservative appraisal of states' financial obligations to public employee pensions.

However, since the employer is a state government, it may not be correct to assume that the sponsor can completely stop employees' pension accrual at will, as is implicitly assumed in the ABO. This inability to freeze matters if state employees will be overpaid in the future relative to their future marginal product — which seems possible since casual observation suggests a willingness by public employees to accept low salaries today in exchange for job security.[8] The future overcompensation, which may be in the form of rapidly accruing pension benefits, then represents a current financial liability. Such considerations suggest the use of broader liability measures that reflect expected future wage increases and/or years of service.[9] The states themselves also typically report their pension liabilities using measures that are broader than the ABO. These facts lead us to consider some broader liability measures.

B. The Projected Value of Benefits (PVB)

A very broad way to measure pension liabilities would be to demand that actuaries begin with the full projection of what current employees are expected to be owed if their salary grows and they continue working, retire, and die according to actuarial assumptions. One could then discount those payments and arrive at a broad present value liability. To make such projections, one needs two additional ingredients beyond those employed in the ABO calculation: salary growth assumptions by age, and separation probabilities by age.

If a vested worker of age a and service s separates this year, her PVB is equal to her ABO because she will not earn any more benefits. Superscripting the years until separation and subscripting age (a) and service (s), we write

$$PVB_{a,s}^{0} = ABO_{a,s}^{0} = \left[\min(\alpha \times s, 1) \times W_{a,s}\right] \times A_{a}, \tag{1}$$

where $W_{a,s}$ is the worker's annual wages, α is the benefit factor so that $\min(\alpha \times s, 1)$ is the fraction of these wages she will receive, and A_a is the annuity factor for a worker of age a receiving cost of living-adjusted benefits every year until death, starting no earlier than the year after they turn 65. This annuity factor is equal to

$$A_a = \sum_{i = \max(65-a,0)+1}^{\infty} \left(\frac{1+cola}{1+r}\right)^i S_{a,i} , \tag{2}$$

where $S_{a,i}$ is the probability of surviving from age a to age $a+i$.

The PVB of a worker separating T years in the future is the value, discounted for both time and mortality, of the expected obligation at the time of separation,

$$PVB_{a,s}^{T} = \frac{S_{a,T}}{(1+r)^T} \times \mathbf{E}\left[PVB_{a+T,s+T}^{0}\right]. \tag{3}$$

The unconditional PVB for an employee of age a with s years of service is the expectation, over years until separation, of the PVB conditional on years until separation.

The PVB method is extreme because it does not credit the state for the fact that it might have some ability to limit benefit accruals, even if it cannot stop them completely at will. It also requires that we recognize today liabilities that are due to employees' future service. Of course, one could consider an even broader concept that assesses benefits expected to accrue in the future to workers who have not yet been hired.

C. Entry Age Normal (EAN) and Projected Benefit Obligation (PBO)

All of our 116 state plans report liabilities using an actuarial method that recognizes more than the ABO liability but less than the PVB liability. Entry age normal (EAN) is the dominant method employed by our 116 state plans. Matching our data set to that of the Boston College Center for Retirement Research (2006), we find that approximately 68% of the liabilities in the CAFRs are calculated on an EAN basis, and an additional 17% use closely related methods. The remaining 15% of liabilities are stated using an actuarial method called projected unit credit (PUC), which as implemented by the states yields the projected benefit obligation (PBO).

Both the EAN and PBO recognize a fraction of the PVB (Winklevoss (1993), Lenze (2009)). The PBO method recognizes the PVB prorated by service,

$$PBO_{a,s}^{T} = \left(\frac{s}{s+T}\right) \times PVB_{a,s}^{T}. \tag{4}$$

That is, the PBO projects future wage growth, but does not recognize future service. For a comparison of the ABO and PBO in a corporate pension context, see Bodie (1990).

The EAN method recognizes the PVB in proportion to discounted wages earned to date relative to discounted expected lifetime wages,

$$EAN_{a,s}^{T} = \left(\frac{\sum_{i=1}^{s} \frac{S_{a-s,i}}{(1+r)^{i}} \times W_{a-s+i,i}}{\sum_{i=1}^{s+T} \frac{S_{a-s,i}}{(1+r)^{i}} \times W_{a-s+i,i}} \right) \times PVB_{a,s}^{T}, \tag{5}$$

where wages are discounted to reflect both the time value of money and mortality rates. Under the EAN method, the normal cost (the annual growth in the liability due to new service) is a constant percentage of a worker's salary. The EAN may consequently be interpreted as estimating the percentage of employees' wages that would have to be set aside to meet retirement benefits, under the implicit assumption that the savings can be invested risk-free at the discount rate used to value the liabilities. This accrual method therefore resembles a DC plan in which participants do not bear investment risk, since contributing a constant fraction of salary is similar to how many individuals without a DB pension plan save for their own retirement.[10]

Provided wages grow slower than the discount rate that reflects the time value of money and mortality rates, the EAN always exceeds the PBO. The EAN is often therefore interpreted as recognizing some future service. Both the EAN and the PBO exceed the ABO, and both are smaller than the PVB. The four measures converge at retirement, requiring the methods that recognize less of the liability early on to have larger accruals close to retirement. If an individual tried to save for retirement in a way that mimicked an ABO, he would have to save a much higher fraction of his salary later in life than earlier in his life.

D. Accrual Methods are Irrelevant for Annuitants and Separated Workers

All the accrual methods treat separated workers in the same way. In every case the obligation posed by separated workers — both those currently receiving benefits and those that have not yet started collecting — are recognized on the same basis. The liability of a separated worker is the present value of the benefits that they are expected to receive, where the present values are calculated using the plan's discount rate. This is just the annuitized value of the annual benefit that they are currently receiving, or in the case of workers not yet eligible for benefits, the annual benefit they would receive if they were currently eligible.

E. An Example

Figure 1 illustrates the different accrual concepts using a simplified set of assumptions. In particular, the figure shows the liabilities represented by workers age 21 to 65, hired at age 20 and retiring at age 65. It assumes wages are consistent with the wage growth given by age and service assumptions derived from the state CAFRs (as will be explained in the following section). The figure also uses an assumed 3.5% expected inflation rate (the states' modal assumption), and calibrates to an income of $100,000 by a 65-year-old worker with 45 years of service. Other model inputs for this figure are close to the averages of those actually employed by the states: a 2% benefit formula, a 3% COLA, an 8% discount rate, and mortality rates taken from the RP2000 combined mortality table.

[Figure 1 here]

The figure illustrates three salient features of the different methodologies. First, the three non-PVB methods start at zero because employees have no years of service; the PVB starts at a positive level because it recognizes liabilities from future years of service. Second, all four measures converge to the same value at retirement. Third, the rank ordering of the accrual methods from narrowest to broadest is ABO, PBO, EAN, and PVB.

Note that the figure depicts liabilities represented by active workers, and thus shows significantly more variation across accounting measures than there is in total liabilities. All four accounting methods treat retired and separated workers symmetrically, and these workers represent roughly one-half of aggregate state pension liabilities. Total aggregate liabilities accounting for all claimants are consequently more similar under different accounting measures than suggested by the figure.

III. Calculating State Pension Liabilities Under Different Accrual Methods

To calculate state pension liabilities under the different accrual concepts, we begin with a nine-item array for each of the 116 plans that includes: 1) the plan's stated liability; 2) its state-chosen discount rate; 3) the actuarial method (EAN or PUC) employed by the state to calculate the liabilities; 4) a benefit factor, the constant fixed fraction of salary times years of service, which appears in the benefit formula; 5) a cost of living adjustment (COLA); 6) an inflation assumption; 7) the share of active workers in the plan; 8) the share of retired workers in the plan; and 9) the dollar amount of benefits paid in the most recent year.

We collect these nine data items from the CAFRs of the plans themselves, with a few exceptions. The actuarial method (item 3) combines our own data collection with information from the state and local pension data made available by the Center for Retirement Research (2006). For the benefit formula, the COLA and the inflation assumption (items 4 through 6), we collect plan-specific data directly from the CAFRs, but some imputations are made when data are unavailable.

Table I summarizes the results of this data collection. For each of these items we are able to collect data for at least 90 of our 116 plans. Where data are unavailable, we ultimately fill these items in with sample means, but the table shows the data before that step where applicable. The first column shows the discount rate distribution, already discussed in Section I above. The second column shows benefit factors. For 28 plans, benefit factors are given as a range, for which we pick the midpoint. The model restricts the benefit formula be a constant fixed fraction of salary times years of service, with employees vesting after five years service

[Table 1 about here]

The summary statistics on COLAs shown in Table I are based on the COLAs built into the states' own nominal cash flow projections. The easiest case is if the COLA is fixed, in which case the COLA is just the fixed number given. If the COLAs are tied to the CPI with a cap, or equal a fraction of the CPI (a practice called "partial CPI"), then the given formula is applied to the state's inflation assumption. If the COLA is ad hoc, excess earning, or other, we assume that the projected COLA equals the state's inflation assumption. COLAs are assumed to operate only after the individual has retired, not during the years in which a worker might be separated from a job but not yet drawing a benefit.

The final columns of Table I show the share of active and retired workers among total plan members. The average active share is 55.4%, and the average retiree share is 35.7%. Large plans with a very small active participant share include the Michigan State Employee Retirement System at 33% and the Texas Employee Retirement System, which has almost 180,000 active members and over 252,000 retirees.[11] The Teacher Retirement System of Texas, on the other hand, has an active share of 73%, around the 90th percentile. Note that the workers who are neither active nor retired are the separated workers entitled to but not yet receiving benefits. Separated non-vested workers are excluded from all member counts.

In total, there are 22.3 million participants in the 116 plans, of which 12.9 million are active workers, 6.8 million are annuitants, and 2.6 million are separated and vested. The Internet Appendix shows the plan participant distribution in levels.

We next convert the nine-item array for each state into a stream of payments that yields the reported liabilities when discounted using the reported discount rate. The stream of payments can then be re-discounted using alternative yield curves. Formally, define $L_{i,stated}$ as the liabilities that a given plan i reports, and define $r_{i,stated}$ as the flat discount rate that the plan reports it uses. Plans discount cash flows using a simple discounted cash flow formula:

$$L_{i,stated} = \sum_{t=1}^{T} \frac{C_{i,t}}{(1+r_{i,stated})^t}. \tag{6}$$

However, plans do not report the cash flows ($C_{i,t}$), which appear in the numerator. We use our model to estimate the stream of cash flows ($C_{i,t}$) and to deliver the sensitivity of liabilities to discount rate variation ($-d \ln L / dr$).

After the nine-item array for each plan, we calculate a set of matrices that reflect assumptions about salaries, years of service, and separation probabilities by age for active workers. In particular, we require a vector of salary growth by age; a vector of separation probabilities by age; the distribution of plan participants by age and years of service (an "age-service matrix"), and the average wages of employees in each cell. To derive these inputs, we examine the CAFRs of the 10 states with the largest total liabilities and take the assumptions from the reports where they are usable: New York, Illinois, Pennsylvania, Ohio, and Texas. The matrices we use are an average over the reports. These matrices are shown in the Internet Appendix.

