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

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**Abstract**

We calculate two present value measures of already-promised state pension liabilities using discount rates that reflect their risk. If benefits have the same priority in default as general obligation debt, aggregate underfunding is $1.21 trillion. If states cannot default on these benefits, underfunding is $3.12 trillion. The first measure is a lower bound on the value of the liability to taxpayers, and is more than the $0.94 trillion in state municipal debt. The second measure is a better benchmark for funding adequacy. We also estimate broader concepts of accrued liabilities that account for projected salary growth and future service.

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Government accounting rules currently obscure the true extent of public pension underfunding 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 counter to the entire 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 underfunding in state pension plans 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 numbers and average wages 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.

We begin by focusing only on payments that have already been promised and accrued. In other words, even if all government workers were fired today, or 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. The ABO is not affected by uncertainty about future wages and service, because it is 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 for 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. We make conservative assumptions so that this measure represents a lower bound. In particular, we assume 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 taxpayer obligation measure, public pension underfunding as of the end of 2008 was $1.21 trillion (38.5% of liabilities), substantially larger than the $0.94 trillion of state municipal bond debt that was outstanding according to the latest figures from the U.S. Census of Governments.

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

The $1.21 trillion underfunding is 35% larger than the $0.90 trillion underfunding obtained by summing the unadjusted liabilities from state government reports. The harmonization of the liabilities to the ABO method actually reduces the liability slightly, since most states use a slightly broader measure, but the application of appropriate discount rates raises liabilities substantially. So it is fair to say that at an absolute minimum, the underfunding of state public pension plans is 35% worse than is implied by state government accounting.

This $1.21 trillion lower bound recognizes a significant probability that plan participants, including those already retired and receiving benefits, will not receive promised benefits in the future. Indeed, assuming that pension liabilities are as risky as state GO debt ascribes the same default probabilities to both types of state liability. From the perspective of the taxpayer, the calculation credits the state for the notion that it could walk away from pension promises with the same probability and under the same circumstances that it could walk away from its other debt. Moreover, this credit is substantial. The risk-neutral default probability implied by bond prices is currently large, even for highly rated municipal bonds.

Crediting states by reducing liabilities on the grounds that they might default on their debt is problematic for two reasons. First, it might be misleading to use a liability measure arising from this method as a benchmark for pension funding. A state with poor credit quality should not set aside less money to fund its pensions simply because it has a high probability of defaulting on its obligations. So while this first measure is useful from the perspective of taxpayers, it is less useful as a measure of funding adequacy. Furthermore, state constitutions frequently offer protections to benefits that go above and beyond protections to state GO debt (Brown and Wilcox (2009)). The higher priority accorded to public pensions suggests that they should probably be discounted at rates lower than state GO bond yields.

The second main measure we present is a measure of funding adequacy. This is effectively the present value of the payments as promises. The possibility of default does not reduce this measure because in default events someone loses, namely the participants. Under this measure of liabilities, underfunding is $3.12 trillion (61.7% of liabilities) and over three times the magnitude of state debt.

Moreover, these calculations all 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, 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. Since 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 (and hence required funding) until late in the employee's life. Indeed, the newly accrued liability under the ABO rises dramatically as a fraction of the worker's salary as he approaches retirement. It may be desirable to recognize more of the liability early on than the ABO does, especially given that states cannot simply freeze pension accruals and fire employees as easily as companies can.

An extremely broad liability concept is the Projected Benefit Obligation (PBO), which discounts a full projection of what current employees are expected to be owed if their salary grows and they retire and die according to actuarial assumptions. If states truly could not freeze pension accruals, the PBO would be the most relevant liability measure. Most states report actuarial liabilities under yet another measure, 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 somewhere between the ABO and the PBO. It forces states to recognize liabilities in a manner which most closely resembles a defined contribution (DC) plan. The rest of state liabilities, approximately 15%, are calculated using still another method, the Projected Unit Credit (PUC), which we find generally fails to recognize even the entire ABO liability.

In addition to the ABO measures, we also model streams of payments for state pension liabilities under the PBO and the other liability concepts, and we consider their discounted values as well. Broader measures such as the EAN and PBO methods have the additional complication that their evolution depends on the path of future government wages, which may be correlated with stock market returns (the pricing factor) over long horizons. If this is the case, the streams of payments in the EAN and PBO (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 in the data, we see little evidence of this sort of correlation in the data. However, in order to be conservative, we consider the EAN and PBO measures under discount rates that reflect high correlations between government worker salaries and the stock market, in addition to the municipal bond and Treasury rates.

We emphasize that considerations about the accrual method affect only the liability for active workers, whom we calculate are responsible for only around one-third of the total liability. The rest of the liability comes from retired and separated workers. 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 to the yield curve as well as parallel shifts in yield. Our model of the stream of promised pension payments does nonetheless lend new insight into the duration and convexity of state public pension liabilities overall and of their constituent components (active, separated, and retired workers). The effective average duration over the range of discount rates we consider is roughly 15 years, which is similar to the durations 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 posed by active, separated and retired workers.

Our calculations refer to liabilities that have been accrued already under these different measures. They ignore the problem that states may fail to fund future benefits as they accrue. They also ignore other postretirement employee benefits (OPEBs), including state-provided retiree healthcare, which total $380 billion in present value according to recent disclosures. Furthermore, we focus only on state pension plans, not local city and county plans, whose size is about 20% of state plans.[2] Therefore, our calculations certainly understate the extent of the funding crisis.

The crisis in state pension funds is currently much larger than taxpayer exposure to underfunded corporate pension plans, although the latter has received more attention. The Congressional Budget Office estimated in 2005 that the present value of PBGC costs over 15 and 20 year horizons was $119 billion and $141.9 billion (Congressional Budget Office (2005)). Total ABO liabilities of all PBGC-covered DB plans were $1.6 trillion at the latest estimate (in 2003). For all $1.6 trillion to be offloaded to the US government, all DB firms in the economy would have to go bankrupt with zero dollars of aggregate pension assets.[3] Thus, even though corporate funding has surely deteriorated and corporate liabilities have grown since 2003, the PBGC problem is still smaller than the $1.2-$3.1 trillion gap in state pension funds.