The calculation requires a number of technical assumptions, specifically: a vector of mortality assumptions by age; an age at which beneficiaries can begin receiving full benefits; an age at which employees can retire with reduced benefits; and a benefit reduction factor for early retirement.

For mortality, we use the RP-2000 mortality tables employed by many states, tabulated in Society of Actuaries (2000). We use the combined (employee/retired) healthy rates, and assume participants are evenly divided by gender. We also assume that 60% of participants are married at the time they retire, to a spouse of the same age, and that plans allow for 50% survivor benefits.[12]

For retirement age and early retirement age, we use a full retirement age of 60 and an early retirement age of 55, based on common practice and the age distribution of retirees shown in the Internet Appendix. As an adjustment for early retirement, we use a linear 6% benefit reduction for each year a participant starts taking benefits before the full retirement age, which we find to be a common practice in state public pension systems.[13] This practice is not "actuarially fair," but extremely generous to plan participants.[14] Since COLAs only apply after participants start taking benefits, the effective cost of retiring one year early is only 3% to 4% of the annuity's value. This is roughly two-thirds the market value of a joint life annuity for a 60-year-old couple, suggesting that plans reward each year of early retirement with a "gift" equal in value to roughly four months of benefit payments.

For retired workers, we employ a distribution of retirees by age and the average annuity benefit in each age category. This information is only disclosed sporadically, but by randomly sampling the CAFRs we obtain an average distribution across 10 plans covering approximately 1.2 million retirees out of the 6.8 million annuitants. This distribution is shown in the Internet Appendix. Using this information, we forecast the payout in each year going forward by adjusting for COLAs and expected mortality as described above.

For workers who are separated and vested but not yet receiving benefits, we assume that their service distribution is between 6 and 15 years of service, and that the age distribution at each service level is the same as that for currently employed workers with the same level of service. The assumption is that longer tenured workers rarely ever leave public employment with more than 15 years service but without actually retiring and beginning to take benefits. This assumption generates a relatively small liability owing to separated workers, consistent with actuarial reports.

If we were modeling liabilities "from scratch" (i.e., without knowing each plan's reported liability at state-chosen discount rates), the total liability would likely be sensitive to changes in the above assumptions. Crucially, however, we know both what the state is claiming its liability is and what discount rate it used to obtain that liability. The derivative of the liability with respect to the discount rate is relatively insensitive to these various assumptions.

As a check of the model we consider how it performs when we replicate the states' aggregate reported liabilities "from scratch," using neither the reported liabilities themselves nor the first-year cash flows. That is, we use the model to generate the stream of states' expected future pension payments without making use of $L_{i,stated}$ or the first-year cash flows, and then we discount these future payments at the average discount rate assumed by the states. It is not important that our model-generated liability perfectly match the reported liability. The purpose of modeling the stream of future pension payments "from scratch" is not to calculate the level of the liability, but rather to investigate how the liability changes with discount rate assumptions,. We know the level of states' reported liabilities, and can use them to calibrate the model.

To perform this check, we generate the expected future pension payments using the total number of active plan employees (12.920 million), their average salary ($46,131), the total number of annuitants and separated employees not yet receiving benefits (6.813 million and 2.592 million, respectively), as well as the liability-weighted average benefit factor (2.03%), COLA (2.84%), and inflation (3.39%)

assumptions.[15] We then account for these payments on an 85.6% EAN / 14.4% PUC basis, the relative liability weights of plans using EAN-like and PUC accounting. We discount these payments using the states' liability-weighted average assumed discount rate (7.94%). The model generates an aggregate liability of $3.15 trillion. This number was produced without using the states' actual stated liabilities and is essentially equivalent to the $3.14 trillion reported by the states themselves. This provides us with some confidence that our model reasonably approximates the cash flow projections of the states themselves.

Despite the fact that we generate relatively accurate aggregate cash flows, not calibrating to stated liabilities would throw away state-level variation in all the elements of the nine-item array described previously. The reported liability may well capture information where our state-level actuarial data are incomplete. In the last step of our procedure, we therefore calibrate the model plan by plan, using plan-specific information. That is, for each plan we calibrate the stream of modeled benefit payments so that it is consistent with the stated liability provided in its CAFR.

For this calibration we separately calculate the projected liabilities each year, for both the current active workers and the inactive workers (separated and retired) using plan-level information regarding the relative number of separated and retired workers. This calculation uses the information for each plan regarding its benefit formula, COLA, and inflation assumption. We then adjust these cash flows, by adjusting the average salary of the currently employed workers and the average benefit of the inactive workers, to generate a new cash flow series that simultaneously matches both the plan's stated accounting liability when the cash flows are discounted at the stated rate and the plan's expected first-year cash flow.[16] This calibrated stream of benefit payments can then be used to calculate the plan's liability under any accounting methodology, using any discount rate (or yield curve), employing the formulas presented in Section II.

Figure 2 shows projected aggregate cash flows by state governments due to state pension promises to workers hired prior to today, as would be recognized under the four main accrual methods, ABO, PBO, EAN, and PVB. In the near future, aggregate expected annual cash flows are roughly $160 billion under all four measures. These obligations rise over time, peaking at around $270 billion in 15 years (ABO), $340 billion in 20 years (EAN and PBO), and more than $500 billion in 30 years (PVB).

[Figure 2 here]

Figure 3 decomposes the cash flows into those owed to the different worker groups. These categories are assigned based on the participant's status as of the end of 2008. The top graph shows the projected future cash flows for workers who were still active in 2008; these cash flows depend on the accrual methodology. The bottom graph shows the cash flows for workers who were retired and separated as of 2008; these liabilities as discussed above do not depend on any particular accrual methodology. Initially all the cash flows go to workers who were already retired as of 2008. Cash flows going to these annuitants decrease each year, reflecting the expected mortality of these claimants. These cash flows become insignificant after 40 years, at which time the youngest of these workers are 95 years old. Cash flows going to separated workers initially increase each year, as more and more of these individuals reach the age at which they can claim benefits. These cash flows to separated workers continue to increase for roughly 30 years, at which point the decrease in cash flow due to these claimants' mortality more than offsets the increases due to new claimants reaching benefit age.

[Figure 3 here]

The portion of the cash flows due to active workers has a profile similar to that due to separated workers, albeit with a later peak. It slopes upward initially, as more and more newly retired workers reach the age at which they can draw benefits. The projected cash flows going to currently active employees continue to increase until downward pressure from worker mortality exceeds upward pressure from those reaching benefit age. The peak occurs much later for PVB cash flows than for ABO, EAN, or PBO. The PVB recognizes the full expected service and terminal salary of even the youngest workers, while the EAN and PBO recognize only a fraction of these and the ABO recognizes only the current service and salary of these workers.

Table II shows total state pension liabilities without adjustments to the discount factor, but applying different liability concepts, using all the state-level variation. The first number in the table, $3.14

trillion, represents the sum of reported liabilities from the 116 CAFRs (projected to 2009 as necessary). Although most of these liabilities are stated on an EAN basis, not all of them are. Therefore, this sum is "unharmonized" in that it represents the sum of liabilities under somewhat heterogeneous actuarial methods.

[Table II about here]

The next rows of the table show the ABO, PBO, EAN, and PVB liabilities, again without adjustments to the discount factor. The EAN is $3.15 trillion, which is very similar to the aggregate reported liability, as would be expected since most plans report using the EAN method. The PBO, the other measure occasionally employed by states, is $3.07 trillion. The broadest measure is the PVB at $3.75 trillion. The narrowest measure is the ABO at $2.76 trillion, which implies that the typical accrual method that states use increases the stated liability by $0.4 trillion or 14% relative to the ABO.

The table also shows a decomposition into the three groups of plan members from which the liabilities arise, namely, active participants, annuitants, and those separated but not yet receiving benefits. As can be seen, the latter two categories are insensitive to the choice of actuarial method since they do not depend on future salary or service outcomes. Indeed, 55% of the liability comes from the active participants in the broadest measure (PVB) and 39% in the narrowest (ABO). The impact of the different actuarial methods on total liabilities is muted relative to what it would be if all the categories were affected.

IV. The Value of State ABO Pension Promises Under Appropriate Discount Rates

In this section we discuss appropriate discount rates for the stream of payments arising from a state's ABO liability. A financial stream of payments should be discounted at a rate that reflects its risk (Modigliani and Miller (1958)), and in particular its covariance with priced risks (Treynor (1961), Sharpe (1964), Lintner (1965)). In Section II, we explain that the correct discount rate for the ABO should not reflect any wage or salary risk, because the ABO does not account for future wage growth. In this section we consider appropriate discount rates in light of the possibility of other priced risks, particularly default risk, and we calculate the present value of ABO liabilities under these discount rates.

As several studies have pointed out previously (see, for example, Barclays Global Investors (2004)), the 8% average discount rate used by state-sponsored pension plans is almost certainly too high. The discount rate assumptions come from Government Accounting Standards Board (GASB) ruling 25 and Actuarial Standards of Practice (ASOP) item 27, which together stipulate that the actuarial value of pension liabilities should depend on the assumed return on pension plan assets. Most finance academics and practitioners view this rule as misguided (see Gold (2002) and Bader and Gold (2004)). Financial liabilities should be discounted using discount rates that are specific to the factor (or market) risk inherent in the liabilities.[17] The way the liabilities are funded is irrelevant to their value.

Note that the government accounting treatment of pensions differs substantially from the treatment of corporate pension plan liabilities. Under FASB rules for corporate reporting, a PBO must be reported. For FASB purposes, the PBO must be discounted using a blended corporate bond yield.[18]

From the perspective of taxpayers who are concerned with how large taxes will have to be in the future to cover liabilities, it is important to consider default risk. One hint as to the appropriate discount rate that reflects default risk comes from state-specific GO credit ratings, to which yields on states' municipal GO bonds are closely related. If government pension liabilities default in the same states of the world as other government debt, and have the same recovery rates, then the discount rate should be closely related to municipal bond yields.

For 20 states, a specific general obligation municipal bond yield curve is obtainable from Bloomberg.[19] For the remaining 30 states, we use the Bloomberg municipal yield curve specific to the credit rating of the state in question. The upper three lines in Figure 4 show zero-coupon yield curves as of June 30, 2009 for state GO bonds with A, AA, and AAA ratings. These curves were calculated by stripping par yield curves from Bloomberg.[20] Our liability calculations additionally employ the AA+, AA–, A+ and A– curves for plans sponsored by states with those ratings, but for simplicity they are not shown in the figure. Eighteen of our 116 plans are sponsored by states rated AAA, 72 by states rated in an AA category (including AA+ or AA–), and five by states rated in an A category (including A+). Note that 21 plans are sponsored by unrated states; for these plans we use the AA curve.

[Figure 4 here]

Suppose that a state wanted to defease its entire pension obligation by paying off the beneficiaries with a portfolio of bonds that generates the same stream of payments as the benefits and defaults in exactly the same states of the world. The cost of the defeasance would be the market value of the bonds the state must deliver today. Unlike coupons on municipal bond debt, state pension benefits are not tax exempt for beneficiaries. Therefore, the state would need to deliver the beneficiaries taxable bonds that generate the same stream of payments as the benefits in all states of the world.

This leads us to consider our first discount rate candidate for a given pension-related cash flow: the yield on a zero-coupon state GO municipal bond with the same term as the payment, grossed up to eliminate the tax preference given to borrowing. In other words, for state i at time t, the tax-corrected yield would be $r_{it} / (1- \tau_B)$, where τ_B is a personal investor's marginal tax rate on interest income and r_{it} is the yield on a zero-coupon state GO bond of comparable maturity. We refer to this rate as the "taxable muni rate."

A key input to this calculation is the value of τ_B, the marginal tax rate on municipal bond investors. While the statutory rate is 35%, a number of papers have looked at the implicit tax rates on prime-grade municipal bonds relative to taxable Treasury bonds. Most recently, Poterba and Verdugo (2008) document that over the 10 years from 1998 to 2007 the spread of Treasuries over municipal bonds has been in the range of 50bp to 139bp, representing an implicit tax rate of between 14.9% and 30.0%. Over the period from 1991 to December 2008, the average implicit tax rate was 26.3%, and over 1997 to 2008 it was even lower.

Poterba and Verdugo (2008) assume that the market believed municipal bonds were no more likely to default than Treasuries, an assumption that is clearly violated today. At various times during 2008 and 2009, Treasuries traded at a premium to AAA municipal bonds. Based on Poterba and Verdugo's (2008) findings, we set τ_B to 25%. Our assumption is therefore equivalent to the notion that during the Poterba and Verdugo (2008) period, the default probabilities for AAA municipals equaled the default probability for Treasuries, even though this is likely no longer the case today.[21]

The ABO liability discounted at the taxable muni rate captures some of the spirit of the FASB rules for corporate pension discounting. The FASB rules let corporations discount pension obligations at high-grade corporate bond rates. Discounting state pension obligations at state bond rates bears some similarity in that the creditworthiness of the asset class (municipal or corporate bonds) plays a role. However, the FASB rules do not specify that firms use company-specific bond rates, whereas our measure for public plans is based on state-specific discount rates.[22]

The taxable muni rate is appropriate if the state is equally likely to default on its pension obligations as it is to default on its other debt. State constitutions, however, often build in protections for government-sponsored pensions. Brown and Wilcox (2009) document that in the majority of the 50 U.S. states, public pension obligations are specially protected by state constitutions in ways that make membership in a pension plan an "enforceable contractual relationship."[23] These provisions seem to give special protection to accumulated pension benefits, above and beyond protections that municipal creditors have. Finally, they document that in local fiscal crises such as those of Orange County in the mid-1990s and New York City in the mid-1970s, DB pensions are usually preserved.

The Brown-Wilcox analysis suggests that the default probability of state public pension liabilities is generally lower than that of state GO debt, and that their priority (recovery rate in default) is higher. This seems especially true for the already-promised benefits represented by the ABO.

If state pension promises were truly default-free, meaning that pensioners would get the expected benefit in all states of the world, and taxpayers were the ultimate underwriters of this default-free promise, then from the perspective of taxpayers it would be correct to discount the cash flows at a default-free rate. Alternatively, discounting with a default-free rate would be a correct procedure for measuring the liability from the perspective of the beneficiaries if their ABO liabilities are indeed protected (either by state constitutions or by a federal bailout) in all states of the world.

Our second discount rate candidate is therefore a zero-coupon Treasury rate with the same term as the cash flow in question. The dark line in Figure 4 shows the Treasury yield curve as of June 30, 2009, which we calculate by stripping the par yield curve using the same procedure employed for the municipal curve.

There are a number of caveats to using Treasury yields in discounting a default-free pension promise. The zero-coupon Treasury yield may be thought of as consisting of four components: a riskless real interest rate, a market-expected rate of inflation, an inflation risk premium (Fisher (1975), Barro (1976), Benninga and Protopapadakis (1985)), and a liquidity premium (Woodford (1990), Duffie and Singleton (1997), Longstaff (2004), Krishnamurthy and Vissing-Jorgensen (2008)). Due to the inflation risk premium and liquidity premium, holders of long-dated Treasury bonds hold a default-free asset, but one that contains some other priced risks.

Treasury investors are exposed to inflation risk because realized inflation determines the real value of a bond's payoffs. If inflation is correlated with pricing factors then this inflation risk will raise nominal Treasury yields. Buraschi and Jiltsov (2005) estimate an average 10-year inflation risk premium in Treasury bonds of 70bp over the period 1965 to 2005, ranging from 20bp to 140bp over the business cycle. If pension beneficiaries enjoy COLAs that fully remove inflation risk, one would want to adjust nominal Treasury yields downward for the full amount of this inflation risk premium. Therefore, to the extent that COLAs provide beneficiaries with a partial hedge against inflation risk, nominal Treasury bond yields may be too high.

Treasury bond investors also may receive lower nominal yields because of the liquidity price premium that Treasury bonds enjoy. The liquidity price premium is small and positive on average, but displays a great deal of variation over time. Longstaff (2004) estimates a 10bp to 15bp liquidity spread on average of Treasuries over U.S. non-Treasury debt with the same explicit government guarantees. Krishnamurthy and Vissing-Jorgensen (2008) estimate that superior trading liquidity accounts on average for 50bp of the spread between Treasuries and AAA corporate bonds. Therefore, if there were no COLAs, it would be clear that one would want to adjust nominal Treasury yields upward for the purpose of calculating a default-free pension liability.

We proceed using the Treasury yield curve to discount liabilities as an approximation to using a hypothetical default-free rate that does not contain priced inflation and liquidity risks. While the inflation and liquidity risk premiums typically go in opposite directions, we of course do not assert that they cancel each other out, which they would have to do for the Treasury curve to provide an exactly correct set of discount rates for default-free public pension obligations. Due to these risks priced into the Treasury curve, even default-free public pension obligations are not equivalent to Treasuries.

An additional factor that complicates the relation between Treasury rates and the ideal default-free yield curve is the fact that Treasuries are exempt from state and local taxes in all states. Public pension benefits, on the other hand, are fully taxed at the state level in about 25% of plans, for example, the California plans (see Lehrer and Stanek (2010)). For these plans the appropriate risk-free discount rate should ideally be slightly higher by a tax adjustment equal to the state income tax rate of the marginal investor. For around 37% of state plans, pension benefits are partly taxed at the state level, so a partial adjustment would be required. For around 37% of state plans (for example, the Illinois and New York plans), no adjustment is required as these plans are also exempt from state and local taxation.

Table III presents our main estimates of aggregate state pension fund liabilities under taxable muni and Treasury discounting, respectively. The key results are that total liabilities are $3.20 trillion and $4.43 trillion under the two measures.

[Table III about here]

Looking first at the taxable muni measure, the re-discounting from the flat 8% state-chosen rates affects short-duration cash flows much more than long-duration cash flows, because the long end of the taxable muni yield curve is itself close to 8%. As a result the liability owed to annuitants increases by 18% ($1.40 trillion to $1.66 trillion). Even though the active component has the longest duration, the ABO for active workers only rises by 13% (from $1.09 trillion to $1.23 trillion), because most of the cash flows are long-dated, at points on the yield curve where taxable muni yields are close to 8%. Under this measure, the active component remains at 39% of the total liability.

In contrast, moving from the state-chosen discount rate of 8% to the Treasury yield curve affects active workers' liabilities much more than those of annuitants. The discount rate for the short end of the curve is still decreasing by more than the discount rate for the long end of the curve, but the effect of the longer active-worker duration dominates. The annuitants' liability is $2.28 trillion (44% higher than under the state-chosen rates), and the active workers' liability is $1.94 trillion (78% higher).

It is interesting to note that liabilities net of the $1.94 trillion in total assets are $1.26 trillion and $2.49 trillion, respectively, under the taxable muni and Treasury discounting measures. For comparison, total state non-pension debt was $1.00 trillion and total state tax revenues were $0.78 trillion in 2008.[24] However, just as the funding of the liabilities is irrelevant to their value, the value of liabilities does not determine whether they are adequately funded.

Liabilities calculated using discount rates that are marked to market will vary with market conditions. As mentioned above, one caveat to this entire analysis is that 2009 may be an unusual time for bond markets. Indeed, the highest rated municipal bonds were trading at a higher yield than Treasuries despite the tax deductibility of interest on municipal debt. To the extent that the change in the muni spread represents a temporary aversion by investors to all but the safest and most liquid debt securities, one might view the muni rates as "abnormally" high and the Treasury rates as "abnormally" low due to a large liquidity premium. In that case, under more "normal" market conditions, our Treasury measure should be smaller but our taxable muni measure should be larger. To the extent that the increase in muni yields relative to Treasury yields reflects increased state default probabilities, today's marked-to-market liability measures reflect market expectations.

The Internet Appendix shows ABO, EAN, and PVB liabilities using yield curves from each day of 2009. As of the time this paper went to press, Treasury yields were slightly lower than they were in June 2009.

For readers interested in seeing the present value of liabilities state-by-state, Table IV lists liabilities under each measure, as well as pension assets, debt, revenue, credit rating, and GDP at the state level.

[Table IV about here]

V. Duration of Pension Liabilities

The analysis performed in the previous section also yields, as a byproduct, the sensitivity of the states' liabilities to the rate employed to discount them. The liabilities we calculated in the previous section are higher than the liabilities states reported in their CAFRs. This is because the discount rates we employ, which more accurately reflect the risks of the plans' future obligations from a taxpayer perspective, are lower than those employed by the states. While we are primarily interested in the magnitudes of the states' liabilities, the methodology we develop to value these liabilities can also be used to calculate their duration, and analyzing the duration of the liabilities provides additional intuition as to why the liabilities we calculate differ so dramatically from the states' reported liabilities.

Figure 5 depicts the duration, as a function of the discount rate, of the states' aggregate ABO liability, as well as the durations of the liabilities posed individually by the active, retired, and separated workers.[25] The liabilities represented by active and separated workers are quite sensitive to the discount rates employed. These plan participants are relatively young, and consequently expect to receive benefit payments far into the future. Conversely, the liability represented by retired workers is relatively insensitive to the discount rate employed, because the payments they expect to receive are concentrated in the near future. The duration of the aggregate liability is the value-weighted average of the liabilities of employed, retired, and separated workers.

[Figure 5 here]

The fact that the durations decrease with the discount rates — i.e., the downward-sloping duration profiles observed in Figure 5 — simply reflects the convexity of the liabilities. For any given discount rate, the liabilities' duration is a weighted average of the times until the payments come due, where the weights are the fractions the payments represent of the total liability.

Because we are interested in relatively large (non-infinitesimal) changes in the discount rate, and the duration is itself sensitive to the discount rate, there is not a single discount rate at which it is appropriate to measure the duration. We can, however, consider the effective average duration over the relevant range of discount rates. That is, we can calculate a single "duration" that corresponds to the average elasticity of the liabilities with respect to discount rates ($-\Delta \ln L / \Delta r$) over the range of discount rates encompassing the states' stated discount rates and the approximate discount rates we use. Over the range 6% to 8%, the effective average duration is just over 12 years, while over the range 4% to 6% it is just over 14 years. This effective average duration over the range of discount rates we consider, roughly 13 years, is somewhat smaller than the durations typically assumed for public pension liabilities (Barclays Global Investors (2004), Waring (2004a, 2004b)).