We note that some similar issues have arisen in the measurement of Social Security liabilities (Geanakopolos and Zeldes (2007a, 2007b), Geanakopolos, Mitchell, and Zeldes (1999)). Geanakopolos and Zeldes (2007a) 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 assets and liabilities as given and, as a starting point for our analysis, calculates underfunding in US state pension plans on this

[2] 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 2008 the largest of these local plans were New York City ($93 billion in assets), Los Angeles County ($35 billion in assets), and San Francisco County ($14 billion in assets). If local plans were as underfunded as state plans, the "taxpayer obligation" underfunding (on local plans only) would be $0.35 trillion, while the local "funding obligation" underfunding would be $0.90 trillion.

[3] S&P 500 corporations were recently estimated as having an average funding ratio of 66% on a PBO basis (Haugh and Latter (2009)).

reporting basis. Section II outlines the different liability concepts: ABO, PUC, EAN, and PBO 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 funding concepts, but still under state-chosen discount rates. Section IV discusses the duration and convexity of outstanding state pension promises as implied by our calibration. Section V calculates the value of ABO pension liabilities under appropriate discount rates for measuring the taxpayer obligation and funding adequacy. Section VI considers how a broader measure such as EAN would affect these results, including an analysis of the correlation between government wages and the stock market. Section VII concludes.

## I. The Extent of Underfunding 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 US 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 and under 20% are enrolled in a DC plan (Bureau of Labor Statistics (2008)). The GAO in late 2007 reported that only Alaska and Michigan offered new employees in their "primary pension plan" a DC plan but not a DB plan, and 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)).[4] Finally, according to data from the *Pensions and Investment*s (P&I) survey of the 1000 largest pension plans, 32 states reported nonzero defined contribution (DC) assets in a state-sponsored pension plan. However, the total magnitude of DC assets was $83 billion compared to $2.30 trillion in DB assets.

We collected data on the largest DB pension funds sponsored by U.S. state governments. To assemble the list of plans, we began with data from the U.S. Census of Governments, published by the U.S. Census Department. We listed all plans with more than $1 billion of assets, including only those plans sponsored by state governments themselves.

[4] 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.

The Census of Governments does not contain measures of pension liabilities. We therefore examined the most recent Comprehensive Annual Financial Report (CAFR) for each pension plan and collected 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 found to have separate CAFRs, or separate disclosures within a CAFR. Disaggregating as much as possible, we identified 116 individual state plans at the end of 2008.

We collected the total DB plan assets for these plans as stated in the CAFR on both an actuarial and market-value basis. The actuarial basis for assets allows for smoothing of investment returns over a certain number of years according to actuarial rules. To avoid these effects, we use market values in our analysis, which come from the consolidated balance sheets of the plans in the CAFR.

Of the 116 CAFRs, 66 were for the year ended 30 June 2008, 16 were for the year ended 31 December 2007, 22 were for the year ended 30 June 2007, and 12 were as of another date between June 2007 and September 2008. The dates were therefore heterogeneous, in some cases old, and in all cases before the massive market declines of late 2008. We therefore used two distinct methods to project assets forward from these heterogeneous dates through to December 2008. These two methods yield essentially identical results.

First, we collected asset and asset allocation data from the *Pensions and Investments* survey for all state plans. The latest survey, published in January 2009, contained data for 30 September 2008 on all plans. The P&I asset allocation data decomposes assets into 9 categories: Domestic Stock, International Stock, Domestic Fixed Income, International Fixed Income, Cash and Equivalents, Private Equity, Real Estate Equity, Mortgages, and Other. For these categories we obtained return indices for September 2008 through December 2008 from the Kenneth R. French Data Library (the Fama-French factors), Barra MSCI, and Lehman Brothers / Barclays, as shown in Appendix Table I.[5] Using P&I data and these asset class returns, we were able to project plan assets forward to December 2008, arriving at a value of $1.94 trillion.[6]

The P&I data had the advantage of being harmonized to one date. However, they are survey data, whose quality is likely worse than the audited CAFRs. We therefore collected asset allocation data from the CAFRs as well, compiled them into the same 9 categories, and used the category return indices over the applicable dates to project all the assets forward to December 2008. From this exercise we arrived at a

[5] These asset allocation figures in Appendix Table I bear similarity to the tabulations in Rauh (2008) of corporate pension plans, in which total allocations to equity among major pension sponsors as of the end of 2003 were approximately 60%.

[6] This analysis assumes that public pension plans do not generate negative alpha, i.e. that they do not perform worse than the market benchmark. Coronado, Engen and Knight (2003) provide evidence that public plans earned a significantly lower rate of return than private plans during the period they analyze. Yang and Mitchell (2006) find that certain governance structures can enhance public pension plan investment performance.

similar asset value of $2.02 trillion. While based on higher quality data, this method required us to project assets using the aggregated asset class return assumptions over a longer period.

Appendix Table I shows the asset allocations and the return indices used to project assets through December 2008. In our calculations on funding, we use the $1.94 trillion projection based on the more recent survey of assets instead of the $2.02 trillion based on the older CAFR assets, although the difference of $80 billion is minor in this context.

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 which is not going to be reflected in future normal costs. This subtlety, which we will consider in Section II, matters only for the part of liabilities attributed to the current workforce, since all benefit promises to retired and otherwise separated workers have obviously already been made based on the past work of those former employees.