VI. State Pension Liabilities Under Broader Measures

Since our model of pension payments delivers a payment stream under each liability measure, we can calculate the present value of benefits under all four of the actuarial methods, ABO, PBO, EAN, and PVB. The first two columns of Table V show the payment streams under all of these measures discounted under our two main yield curves: the taxable muni yield curve and the Treasury yield curve. Recall that the liabilities of the annuitants and separated employees not receiving benefits are not sensitive to the actuarial method.

[Table 5 about here]

The first two columns of the first row repeat our headline numbers from Table III. These are total liabilities under the taxable muni and Treasury discount rates: \$3.20 trillion and \$4.43 trillion, respectively. The second row shows that the PBO calculated using the same discount rates is 10% higher under the taxable muni measure than the ABO, and 15% higher under the Treasury measure. The third row shows the EAN liability. The EAN liability is 13% higher than the ABO under the taxable muni measure and 19% higher under the Treasury measure. Note that in dollar terms, the increase in the active participant liability is the same as the increase in the total liability, as the accrual methodology only differs on this component. Given our cash flow estimates, these increases represent upper bounds on the extent of the differences between the broader liability measures and the ABO, since the part of the broader measures above and beyond the ABO is more easily defaultable than the ABO and should be discounted at a higher rate than the ABO.

The fourth row shows the PVB. Moving from the ABO to the PVB under taxable muni discounting increases active and total worker liabilities by \$1.0 trillion, which is 84% of active ABO liabilities and 32% of total ABO liabilities. Since most states have at least some freedom to change future benefit accruals for currently employed workers, the discount rates we employ in these first two columns probably overstate the PVB. However, Brown and Wilcox (2009) show that eight state constitutions, including those of major pension sponsors Illinois and New York, specify that pensions may not be "diminished or impaired," a clause that presumably protects far more than the ABO by limiting the extent to which ongoing pension accruals can be slowed or stopped. In any case, this exercise does give a sense of the maximum amount that moving from the ABO to the PVB could increase the measure under taxable muni discounting.

As discussed previously, discounting the PBO at the taxable muni rate bears some resemblance to what FASB requires of firms. This calculation yields a value of \$3.53 trillion. Under FASB rules, firms must use a high-grade corporate bond rate to discount and recognize the PBO. The corporate bond rate reflects the risk that highly rated corporations will default on their debt. The taxable muni rate reflects the risk that a given state will default.[26]

What if the evolution of pension liabilities is correlated with the market over long horizons? For retired and separated workers, as well as for the entire ABO, this correlation is not relevant. However, it is relevant for broader accrual measures. A correlation between real wages and the market can generate positive covariance between pension liabilities and the market through variation in salary growth, a point made by Black (1989) and others.

This issue has been analyzed in a general context with closed-form solutions by Sundaresan and Zapatero (1997). Benzoni, Dufresne, and Goldstein (2007) argue that while the correlation between earnings growth and stock returns is negligible on a short horizon, the correlation is higher on a longer horizon. Lucas and Zeldes (2006) discuss these effects in the context of corporate pension plans with a model in which the value of human capital and the value of the stock market have positive covariance. In data simulated from their model of corporate outcomes, the one-year correlation between earnings growth and stock returns is zero, the three-year correlation is 0.11, and the five-year correlation is 0.22.

The extent to which the correlation between earnings growth and stock returns affects the discount rate depends on the volatility of wage growth and market returns, as well as their correlation. The loading of liabilities on the market is $\beta_L = \sigma_{L,M}/\sigma_M^2 = \rho_{L,M}\sigma_L\sigma_M/\sigma_M^2$, where σ_L is the volatility (annualized standard deviation) of liabilities, σ_M is the volatility of the market portfolio, $\sigma_{L,M}$ is the covariance between the two, and $\rho_{L,M}$ is the correlation coefficient between the two. The discount rate would have to be adjusted upwards by β times the market risk premium. The volatility of liabilities (σ_L) relevant for this equation is the volatility of accrued pension liabilities as the future unfolds.

To the extent possible, we investigate the short- and long-horizon covariance between the market and public pension liabilities. First, we examine the annual standard deviation of the actuarial liabilities for some samples of state pension funds for which we have a balanced panel of data over a medium horizon. We consider one sample of 62 plans for which we have data for 11 years (1997 to 2007) and another of 27 plans for which we have data for 15 years (1993 to 2007). The average standard deviation of annual liability growth in these samples is 4.0% and 4.7%, respectively, while the standard deviation of total liability growth is 1.6% and 1.4%, respectively.[27] Most of these liabilities are on an EAN basis.

Second, we make use of government salary data over a 57-year horizon and consider the fact that late-career salaries enter the benefit formula. We use the Current Population Survey (CPS) of the U.S. Census for salary data from 1962 to 2008. The Internet Appendix shows the raw data. We use these data to calculate the annual growth in full-time government employee average wages during the period 1963 to 2008. We deflate wage growth by the CPI from the Bureau of Labor Statistics (BLS) website. Figure 6 shows the experience of government salaries versus market returns over the entire sample period. Government worker wages appear to grow in a relatively steady fashion and slightly faster than inflation, while the market is substantially more volatile and has a higher average return.[28]

[Figure 6 here]

To estimate an accurate relation between government wage growth and the stock market requires more years of data than are available. It does seem, however, that the covariance of government worker wages with the stock market should be smaller than the covariance of corporate worker wages with the stock market. States have rights to tax, and government employment terms are less driven by market forces than corporate terms of employment.

In order to be conservative in discounting the broader liability measures, one might consider assuming that liabilities for active workers have a volatility of 0.05 (based on the EAN balanced panel discussed above) and a correlation with the stock market of 0.25 (the five-year horizon number from Lucas and Zeldes (2006)). Assuming a 6.5% risk premium, this would raise the implied discount rate by 6.5%*0.05*0.25/0.16 = 51bp.[29] Our evidence suggests that liabilities are neither this volatile nor this correlated with the market, and a number of studies suggest the risk premium is lower than 6.5% (Graham and Harvey (2005), Fama and French (2002)). However, we pick this set of assumptions to be conservative in measuring EAN liabilities. If we set the risk premium to 3.5% to 4.5%, the discount rate would only rise by 31bp under this correction.[30]

The final two columns of Table V show the effects of adding the 51bp wage risk in cases where such an addition may be applicable. The third column presents measures assuming that salary risk raises the appropriate discount rate by 51bp above the taxable muni rate. However, this salary risk only affects the PBO, EAN, and PVB measures, and of course only affects active participants. The figures for annuitants and separated workers are therefore identical to those in the first column, as is the entire ABO.

Adding wage risk in this fashion has a moderately small effect on the results. The PBO and EAN for active workers decline by 7% to 10% depending on the measure. The percentage impact of wage risk on *total* liabilities is a downward effect of 3% to 5% for the PBO/EAN, around 5% for the PVB under taxable muni discounting, and around 7% under Treasury discounting. The effect is substantially muted by the fact that active liabilities only comprise about one-half of the total. Hence, wage risk in this context appears not to be quantitatively important unless the correlation between the stock market and government wages is substantially higher than 0.25, liabilities are much more volatile over the long run, or the market risk premium is substantially higher than 6.5%.

It is interesting to note, however, that discounting the active-worker component of the PBO at a taxable muni rate with wage risk brings the total PBO to \$3.41 trillion. This PBO measure is only 7% higher than the ABO at a taxable muni rate that does not reflect wage risk (\$3.20 trillion). This is because the salary risk offsets some of the increase in the active-worker liability when one moves to the broader measure, and because the active-worker liability is only one component of the total liability. Similarly, the PBO discounted at the Treasury rate plus wage risk is \$4.86 trillion, only about 10% larger than the \$4.43 trillion ABO discounted at the risk-free rate. Thus, moving from the ABO without wage risk to the PBO with wage risk has a relatively small effect.

VII. Conclusion

In this paper we measure state pension liabilities under a variety of different accrual methods and discount rates. Our main estimates focus on two primary measures of already-promised pension benefits. The first measure uses a discount rate based on municipal bond yields, corrected for the tax preference enjoyed by municipal bond coupons. The second measure uses a Treasury yield curve.

We find that the pension promises already made to state workers are worth at least \$3.20 trillion as far as taxpayers are concerned, under the assumption that the state can default on these promises to the same extent that it can default on its general obligation debt. This is a conservative estimate because most state constitutions suggest that pension promises are higher in priority than general obligation debt. Also, while a federal bailout of states might affect the distribution of the tax burden across taxpayers in different states, taxpayers would ultimately bear the cost of the bailout. So a federal bailout would not reduce this measure from a national taxpayer perspective. Under the Treasury discounting measure, which does not credit states for the ability to default but has the drawback of including risks priced in Treasuries that may not be relevant for public pensions, state pension promises are worth a substantially larger \$4.43 trillion.

These numbers are clearly higher than those reported by the states themselves in their annual reports. The first-order difference between our calculations and the states' calculations is the discount rate. The discount rate used by most states is around 8% at all horizons. Especially for near-term cash flows, this discount rate is far too high. At long horizons it would only be appropriate if one wanted to give states substantial credit for their ability to default on these promises. This does not seem an appropriate basis for financial reporting of public financial liabilities if the goal is to inform taxpayers.

In our main measures we include only ABO liabilities, which are narrowly defined and delay recognition of a large share of liabilities until later in the employee's life. The covariance between government salaries and pricing factors is also irrelevant for the ABO. The broader PBO and EAN measures are somewhat larger. The EAN for active workers is about $0.4 trillion larger than the ABO for active workers using taxable muni rates and $1.0 trillion using Treasury rates.

These relatively small potential differences between the ABO and the broader measures are further mitigated by two factors. First, governments are much more likely to default on payments above and beyond the ABO than they are to default on the ABO itself. The cash flows above and beyond those associated with the ABO should therefore be discounted at a higher rate to reflect that greater default risk. Second, the cash flows that are not recognized in the ABO vary with wage growth, which may be correlated with priced risk factors. Our coarse method of capturing salary risk reduces the difference between the EAN and the ABO to $0.3 trillion to $0.8 trillion.[31]

For comparison to our liability measures, we note that assets in state pension funds were worth approximately $1.94 trillion as of June 2009. Also for comparison, total state non-pension debt was $1.00 trillion and total state tax revenues were $0.78 trillion in 2008. However, just as the funding of the liabilities is irrelevant to their value, the value of liabilities does not determine whether they are funded in an adequate manner.

This raises several important questions for future research. First, what level of assets should be seen as adequate to fully fund the liabilities we measure? To answer this question requires specifying an objective function for the state and its pension managers. Second, how should dedicated pension assets be invested? If households form their own financial portfolios taking government pension policy into account, then how the government invests pension assets does not matter. However, if some households fail to fully undo the government's investment strategy, then investing in risky assets raises both the mean and variance of future generations' after tax-wealth, with indeterminate consequences for taxpayer welfare. A large literature argues that investing public assets in risky securities may allow future generations to benefit from improved intergenerational risk sharing. But if future taxation to meet pension promises has nonlinear distortionary costs, then investing public pensions in risky assets with high expected returns and high volatility may impose a large expected cost of distortionary taxation on future generations, as shown by Lucas and Zeldes (2009). The consideration of this burden in the context of overlapping generations is an important area for future research.

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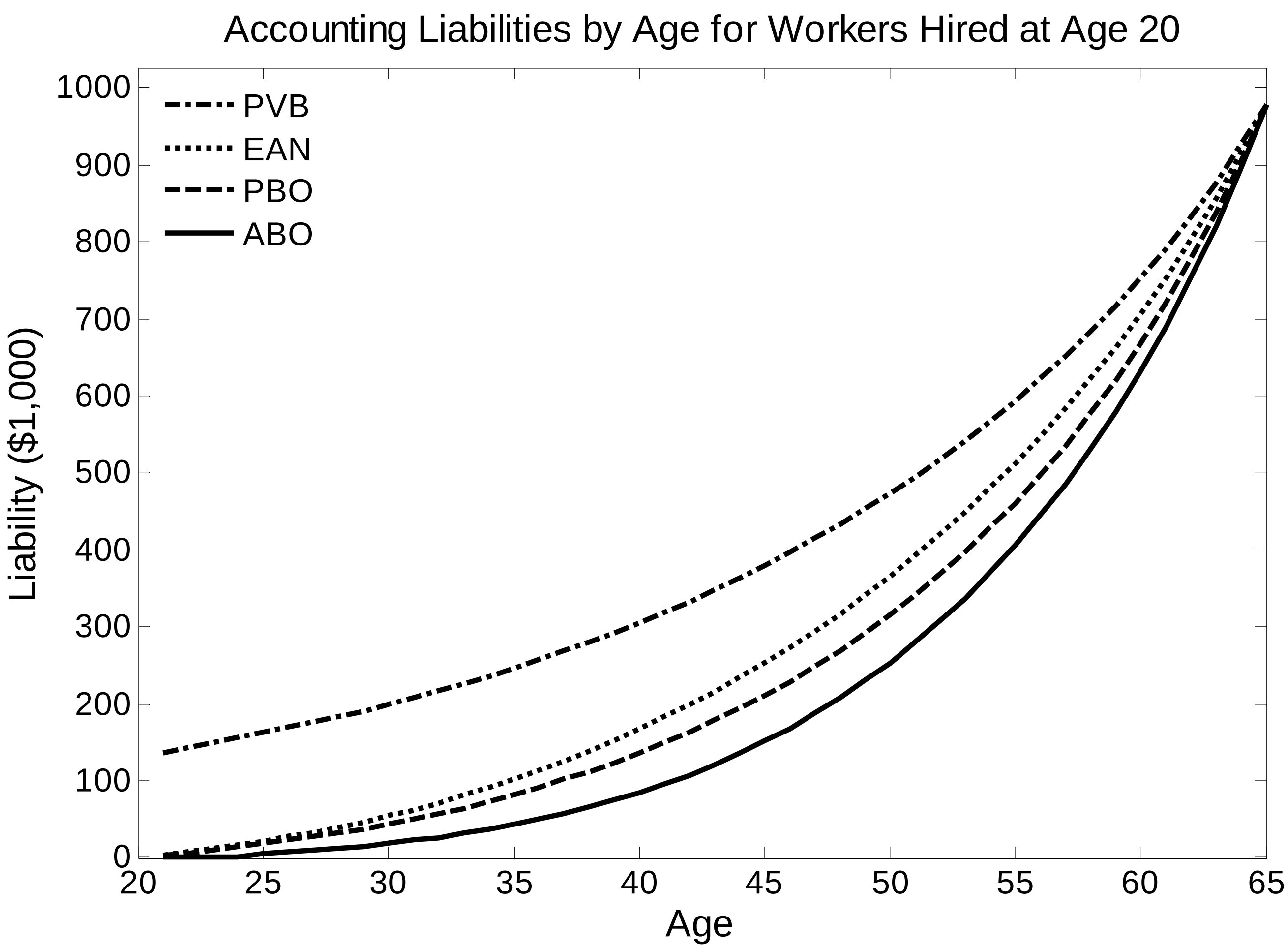


Figure 1. Illustration of liabilities under different accrual concepts. Liabilities by age are shown for hypothetical workers hired at age 20 and retiring at age 65. Four different accounting methods are illustrated: Accumulated Benefit Obligation (ABO), Projected Benefit Obligation (PBO), Entry Age Normal (EAN), and Projected Value of Benefits (PVB). The figure relies on assumptions about wage growth by age, as well as the age-service distribution of workers, based on CAFRs from the 10 states with the largest pension liabilities (see the Internet Appendix for details). It assumes that a 65-year-old worker with 45 years of service would earn $100,000. It also uses a 3.5% inflation rate, a 2% benefit formula, a 3% fixed cost of living adjustment (COLA), an 8% discount rate, and death probabilities taken from the RP2000 combined mortality table.

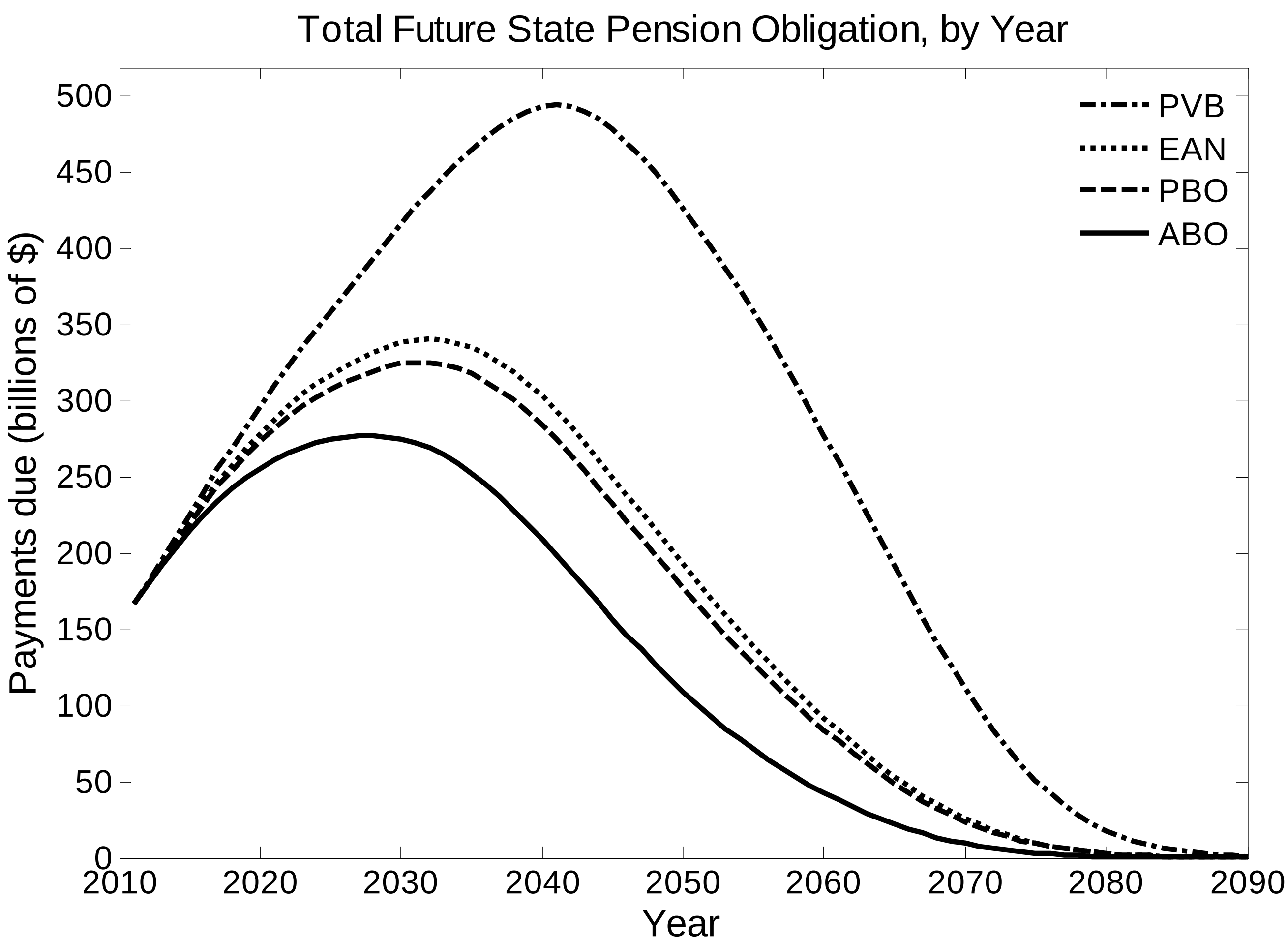
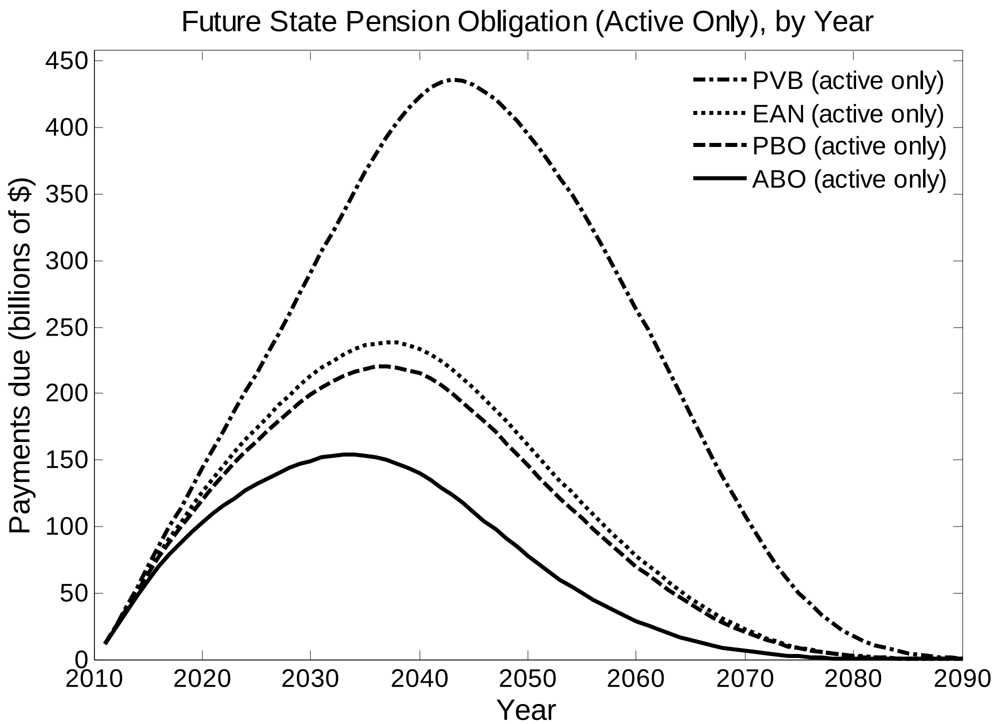


Figure 2. Projected aggregate cash flows for public pension promises. This figure shows projected aggregate cash flows by state governments due to public pension promises, as would be recognized under different accrual methods. Cash flow projections for each state plan are made so that the state plan's reported liability equals the discounted value of these cash flows under the state's chosen accrual method and reported discount rate. The distribution of cash flows over years relies on assumptions about wage growth by age, as well as the age-service distribution of workers, based on CAFRs from the 10 states with the largest pension liabilities (see the Internet Appendix). Benefit formulas, cost of living adjustments (COLAs), and inflation assumptions are derived on a plan-by-plan basis from the CAFRs and the Center for Retirement Research (2006).