The actuaries then need to choose a discount rate with which to discount the future payments from these accrued benefits. For our 116 sample plans, we were able to locate 102 disclosures of discount rate assumptions. The discount rates used by the state plans to calculate these liabilities had a mean of 7.94% with a standard deviation of 0.43% and a median of 8.00%. The modal discount rate was also 8.00% with 43 entities using this rate. The minimum rate was 7.00% and the maximum was 8.5%.[7]

We begin by taking the AAL calculations at face value, and then consider how different AAL methods and discount rates might affect them. A simple sum of stated liabilities over our 116 plans yields $2.84 trillion in liabilities.

Taking the pension liability calculations from the state plans at face value, the state public sector faces an aggregate deficit in pension funding of $0.90 trillion (= $2.84 trillion in liabilities – $1.94 trillion in assets). Similar face-value calculations for previous years have also been performed by the Pew Charitable Trust (2007), National Association of Retirement Administrators (2003-2007), Merrill Lynch Research (2007), and Munnell et al (2008). On average for these studies, underfunding was closer to $0.3 trillion, due to higher asset values before the market decline of 2008.

This alleged $0.90 trillion pension gap represents an underfunding of 31.9% of the pension liabilities that states have chosen to recognize. The vast majority of plans are underfunded, as is the vast

[7] Giertz and Papke (2007) find some evidence that these assumptions are manipulated to reduce funding pressure.

share of total liabilities. The modal state is around 40% underfunded. Forty-five states report liabilities that suggest underfunds of $0-$50 billion, three suggest underfunds of $50-$100 billion, and one (California) suggests an underfund of more than $100 billion.

It is instructive to compare this number to total state debt outstanding excluding pensions, which we collected from the US Census Bureau *Survey of State Government Finances* (US Census Bureau 2007). Total state nonpension debt is $0.94 trillion, so that even taking the pension liability calculations from the state plans at face value reveals an underfunding equivalent to 97% of state debt. In other words, if one treats unfunded pension liabilities as state debt, total state debt is 97% higher than if one ignores unfunded pension liabilities as is typically done. For 24 states, adding the pension funding gap even at stated levels more than doubles state debt. In aggregate, pensions are underfunded by 45% of total state revenue using the state-given liability numbers.

In the following sections, we will see that these face-value calculations substantially understate the extent of the funding gap in state pension plans.

## II. Liability Concepts for State Pension Promises

One issue that arises in calculating the extent of pension liabilities and funding is the question of how exactly liabilities should be measured. In this section we explain the problem of liability concepts for active workers. In Section III we will show stylized examples of these different liabilities as well as our calculations of actual state pension liabilities under the different actuarial liability 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. So 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 cost of living adjustments (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 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 will grow with each year of work, so that the nominal benefit the worker expects to receive increases convexly with their 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 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 cost of living as 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, as well as inflation assumptions if the benefit is indexed to the CPI, and appropriate discount rates.

Now consider instead a plan in which Alice and Bob are both 45 years old but have both 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, both adjusted for COLAs, 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 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 working. Here the funding concept 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 the pension plan or firing the workers. This method is the Accumulated Benefit Obligation (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 assumptions about COLAs. To calculate a plan's total ABO, one simply adds up the ABOs represented by each individual employee. To do this 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.

For a plan to be considered funded, it is clear that it should at a *minimum* have funded a properly calculated ABO. However, since the employer is a state government, it may not be valid to assume that it can completely stop the employees' pension accrual at will. If states cannot simply freeze pension accruals, the taxpayer should possibly be concerned if the state has not funded some amount more than the ABO. As Alice and Bob work for more years, their pension benefits will grow very quickly. For this reason we consider some other funding concepts for active workers.

*B. The Projected Benefit Obligation (PBO)*

An extreme way to evaluate plan funding 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 retire and die according to actuarial assumptions. They could then discount those payments and arrive at present value liability. To make these projections, one needs two additional ingredients beyond the mortality tables and the ABO ingredients: salary growth assumptions by age, and separation probabilities by age.

The PBO for a vested worker of age $a$ and service $s$ separating this year is her ABO. Superscripting the years until separation and subscripting age ($a$) and service ($s$), we write:

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

where $W_{a,s}$ is the worker's annual wages, $\alpha$ 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

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

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

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

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

The unconditional PBO for a employee of age $a$ with $s$ years of service is the expectation, over years until separation, of the PBO conditional on years until separation as a function of worker age. Note that the accrued benefit obligation (ABO) for a worker is the projected benefit of the worker under the assumption that she is separating immediately.

The PBO 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. It does, however, provide a useful benchmark for understanding the other funding concepts. For a comparison of the ABO and PBO in a corporate pension context, see Bodie (1990).

*C. Entry Age Normal (EAN) and Projected Unit Credit (PUC)*

The entry age normal (EAN) and projected unit credit (PUC) methods each recognize a fraction of the PBO. These are the dominant methods actually employed by our 116 state plans. Matching our dataset 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 a EAN basis, and 15% of liabilities are calculated on a PUC basis. The remaining 17% are on another basis such as the aggregate cost method or the entry age frozen method, which are closely related to the EAN.

The fractions of the PBO that the EAN and the PUC methods recognize differ, with the EAN method always recognizing a greater portion of the PBO than the PUC method. In each case this fraction is constructed so that it converges to one at separation. The PUC method recognizes the PBO in proportion to the ratio of cumulative wages earned to (undiscounted) expected lifetime wages,

$$PUC_{a,s}^{T} = \left(\frac{\sum_{i=1}^{s} W_{a-s+i,i}}{\sum_{i=1}^{s+T} W_{a-s+i,i}}\right) \times PBO_{a,s}^{T}.$$

Note that it is quite possible for the PUC method to fail to recognize even the entire ABO.[8]

The EAN method is similar to the PUC in that it recognizes the PBO in proportion to wages earned to date relative to expected lifetime wages, but this method discounts these wages based on when they are earned to reflect both the time value of money and mortality rates,

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

*D. Funding Concepts are Irrelevant for Annuitants and Separated Workers*

All the accounting methods treat separated workers consistently. 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 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 are essentially 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.

The figure illustrates three salient features of the different methodologies. First, the three non-PBO methods start at zero because employees have not accrued any service yet, whereas the PBO starts at a positive level because it recognizes liabilities from future years of service. Second, all four measures converge to the same number at retirement. Third, the EAN is between the ABO and PBO, while PUC does not even recognize the full ABO.

[8] For example, if the COLA is as large as expected wage growth, the ABO must exceed the PUC. If there is no wage growth and no COLA the PUC and the ABO are equal. Expected wage growth increases the PUC without affecting the ABO, while the ABO is more sensitive to COLAs than the PUC.

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 two-thirds of aggregate state pension liabilities. Total aggregate liabilities accounting for all claimants are consequently less dissimilar under different accounting measures than suggested by the figure.

*F. What Is the "Best" Method?*

We take the ABO as the minimum measure of taxpayer exposure and the minimum measure of active worker liabilities that must be funded. It would be difficult to call a plan funded that did not have the resources to cover the benefits to which employees would be entitled today if the program were terminated. This "termination liability" represents a lower bound on funding adequacy, as states are limited in their ability to terminate DB pension plans. 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."[9] These provisions would seem to give special protection to accumulated pension benefits, above and beyond protections that municipal creditors have. Brown and Wilcox (2009) also show that eight state constitutions, including those of major pension sponsors Illinois and New York, say that pensions may not be "diminished or impaired", a clause which presumably protects far more than the ABO and probably most or all of the PBO. Finally, they document that in local fiscal crises such as those of Orange County, DB pensions are usually preserved.

Of the various measures that consider accruals due to future wages and years of service, the EAN represents an economically relevant liability measure. This method recognizes liabilities as a constant percentage of employee salaries, and consequently prescribes a "saving plan" that resembles a DC plan, though participants are not exposed to investment risk. Contributing a constant fraction of salary is similar to how many individuals without a DB pension plan save for their own retirement. If such an individual tried to save 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.

To see that the EAN resembles a DC saving plan, note that under the EAN method the Normal Cost for a worker of age *a* with *s* years of service, *i.e.,* the liability accrued for the current year of service, is given by

$$NC\_EAN_{a,s}^{T} = EAN_{a,s}^{T} - \left(\frac{1+r}{S_{a-1,1}}\right) \times EAN_{a-1,s-1}^{T+1},$$

[9] In other cases, state statutory and common law offer protections.

the difference between the current liability and last year's liability grossed up by the discount rate and adjusted to account for the fact that the worker survived from last year. Substituting our formula for the EAN into the previous equation and simplifying yields

$$NC\_EAN_{a,s}^{T} = \left( \frac{PBO_{a-s,0}^{s+T}}{\sum_{i=1}^{s+T} \frac{S_{a-s,i}}{(1+r)^i} \times W_{a-s+i,i}} \right) \times W_{a,s}.$$

The term in the parentheses on the right hand side of the previous equation is unchanged if $a$ and $s$ increase by one while $T$ decreases by one. That is, it is invariant over the employee's tenure. The EAN method may consequently be interpreted as prescribing the percentage of employees' wages that must be saved to fund survivors' retirement benefits, under the implicit assumption that these savings can be invested risk-free at the discount rate used to value the liabilities.

In sum, the ABO is a minimum measure of funding for active workers. If a state funds to the ABO then it has enough benefits to pay workers pensions that they have accrued given their current wages and years of service. However, it faces the prospect of having to make payments greater than the new service accruals (normal cost) in order to meet the obligation to its retirees. The EAN is also a useful benchmark because it is the funding level that allows liabilities from newly accrued service to be a fixed percentage of future employee wages.

## III. Calculating State Pension Liabilities Under Different Funding Concepts

To calculate state pension liabilities under the different funding concepts, we use the following procedure. We begin with a three-item array for each of the 116 plans that includes: 1.) the plan's stated liability, 2.) its state-chosen discount rate, and 3.) the actuarial method (EAN or PUC) employed by the state to calculate the liabilities. The stated liability and discount rate come from our own data collection described in Section I. The actuarial method combines our own data collection with information from the state and local pension data made available by the Center for Retirement Research (2006).

We then convert this three-item array for each state into a modeled stream of payments that would yield the stated liabilities if discounted using the stated discount rate. This calculation requires several matrices that pin down 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 examined the CAFRs of the 10 states with the largest total liabilities and took the assumptions from the reports where they were usable: New York, Illinois, Pennsylvania, Ohio, and Texas. The matrices we use are an average over the reports. These matrices are shown in Appendix Table II.

We also require several additional technical assumptions, specifically: i.) a benefit formula, which we assume to be a constant fixed fraction of salary times years of service, with employees vesting after five years service; ii.) a cost of living adjustment (COLA); iii.) an inflation assumption, which we need to estimate the benefits of annuitants; iv.) a vector of mortality assumptions by age, for which we use the RP2000 combined mortality table used by many states; v.) an age at which beneficiaries can begin receiving full benefits, which we take to be 65. We could allow younger retirees to receive benefits prior to turning 65, but assuming retirement benefits are adjusted in an actuarially fair manner, this has no effect on our liability calculations.[10]

For the benefit formula, the COLA and the inflation assumption, we collected data on most plans from the CAFRs or from the Center for Retirement Research (2006). Table II summarizes the results of this data collection. For each of these items we were able to collect data for at least 90 of our 116 plans. Where data were unavailable, these items were ultimately filled in with sample means, but the table shows the data before that step. For 28 plans, benefit factors were given as a range, for which we picked the midpoint. For Cost of Living Adjustment (COLAs), the summary statistics shown are the COLA that we estimate are built into the states' nominal cash flow projections. The easiest case was if the COLA was fixed, in which case the COLA is just the fixed number given. If the COLAs were a CPI with a cap or Partial CPI, the given formula was applied to the state's inflation assumption. If the COLA was ad hoc, excess earning, or other, we assumed the projected COLA equaled the state's inflation assumption.