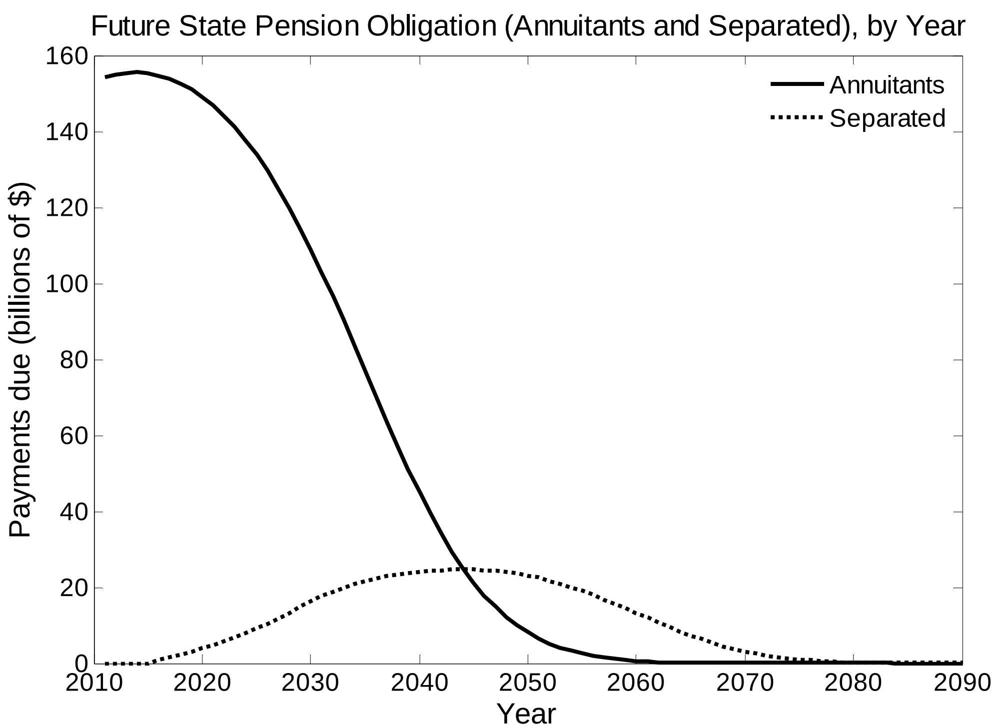


Figure 3. Projected aggregate cash flows for active, annuitants, and separated participants. This figure decomposes the projected aggregate cash flows shown in Figure 2 into cash flows to currently active workers, current annuitants, and people who are no longer working for the state but who are not yet retired. Cash flow projections for each state plan are made so that the state plan's reported liability equals the discounted value of these cash flows under the state's chosen accrual method and reported discount rate.

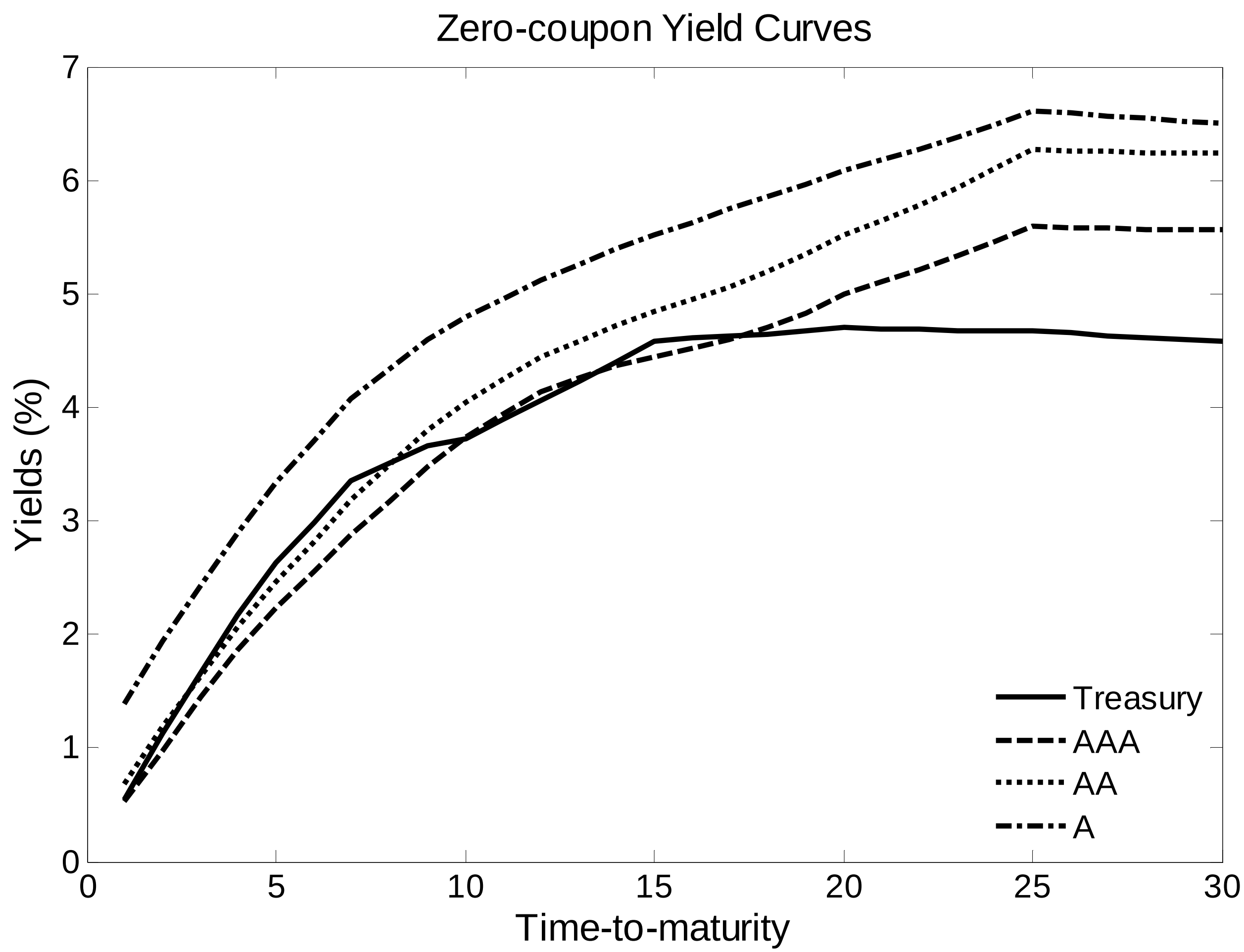


Figure 4. Zero-coupon yield curves for Treasuries and municipal bonds. This graph shows zero-coupon yield curves for Treasuries, as well as municipal bonds of various ratings, as of June 30, 2009. Yields on coupon bonds are collected from Bloomberg for AAA, AA+, AA-, A+, and A- rated state municipal bonds. The zero-coupon yields are calculated from strip prices, which we obtain by constructing long-short portfolios of the coupon bonds. We interpolate between AA+ and AA- to obtain an AA curve, and between A+ and A- to obtain an A curve. In discounting liabilities at the taxable municipal rate, the yield curves shown in this figure are grossed up by 25% to reflect the tax deductibility of municipal bond interest payments. Where available, state-specific (as opposed to rating-specific) curves are employed.

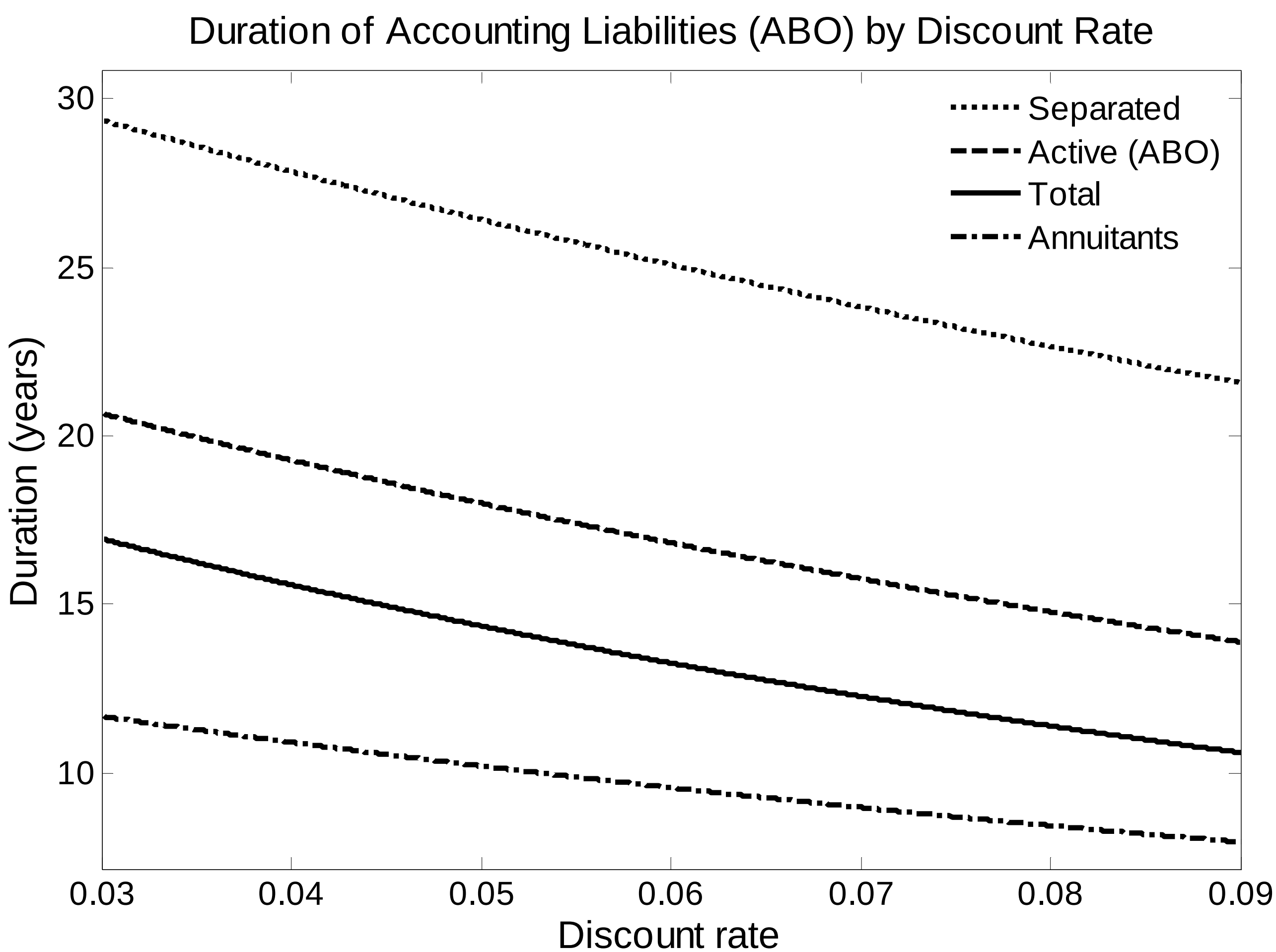


Figure 5. Implied durations of public pension liabilities. This figure shows the duration of the states' aggregate ABO liability (solid line), as a function of the employed discount rate. It also shows the durations of the individual components of the aggregate liability, that is, the duration of the liabilities posed individually by the active, separated, and retired workers (dashed, dotted, and dash-dotted lines, respectively).