If we were modeling liabilities "from scratch" (i.e. without knowing each plan's stated liability at state-chosen discount rates), the total liability would likely be quite sensitive to small changes in these assumptions. Crucially, however, we know both what the state is claiming its liability is and what discount rate it used to obtain that liability. We use our model to deliver the sensitivity of liabilities to discount rate variation ($-d \ln L / dr$). This derivative is relatively insensitive to these additional assumptions.

Regarding retirees and separated workers, we have an approximate service distribution for them, based on disclosures in a subset of the CAFRs of the 10 states with the largest stated liabilities. We do not, however, have the distribution of their ages or benefit salaries. We consequently assume that annuitants are older than 65, and that the distribution of their ages is consistent with mortality rates in the steady state, *e.g.,* the mortality tables suggest that conditional on living to 65 there is roughly a 50% probability of living to 82, so we assume that there are twice as many annuitants of age 65 as there are of age 82. Because wages largely reflect service and not age, and average government wage growth (conditional on service) largely reflects inflation, we estimate the benefit salary of annuitants by adjusting

[10] By "actuarially fair", we mean that the employee's annual benefit is reduced such that the expected present value of lifetime payments equals the value of the life-time annuity that makes full payments beginning at age 65.

the wages of currently employed workers with the same level of service to account for inflation and cost of living adjustments, under the assumption that the annuitant retired at 65. For workers who are separated and vested but not yet receiving benefits, we assume that their age distribution at each service level is the same as that for currently employed workers with the same level of service, and that their benefit wage is the wage of currently employed workers of the same age with the same service.

As a check of the model we consider how it performs replicating the states' aggregate stated liabilities "from scratch", without using the stated liabilities themselves. That is, we use the model to generate the stream of states' expected future pension payments, and then discount these at the average discount rate assumed by the states. Note that it is not important that our model-generated liability perfectly matches the stated liability. The purpose of modeling the stream of future pension payments is to investigate how the liability changes with discount rate assumptions, not to calculate its level. We know the level of states' stated 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 (12.107 million), their average salary ($39,829), the total numbers of annuitants and separated employees not yet receiving benefits (5.814 and 2.171 million, respectively), and the liability weighted average benefit factor (2.03%), COLA (2.86%) and inflation assumptions (3.40%). We then account for these payments on an 85.5% EAN / 14.5% 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 $2.72 trillion. This number was produced without using the states' actual stated liabilities and is within five percent of the $2.84 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 accurate aggregate cash flows, not calibrating to stated liabilities would throw away state-level variation. The stated 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. Using information for each plan regarding its benefit formula, COLA and inflation assumption, we adjust the average wage level of the plan's employees so that its aggregate liability, calculated using its stated actuarial method and employing its stated discount rate assumption, matches its reported liability. 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 rates), 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 three main accrual methods:

ABO, EAN, and PBO. The top graph shows total cash flows each year recognized by each method. In the near future, aggregate annual expected cash flows are roughly $180 billion under all three measures. These obligations rise over time, peaking at $280 billion after 20 years (ABO), $300 billion after 25 years (ABO) and more than $400 billion after 40 years (ABO).

The bottom graph shows these cash flows disaggregated into active workers, annuitants, and separated workers expecting future benefits. Initially all the cash flows go to retired workers. Cash flows going to these annuitants decrease each year, reflecting the expected mortality of these claimants. These cash flows insignificant after 30 years, at which time the youngest of these workers are 85 years old. Cash flows going to separated workers initially increase each year, as more and more of these claimants reach the age at which they can claim benefits. They continue to increase for roughly twenty 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.

The portion of the cash flows due to active workers has a profile similar to that due separated workers. It slopes upward initially, as more and more newly retired workers reach the age at which they can draw benefits. The slope increases markedly after five years, reflecting the fact that most state workers retire before their 60th birthday, with the result that there are relatively few active state workers eligible for benefits in the coming five years. [11] The projected cash flows going to currently active employees continues to increase until downward pressure from worker mortality exceeds upward pressure from those reaching benefit age. The peak occurs much later for PBO cash flows than for EAN or ABO, because the PBO recognizes the full expected service and terminal salary of even the youngest workers, while the EAN recognizes only a small fraction of these, and the ABO recognizes only the current service and salary of these workers.

Table III uses the full set of assumptions and shows total state pension liabilities without adjustments to the discount factor, but applying different liability concepts. The first number in the table, $2.84 trillion, represents the raw sum of liabilities from the 116 CAFRs, without any adjustments of any kind. Although most of these liabilities are stated on an EAN basis, not all of them are. Therefore, this sum is "unharmonized", i.e. it represents the sum of liabilities under somewhat heterogeneous actuarial methods.

The next rows of the table show the ABO, PUC, EAN, and PBO liabilities, again without adjustments to the discount factor. The EAN is $2.87 trillion, and is unsurprisingly the closest to the raw unadjusted sum of liabilities from the reports. The broadest measure is the PBO at $3.19 trillion. The narrowest measures are the PUC and the ABO at $2.70 trillion and $2.74 trillion respectively.

[11] This feature of the figure disappears if we assume younger retirees begin taking actuarially fair benefits prior to turning 65.

The table also shows a decomposition into the three groups of plan members from which the liabilities arise: active participants, annuitants (i.e. retirees), and those separated but not yet receiving benefits. It highlights the fact that the latter two categories are insensitive to the choice of actuarial method since they do not depend on future salary or service outcomes. As was the case in the simplified example in Figure 2, only about one-third of the liability comes from the active participants. Therefore, the impact of the different actuarial methods on total liabilities is somewhat muted.

## 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. In Section II, we determined that the correct discount rate for the ABO need not reflect any wage or salary risk. 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 the 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.[12] 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, the PBO must be reported and must be discounted using a blended corporate bond yield. For funding purposes, corporate ABO liabilities must be disclosed and discounted using Treasury yields.[13]

If state pension promises were truly riskless, meaning that pensioners would get the expected benefit in all states of the world, then one would want to use a risk-free rate. One discount rate candidate for a given pension-related cash flow is therefore a zero-coupon Treasury rate with the same term as the

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

[13] 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 the IRS 5500 may not be more than 5 percent above and must not be more than 10 percent below a 4-year moving average of 30-year Treasury yields.

cash flow in question. The dark line in Figure 3 shows the Treasury yield curve as of January 30, 2009, which we calculated by stripping the par yield curve.[14]

The nominal discount rate may actually understate the value of the liabilities, which are partly linked to inflation. Holders of long-dated Treasury bonds do not hold a truly riskless asset. They are exposed to inflation risk, because realized inflation determines the real value of the bond's payoffs. Investors may consequently demand higher yields on nominal bonds. If that inflation risk were fully removed with COLAs, one would want to adjust the nominal yield downward for the full inflation risk premium.[15] To the extent that COLAs provide the beneficiaries with a partial hedge against inflation risk, nominal Treasury bond yields may be too high.

We argue that the risk-free rate is the appropriate rate for the funding adequacy measure. There are two primary risk factors that affect the evolution of a general liability: i.) default risk; and ii.) salary risk that is correlated with the market.[16] Future salary does not affect the ABO, as future salary does not enter the benefit calculation. Default risk is important to consider from the standpoint of a taxpayer or municipal bond investor, but states with higher probabilities of default should not be given lighter funding requirements. Discounting with the risk-free rate recognizes that if the state defaults on these obligations then some party, namely the pension beneficiaries, will lose.

However, from the perspective of taxpayers who are concerned with how large taxes will have to be in the future to cover unfunded 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 have the same priority as other government debt, then the discount rate should be related to municipal bond yields. The upper three lines in Figure 3 show zero-coupon yield curves for state GO bonds with A, AA, and AAA ratings, which we calculated by stripping par yield curves from Bloomberg.[17] 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. Twenty of our 116 plans are sponsored by states rated AAA, 76 by states rated AA (including AA+ or AA-), and 7 by states rated A (including A+). Thirteen

[14] Beyond a 30-year term, we assume a flat yield curve at the 30-year rate.
[15] Buraschi and Jiltsov (2005) estimate an average ten-year inflation risk premium of 70 basis points over the period 1965-2005.
[16] There are other risk factors in the liabilities, e.g. mortality and retirement assumptions, but these are unlikely to be correlated with the market. There is also the issue of the magnitude of future benefit accruals (due to additional years of service), but again, we begin under the assumption that states will fully fund all future accrued benefits and consider just the liabilities accrued until now.
[17] Specifically, from Bloomberg we obtained 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.

plans are sponsored by unrated states; for these plans we use the A- curve. The full distribution of state ratings is shown in Supplemental Appendix Table I.

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 which generate the same stream of payments as the benefits and default in the same states of the world.

This leads us to consider another 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 roughly $r_{it}$ / (1- $\tau_B$), where $\tau_B$ 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".

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. As discussed previously, state constitutions often build in protections for government-sponsored pensions (National Conference on Public Employee Retirement Systems (2007), Brown and Wilcox (2009)). This suggests that their priority is generally higher than that of GO debt and that the default probabilities of state pension obligations are probably lower than those of state GO debt, especially for the already-promised benefits represented by the ABO.

This "taxpayer obligation" measure captures some of the spirit of the FASB rules for corporate pension discounting. The FASB rule lets corporations discount pension obligations at corporate bond rates, on the grounds that the pension may only have to be fully paid if the company is solvent. Similarly, our taxpayer obligation measure suggests that state pension obligations be discounted at state bond rates, on the grounds that the pension may only have to be paid if the state is solvent.[18]

In sum, to value the liabilities in today's terms from the perspective of taxpayers, a higher discount rate than the risk-free rate is required due to the fact that the plans might default. The taxable muni rate represents the risk that states will default on their GO bonds.

A key input to this calculation is the value of $\tau_B$, 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

[18] There are some 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 they will have to pay pensions.

prime-grade municipal bonds relative to taxable Treasury bonds. Most recently, Poterba and Verdugo (2008) document that over the 10 years from 1998-2007 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 1997-2008 it was even lower.

Poterba and Verdugo (2008) assume 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, as well as on January 30, 2009, Treasuries traded at a premium to AAA municipal bonds. Based on the Poterba and Verdugo (2008) findings, we set $\tau_B$ at 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 that is no longer the case today.[19]

Table IV presents our main estimates of aggregate state pension funds under the taxpayer obligation measure and the funding adequacy measure respectively. For the taxpayer obligation measure, we discount using the taxable muni yield curve that corresponds to the credit rating of the state that sponsors each plan. For the funding adequacy measure, we discount using the Treasury yield curve. The key results are that total liabilities are $3.15 trillion and $5.06 trillion under the two measures. The annuitants component, which is $1.44 trillion and $1.67 trillion under the two measures respectively, has relatively short duration and therefore is the least affected by the re-discounting. Note again that the active component is only about one-third of the total liability, which limits the impact of the actuarial method on the total. The impact of considering broader measures of the liability will be considered in Section VI.

Overall, unfunded liabilities, which are total liabilities net of the $1.94 trillion in total assets, are $1.21 trillion and $3.12 trillion under the taxpayer obligation and funding adequacy measure respectively.

An underfunding of $1.21 trillion (taxpayer obligation measure) is 130% of total state debt and 61% of total state revenues. So from the perspective of a taxpayer who believes that the state can default on ABO pension obligations, state debt is three times as large as the on-balance-sheet debt when one also considers pensions, and almost an entire year of state revenue would be required to pay off the pension debt.