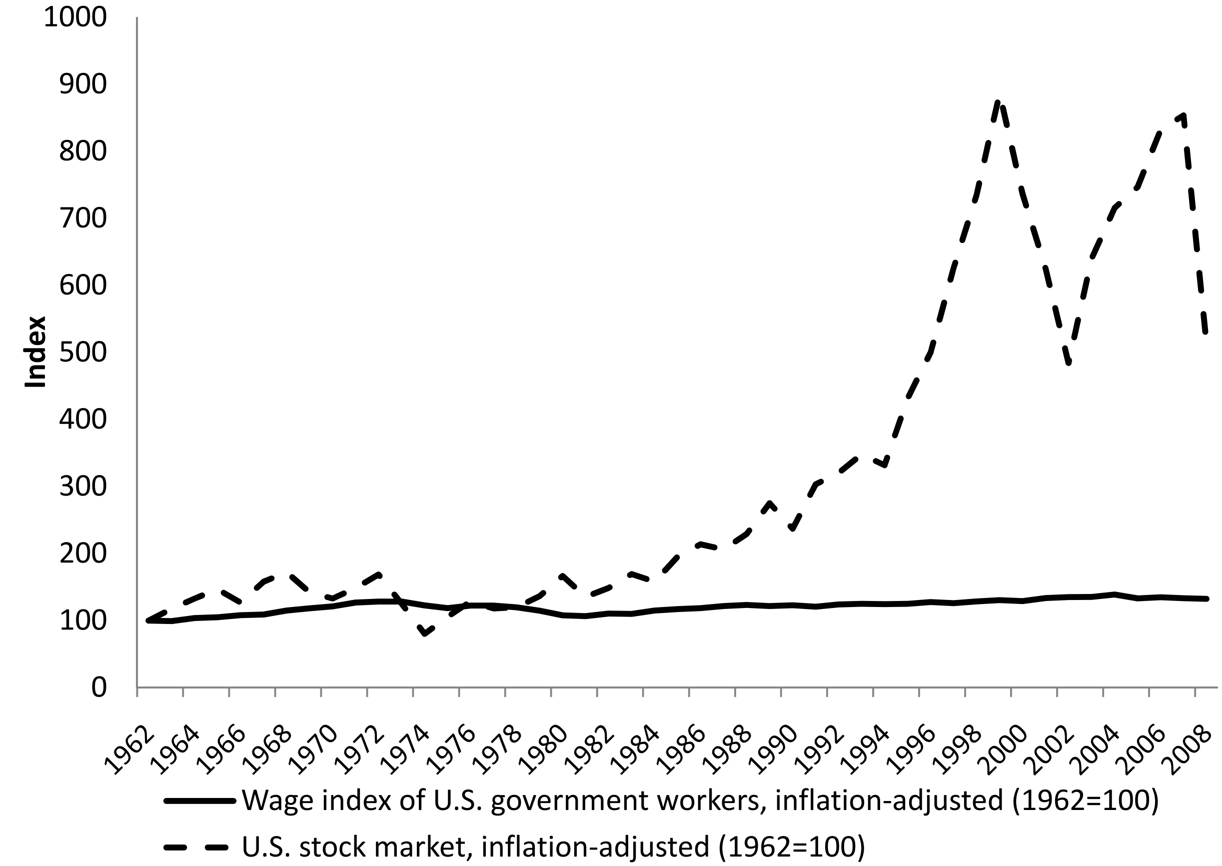


Figure 6. Government salary growth and market returns. This figure shows returns on a wage index of government workers and returns on the market portfolio. The wage index comes from the Current Population Survey (CPS) of the U.S. Census for all government workers between 1962 and 2006. The wage index is deflated by CPI growth, as reported on the BLS website. The return on the U.S. stock market is adjusted by the risk-free rate, and is extracted from the data made available by Kenneth R. French.

Table I
Summary of Plan Characteristics

This table shows plan characteristics as collected for as many of our 116 sample plans as possible. The data come from the CAFRs and from Center for Retirement Research (2006). Where data are unavailable, we ultimately fill these items in with sample means, but the table shows the data before that step. For 28 plans, benefit factors are given as a range, for which we pick the midpoint. For cost of living adjustments (COLAs), the summary statistics shown are an estimate of those built into the states' own nominal cash flow projections. The easiest case is if the COLA is fixed, in which case we use the fixed number given. If the COLAs is a CPI with a cap or partial CPI, the given formula is applied to the state's inflation assumption. If the COLA is ad hoc, excess earning, or other, we assume the projected COLA equals the state's inflation assumption.

	Discount Rate		Benefit Factor		Cost of Living Adjustment (COLA)		Inflation		Active Share		Retired Share	
Mean	7.97%		1.97%		3.13%		3.54%		55.4%		35.7%	
Median	8.00%		2.00%		3.00%		3.50%		58.5%		32.5%	
Mode	8.00%		2.00%		3.00%		3.00%		-		-	
Std Dev	0.31%		0.36%		0.77%		5.71%		15.5%		16.3%	
Count	116		94		94		91		116		116	
Detail	7.00%	1	<2.00%	40	Fixed	19	<3.00%	2	10^{th}	36.4%	10^{th}	22.1%
	7.25%	3	2.00%	20	CPI w Cap	26	3.00%	29	25^{th}	52.0%	25^{th}	27.0%
	7.50%	14	>2.00%	34	Ad hoc	20	3.25%	5	75^{th}	63.5%	75^{th}	40.0%
	7.75%	13		94	Excess Earning	5	3.50%	24	90^{th}	77.0%	90^{th}	69.0%
	7.80%	1			Partial CPI	11	3.75%	7				
	8.00%	54			Other	13	4.00%	12				
	8.25%	17				94	4.50%	5				
	8.50%	13					5.00%	5				
		116					Other	2				
								91				

Table II
State Pension Liabilities Under Stated Discount Rates and Various Actuarial Methods

The table shows aggregate U.S. state public pension liabilities adjusted to different actuarial methods using the state-chosen discount rate (on average 8%). The starting point is the $3.14 trillion of liabilities, which is the sum of liabilities as reported in the latest financial reports of the 116 plans projected as necessary to June 2009. As the reports use a mix of actuarial methods, the next four rows adjust the liabilities based on different measures of accrued liabilities for active workers. These adjustments only affect active participants, as shown in the remaining rows of numbers. As described in the text, the adjustments are done by modeling the implied stream of payments that is consistent with each plan's stated liabilities, plan characteristics, and a set of actuarial assumptions based on representative plans. Table figures are reported in trillions of U.S. dollars.

	Liability
Total (active + annuitants + separated)	
As stated, unharmonized	$3.14
ABO	$2.76
PBO	$3.07
EAN	$3.15
PVB	$3.75
Active participants only	
ABO	$1.09
PBO	$1.40
EAN	$1.48
PVB	$2.08
Annuitants only	$1.58
Separated not yet receiving benefits only	$0.09

Table III
Summary of Aggregate State Public Pension Liabilities

This table presents the two measures of state public pension liabilities, as well as the rates and assumptions used to calculate them. In Panel A, benefits are assumed to have equal priority to state GO bonds. They are discounted at municipal bond rates excluding the tax preference, based on the zero-coupon municipal yield curves as of June 30, 2009. Actual state-specific yield curves are used for the 20 states where they are available; in the remaining 30 states we use the yield curve for the state's credit rating. In Panel B, Treasury rates are used as an approximation for an appropriate default-free rate, even though Treasury yields likely contain priced inflation and liquidity risks. Under the Treasury discounting procedure, liabilities are discounted using the zero-coupon Treasury yield curve as of June 30, 2009. These yield curves are shown in Figure 3. In both panels, active worker liabilities are calculated using the ABO accrual methodology.

Panel A: Taxable Muni Curve Discounting

Risk assumption: Equal priority to GO bonds

Discount rate: $\frac{r_{muni(j)}}{1-\tau_B}$, the state-specific municipal bond rate excluding the tax preference

	Amount	
Annuitants	$1.87	trillion
Separated not yet receiving benefits	$0.10	trillion
Actives (ABO)	$1.23	trillion
Total ABO Liabilities	$3.20	trillion

Panel B: Treasury Yield Curve Discounting

Risk assumption: Default-free

Discount rate: r_f, the Treasury rate

	Amount	
Annuitants	$2.28	trillion
Separated not yet receiving benefits	$0.20	trillion
Actives (ABO)	$1.94	trillion
Total ABO Liabilities	$4.43	trillion

Table IV
State Pension Data for June 2009 ($ billions)