Figure 4 shows the distribution of the funding status across the 50 states under the taxpayer obligation measure, scaled by various denominators. The upper left graph scales by state liabilities, the upper right graph shows the unscaled underfunding, the lower right graph shows the underfunding scaled

[19] If we used rates from the latter part of the Poterba and Verdugo (2008) time period, the Treasury rate would have been higher than it is now, but the muni rates would have been close to today since their spread to Treasuries was substantially negative.

by the level of state debt, and the lower right shows the underfunding scaled by the level of state revenue. We see from these graphs that the median state's pensions are more than 40% underfunded. Unfunded liabilities for the median state represent 150-175% of state non-pension debt, and more than one-half year of revenue. While the largest dollar amounts of underfunding are concentrated in a few states (California, Illinois, New Jersey, Ohio, and Texas), the distribution of funding status is much flatter. As a percentage of revenue, the states with the greatest underfunding are Illinois (159%) and Connecticut (122%), followed by Ohio, Colorado, and New Jersey.

Under the funding adequacy measure, \$3.12 trillion of unfunded liabilities represent 330% of total state debt and 157% of total state revenues. So from this perspective, total state debt is about 4.25 times as large as the on-balance-sheet debt when one also considers pensions, and an entire 18 months of state revenue would be required to pay off the pension debt.

Figure 5 shows graphs analogous to Figure 4 but under the funding adequacy measure, that is, using the Treasury yield curve to discount liabilities. The median state's pensions under this measure are more than 60% underfunded. Unfunded liabilities for the median state represent more than 300% of state non-pension debt, and almost 18 months of revenue.

Supplemental Appendix Table I lists liabilities under each measure, as well as pension assets, debt, revenue, credit rating, and GDP at the state level for readers who wish to examine the state distribution more closely.

## 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 discount rate employed to discount them. The liabilities we calculate in the previous section are higher than the liabilities states reported in their CAFRs because the discount rates we employ, which more accurately reflect the risks of the plans' future obligations, 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' stated liabilities.

Figure 6 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.[20] The liabilities represented by active and separated workers are quite sensitive to the employed discount rates. These plan participants are relatively young, and consequently expect to receive benefit

[20] 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.

payments far into the future. Conversely, the liability represented by retired workers is relatively insensitive to the employed discount rate, 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 the employed, retired and separated workers.

The fact that the durations decrease with the discount rates — i.e. the downward sloping duration profiles observed in Figure 6 — 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. As discount rates fall the fraction of the total liability represented by long dated payments rises, increasing the liability's duration. Note that the duration of the total liability slopes down more than any of the individual components because as the rate goes up more weight goes on the active and separated workers, whose benefits have longer duration.

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 discount rate range. That is, a single "duration" that corresponds to the average elasticity of the liabilities with respect to discount rates ($-\Delta \ln L / \Delta r$) over the discount rate range encompassing the states' stated discount rates and the approximate discount rates we use. Over the range 6% to 8%, the effective average duration is almost 14½ years, while over the range 4% to 8% it is over 15½ years.

This effective average duration over the range of discount rates we consider, roughly 15 years, is similar to the durations 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 posed by active, separated and retired workers.

## VI. State Pension Liabilities Under Broader Measures

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

The first two columns of the first row repeat our headline numbers from Table IV. These are total liabilities under the taxpayer obligation and funding adequacy measures: \$3.15 trillion and \$5.06 trillion respectively. The second row confirms that the PUC method, which does not have solid economic foundations, is in fact in aggregate lower than the ABO for our plans. The third row shows the EAN liability. The EAN liability is only moderately higher than the ABO. Going from the ABO to the EAN for active participants under the taxable muni rate increases the active liability by \$0.13 trillion, from \$0.75 to \$0.88 (an increase of about 17%). Hence the total liability only increases by that same dollar amount, from \$3.15 trillion to \$3.27 trillion, a 4% increase. Under the risk-free discounting (second column), it is a 9% increase. This is an upper bound on the extent of the difference between the ABO and EAN, since the part of the EAN 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 PBO. Moving from the ABO to the PBO increases active and total worker liabilities by \$0.45 trillion, which is 60% of active ABO liabilities and 14% 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 probably overstate the PBO. However, this exercise does give a sense of the maximum amount that moving from the ABO to the PBO could increase the taxpayer obligation measure.

Furthermore, discounting the state PBO at the taxable muni rate is probably the most analogous procedure to what FASB requires of firms. This yields a value of \$3.60 trillion, and an underfunding of \$1.66 trillion (= \$3.60 liabilities – \$1.94 assets). Under FASB rules, firms must use a corporate bond rate to discount and recognize the PBO. The corporate bond rate reflects the risk that the firm will default. Similarly, the taxable muni rate reflects the risk that the state will default.

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 ABO, this correlation is not relevant. However, it is relevant from the perspective of the EAN, which we have argued is a useful economic measure, as well as for the PBO. 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). Empirically, Benzoni et al (2006) show that while the correlation between earnings growth and stock returns are negligible on a short horizon, the correlation is higher on a longer positive 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 this correlation 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 $\sigma_L$ is the volatility (annualized standard deviation) of liabilities, $\sigma_M$ 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 $\beta$ times the market risk premium. The volatility of liabilities ($\sigma_L$) relevant for this equation is the volatility of currently accrued pension liabilities as the future unfolds. It includes variation due to possible default and salary growth, but again not due to future service accruals.

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 (1997-2007) and another of 27 plans for which we have data for 15 years (1993-2007). 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.[21] 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 US Census for salary data from 1962-2008. Supplemental Appendix Table II shows the raw data. We use these data to calculate the annual growth in full-time government employee average wages during the period 1963-2008. We deflate wage growth by the CPI from the Bureau of Labor Statistics (BLS) website. Figure 7 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.[22]

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 a broader liability measure such as the EAN, one might consider assuming that EAN liabilities for active workers have a volatility of 0.05 (based on the balanced panel discussed above) and a correlation with the stock market of 0.25 (the 5-year horizon number from Lucas and Zeldes (2006)). Assuming a 6.5% risk premium, this would raise the implied discount rate by

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[21] 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.
[22] In unreported results, we 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.