State Name (Number of Plans)	Liabilities, Stated	ABO, Taxable Muni Rate	ABO, Treasury Rate	Pension Assets	State Debt (2008)	Tax Revenues (2008)	GDP (2008)	S&P GO Rating
Alabama (3)	42.0	45.2	61.8	21.4	8.5	9.1	170.0	AA
Alaska (2)	15.3	16.2	21.7	12.4	6.5	8.4	47.9	AA+
Arizona (3)	43.6	50.1	73.5	24.8	10.5	13.7	248.9	NR
Arkansas (3)	21.5	21.9	30.4	14.6	4.3	7.5	98.3	AA
California (3)	518.1	425.9	699.7	329.6	121.9	117.4	1846.8	A
Colorado (1)	57.3	62.0	86.2	28.8	15.9	9.6	248.6	NR
Connecticut (3)	45.3	53.7	69.1	20.1	27.6	13.4	216.2	AA
Delaware (1)	7.6	8.8	10.9	5.8	5.7	2.9	61.8	AAA
Florida (1)	136.4	136.8	186.3	96.5	42.3	35.8	744.1	AAA
Georgia (2)	75.8	84.3	110.1	53.1	13.1	18.2	397.8	AAA
Hawaii (1)	17.5	17.8	24.2	8.1	6.0	5.1	63.8	AA
Idaho (1)	11.7	11.7	16.6	8.7	3.4	3.7	52.7	NR
Illinois (4)	151.0	160.7	233.0	65.7	58.4	31.9	633.7	AA-
Indiana (2)	37.3	36.4	49.8	19.6	19.9	14.9	254.9	NR
Iowa (1)	26.0	25.4	35.0	18.0	7.2	6.9	135.7	NR
Kansas (1)	21.3	22.3	30.3	10.2	5.8	7.2	122.7	NR
Kentucky (3)	45.2	47.9	63.4	21.1	12.2	10.1	156.4	NR
Louisiana (2)	36.8	40.4	54.8	18.4	16.4	11.0	222.2	A+
Maine (1)	14.4	14.5	20.1	8.3	5.3	3.7	49.7	AA
Maryland (1)	52.7	55.5	72.1	28.6	23.1	15.7	273.3	AAA
Massachusetts (2)	59.7	67.4	86.9	32.7	71.9	21.9	365.0	AA
Michigan (4)	73.2	75.4	103.1	39.5	29.1	24.8	382.5	AA-
Minnesota (4)	60.6	69.7	91.0	35.9	9.5	18.3	262.8	AAA
Mississippi (3)	31.4	32.5	44.2	15.5	6.3	6.8	91.8	AA
Missouri (3)	53.5	58.7	75.2	33.1	19.7	11.0	237.8	AAA
Montana (2)	9.1	9.1	12.4	5.3	4.9	2.5	35.9	AA
Nebraska (2)	8.4	8.2	11.6	5.5	2.7	4.2	83.3	NR
Nevada (1)	25.4	25.9	36.3	18.8	4.2	6.1	131.2	AA+
New Hampshire	8.5	9.2	12.5	4.3	7.9	2.3	60.0	AA
New Jersey (4)	132.8	147.0	191.2	67.2	52.8	30.6	474.9	AA
New Mexico (2)	28.8	29.1	39.8	15.9	7.8	5.6	79.9	AA+
New York (3)	239.8	247.2	325.7	192.8	114.2	65.4	1144.5	AA
North Carolina	74.9	79.8	101.8	64.0	19.6	22.8	400.2	AAA
North Dakota (2)	4.4	4.5	6.3	2.7	2.0	2.3	31.2	NR
Ohio (5)	197.5	208.2	281.4	114.7	26.9	26.4	471.5	AA+
Oklahoma (4)	33.6	33.8	45.9	15.8	9.1	8.5	146.4	AA+
Oregon (1)	57.5	59.9	80.7	42.9	11.6	7.3	161.6	AA
Pennsylvania (2)	110.6	124.2	164.5	64.3	40.7	32.1	553.3	AA
Rhode Island (1)	13.9	14.9	20.5	6.6	8.9	2.8	47.4	AA
South Carolina	42.4	48.6	63.5	20.3	15.2	8.5	156.4	AA+
South Dakota (1)	7.4	7.4	10.3	5.6	3.4	1.3	37.0	NR
Tennessee (1)	36.7	38.6	49.6	26.4	4.4	11.5	252.1	AA+
Texas (4)	191.2	196.3	268.4	126.1	33.3	44.7	1223.5	AA
Utah (3)	22.6	23.6	31.2	14.7	5.9	5.9	109.8	AAA
Vermont (3)	4.0	4.1	5.7	2.4	3.4	2.5	25.4	AA+
Virginia (1)	69.1	69.4	89.6	41.3	21.9	18.4	397.0	AAA
Washington (7)	62.3	63.1	86.4	43.5	23.5	17.9	322.8	AA+
West Virginia (2)	13.7	13.6	18.3	7.2	6.4	4.9	61.7	AA-
Wisconsin (1)	79.7	84.9	114.6	58.4	22.1	15.1	240.4	AA
Wyoming (4)	7.0	7.1	9.8	4.4	1.3	2.2	35.3	NR
TOTAL (116)	3,136.8	3,198.7	4,427.4	1,941.6	1,004.8	780.7	14,068.3	

Table V

State Public Pension Liabilities Under Various Discount Rates and Accrual Methods

The table shows aggregate U.S. state public pension liabilities adjusted to different discount rates and accrual methods. The first column discounts the pension payments at taxable muni rates, based on taxable municipal zero-coupon yield curves as of June 30, 2009. The second column discounts the cash flows using the Treasury zero-coupon yield curve as of June 30, 2009. These yield curves are shown in Figure 4. The third column discounts using the taxable muni rate plus a 51bp salary risk premium, and the fourth column discounts using the Treasury rate plus a 51bp salary risk premium. The salary risk premium is only added to the active worker component, and it is also not added to the ABO since the ABO is invariant to future salary growth. As described in the text, the re-discounting is done by modeling the implied stream of payments that is consistent with each state's liabilities and a set of actuarial assumptions based on representative plans. Table figures are in trillions of U.S. dollars.

	$\frac{r_{muni(j)}}{1-\tau_B}$	$r_{Treasury}$	$\frac{r_{muni(j)}}{1-\tau_B}$ + Wage Risk if applicable	$r_{Treasury}$ + Wage Risk if applicable
Total (active + annuitants + separated)				
ABO	$3.20	$4.43	$3.20	$4.43
PBO	$3.53	$5.11	$3.41	$4.86
EAN	$3.62	$5.28	$3.49	$5.01
PVB	$4.24	$6.86	$4.04	$6.36
Active participants				
ABO	$1.23	$1.94	$1.23	$1.94
PBO	$1.56	$2.62	$1.45	$2.37
EAN	$1.65	$2.80	$1.53	$2.52
PVB	$2.27	$4.37	$2.07	$3.87
Annuitants	$1.87	$2.28	$1.87	$2.28
Separated not yet receiving benefits	$0.10	$0.20	$0.10	$0.20

[1] One source of uncertainty that might affect the ABO is inflation. We discuss this effect in Section V.

[2] Furthermore, Bulow (1982) argues that even if labor markets fail to be competitive, there could be other implicit contract liabilities that are larger when the PBO is smaller. If that is the case then the PBO is not a good measure of the employer's total implicit contract liability.

[3] In this paper, we use the term "separated" to refer to separated workers who are vested. We exclude separated workers who are not vested from any membership counts.

[4] According to the U.S. Census of Governments, local plans in aggregate held $0.56 trillion in assets as of June 2007, which is about 20% of what state pension plan assets were at the time. According to *Pensions and Investments,* as of September 2009 the largest of these local plans were New York City ($98 billion in DB assets), Los Angeles County ($33 billion in DB assets), and San Francisco County ($15 billion in assets). If the ratio of assets to liabilities were the same as in state plans, local plan liabilities would be $0.93 trillion under taxable muni discounting and $1.27 trillion under Treasury discounting.

[5] Nebraska offered a cash balance plan, a type of DB plan in which the value of the plan is presented to employees as a cash balance and the trajectory of benefit accrual with respect to tenure is more concave than in a traditional DB plan.

[6] Giertz and Papke (2007) find some evidence that these assumptions are manipulated to reduce pressure on governments to make contributions to pension funds.

[7] The Internet Appendix is available on the Journal of Finance website at http://www.afajof.org/supplements.asp

[8] See also footnote 3 for a further caveat.

[9] Furthermore, if pensions are considered part of a compensation package that consists optimally of current and deferred components, there may be additional contractual reasons for the firm to consider a broadly defined pension liability (Lucas and Zeldes (2006)).

[10] See the Internet Appendix for more details.

[11] The Michigan State Employee Retirement System has not taken any new workers into their DB plan since 1998 due to the establishment of a DC plan for new workers at that time. This plan, however, does not include teachers, other school employees, police, and judges, all of whom are still on a defined benefit plan. Alaska is the only other state whose plans were closed to new members as of 2010.

[12] We do not make any adjustments for the nature of the work performed. Adjusting for the fact that the proportion of state workers engaged in white collar work exceeds the national average would reduce the assumed mortality rates, and thus increase the duration of the liability.

[13] This is probably a conservative assumption. Programs using 6% annual actuarial reduction include the California Teachers' Retirement System (CalSTRS) and the Illinois State Employee Retirement System. The Florida Retirement System uses only 5% reductions for each year below the full retirement age, and the New Jersey Public Employees and Teachers systems use 1% to 3% reductions for each year.

[14] An "actuarially fair" adjustment would involve reducing the employee's annual benefit such that the expected present value of lifetime payments equals the value of the lifetime annuity that makes full payments beginning at age 60.

[15] The total number of active employees and average salaries are tabulated in the Internet Appendix. We harmonize these values to a June 2009 date using a procedure similar to that described in Section I for liabilities.

[16] We estimate the first-year cash flow at 107% of the June 2009 level, based on 7% annual benefit growth in recent years. The first-year cash flow is largely due to the annuitants, so the expected first year cash flow largely determines the average benefit payment to the annuitants. The average salary of the employed workers is then adjusted to make the total liabilities match.

[17] This point has been made in the context of corporate pension plans by Petersen (1996) and Ippolito (2002).

[18] For the purposes of determining mandatory contributions, corporate ABO liabilities must be disclosed in IRS form 5500 and discounted using Treasury yields. See Rauh (2006) and Bergstresser, Desai, and Rauh (2006) for more information. The Pension Protection Act of 2006 changed the corporate rules. It stipulated that the discount rate for the current liability reported on IRS form 5500 may not be more than 5% above and must not be more than 10% below a four-year moving average of 30-year Treasury yields.

[19] The 20 states are California, Connecticut, Florida, Georgia, Illinois, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington, and Wisconsin.

[20] Specifically, from Bloomberg we obtain AAA, AA+, AA-, A+, and A- par yield curves. We calculate the zero-coupon yield curves by constructing long-short portfolios of coupon bonds that generate a single payment at one date in the future. We then interpolate between AA+ and AA- to obtain an AA curve, and between A+ and A- to obtain an A curve. Beyond a 30-year term, we assume a flat yield curve at the 30-year rate.

[21] On June 30, 2009, five-year Treasury bonds traded at a yield 40bp above that of AAA general obligation munis, 10-year Treasury bonds traded at yields 4bp above AAA general obligation munis, and 30-year Treasury bonds traded at yields 50bp below AAA general obligation munis.

[22] There are some other important differences. First, FASB rules require firms to recognize the PBO, whereas we are focusing on the ABO. Second, a firm will owe little beyond the assets in the pension fund if the firm becomes insolvent, since the PBGC will take over the plan and become an unsecured creditor in bankruptcy. States are not insured by the PBGC, and even if the state defaults on its debt, there is a high likelihood that it will have to pay pensions.

[23] In other cases, state statutory and common law offer protections. See also National Conference on Public Employee Retirement Systems (2007).

[24] In a few cases, such as the Illinois Municipal Retirement Fund (IMRF), contributions are funded at the state level, and hence for those plans one would also want to include local debt in this benchmark. But these plans are very much in the minority. Even state-sponsored plans in which the employees are paid at the local level receive employer contributions at the state level from state revenues. Such is the case for example with most public retirement plans for teachers.

[25] For simplicity our duration analysis focuses on parallel shifts to a flat yield curve. This simple analysis is sufficient to generate all the relevant intuition.

[26] A procedure that would mimic the FASB procedure even more closely would be to discount all state PBOs at the AA taxable muni rate.

[27] If there is positive serial correlation in liabilities, then long-horizon volatilities would be larger than these one-year volatilities. If there is negative serial correlation in liabilities, then long-horizon volatilities would be smaller than these one-year volatilities.

[28] We also ran regressions of government wage growth on the stock market at one-, three-, and five- year horizons. We found betas that were slightly negative with standard errors of 0.02, 0.05, and 0.07, respectively. None of these coefficients were statistically significant.

[29] We are implicitly assuming that the salary risk is not correlated with the default risk. If defaults are more likely when wages are low, the correction would be less than 51bp.

[30] To the extent that the PVB is more volatile and correlated with the stock market than the EAN, we would want to use larger salary risk corrections for the PVB.

[31] Naturally the difference between the PVB and the ABO is more substantial holding the discount rate constant. However, the cautions about holding the discount rate constant between the ABO and EAN (due to higher default risk and salary risk) are even more relevant for moving between the ABO and PVB.