6.5%*0.05*0.25/0.16 = 51 basis points.[23] Our evidence suggests that liabilities are neither this volatile nor this correlated with the market, and there are a number of studies suggesting 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 make the risk premium 3.5%-4.5%, the discount rate would only rise by 31bp under this correction.[24]

The final two columns of Table V show the effects of adding the 51bp wage risk where such an addition may be applicable. The third column assumes that there is salary risk given by 51bp as calculated above. However, the salary risk only affects the PUC, EAN, and PBO measures, and of course only affects active participants. For this reason, the ABO, Annuitant, and Separated figures are the same as in the first column.

Adding wage risk in this fashion has a moderately small effect on the results. The EAN for active workers declines by approximately 10% (from \$0.88 trillion to \$0.79 trillion), as does the PBO. The percentage impact of wage risk on *total* liabilities is only 3% for the EAN and 4% for the PBO — the effect is substantially muted by the fact that active liabilities only comprise about one-third of the total. So wage risk in this context seems not quantitatively important unless the correlation between the stock market and government wages is substantially higher than 0.25, or 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 EAN at a taxable muni rate that reflects wage risk brings it to \$3.18 trillion, which is only slightly higher than the ABO at a taxable muni rate that does not reflect wage risk (\$3.15 trillion). Similarly, the EAN discounted at the risk-free rate plus wage-risk is \$5.24 trillion, only 4% larger than the \$5.06 trillion ABO discounted at the risk-free rate. Thus, moving from the ABO without wage risk to the EAN with wage risk has a small effect.

## VII. Conclusion

In this paper we have measured state pension liabilities under a variety of different measures. Our estimates focus on two primary measures, a taxpayer obligation measure and a funding adequacy measure. We find the pension promises already made to state workers are underfunded by at least \$1.21 trillion as far as taxpayers are concerned, under the strong 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. Furthermore, we are looking only at benefits accrued up until now under the ABO, a

[23] 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.
[24] To the extent that the PBO is more volatile and correlated with the stock market than the EAN, we would want to use larger salary risk corrections for the PBO.

narrow measure of the accrued liability. From the perspective of our funding adequacy measure, which does not credit states for the ability to default, state pensions are underfunded by $3.12 trillion.

We conclude with several general observations, one of which regards the liability concepts. We have taken great care to examine only ABO liabilities for our main funding measures. This is a clean measure, since risk related to the covariance between government salaries and pricing factors is not relevant for the ABO. It is also a narrow measure that delays recognition of a large share of liabilities until later in the employee's life.

The broader EAN measure, however, is not substantially larger. The EAN method, which is used by the majority of state plans in their reports, recognizes as accrued some liabilities owing to future wage growth and years of service. It does so in an economically sensible way, since service liabilities increase as a fixed percentage of wages, not unlike in a DC plan. The EAN for active workers is 17% ($0.13 trillion) larger than the ABO for active workers, if one assumes that both the ABO and the EAN can also be discounted at taxable muni rates. The rise is 26% ($0.43 trillion) if one assumes that both the EAN and the ABO can be discounted at Treasury rates.[25] Given the relative importance of non-active workers, the percentage effects on total liabilities are about one-third as large as the effects on active workers. The total EAN *underfunding* would be $1.33 trillion under the taxpayer obligation measure and $3.56 trillion under the funding adequacy measure, compared to $1.21 trillion and $3.12 trillion under the ABO — an increase of $0.13 and $0.43 trillion respectively.

Even these relatively small potential differences between the EAN and the ABO are further mitigated by two factors. First, states are more likely to default on the part of the EAN-implied payments that is above and beyond the ABO-implied payments. The EAN should be discounted at a higher rate to reflect greater default risk. Second, the EAN cash flows that are not recognized in the ABO vary with wage growth, which may be correlated with priced risk factors. Therefore, the $0.13-$0.43trillion increase in underfunding calculated above when one goes from the ABO to the EAN must be an upper bound.[26] Our method of capturing salary risk reduces the difference to $0.04-$0.17 trillion.

Regardless of the funding measure used, our calculations focus only on liabilities accrued until now. Our summary numbers therefore assume that states will fully fund new liabilities accrued in the future, both from current and future workers. Munnell et al (2008) report that 57% of state and local governments paid their full Annual Required Contributions (ARCs) in 2006, with 16% contributing 80-99%, 13% contributing 60-79%, and 14% even less than 60%. Mitchell and Smith (1994) find wide variations in this funding behavior. Since there is no material penalty for not funding newly accrued

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[25] 17% is from $0.75 trillion to $0.88 trillion, and 26% is from $1.68 trillion to $2.11 trillion.

[26] Naturally the difference between the PBO (which is the broadest measure) 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 PBO.

benefits (i.e. for violating the ARCs implied in the funding standards), states do not always comply with funding to their own standards. The dynamic effect of state behavior on future benefit accruals is an important topic for future research.

Finally, it is interesting to consider what this public pension underfunding and state pension fund investment policy imply for intergenerational transfers and the burden this underfunding places on future generations. If households form their own financial portfolios taking government pension investment policy into account, then how the government invests pension assets does not matter, the only thing that matters is the underfunding we measure in this paper. However, if some households fail to fully undo the government's investment strategy, then investing in risky assets subjects future generations to more risk in the value of their after tax wealth. Furthermore, as shown by Lucas and Zeldes (2009), if taxation to correct pension underfunding has nonlinear distortionary costs, investing underfunded public pensions in risky assets with high expected returns and high volatility may impose a large expected cost of distortionary taxation on future generations. Considerations of this burden in the context of overlapping generations is an area for future research.

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**Figure 1: Illustration of Liabilities Under Different Funding Concepts**

Accounting liabilities are shown for workers age 21 to 65, hired at age 20 and retiring at age 65. Liabilities are shown for four different accounting methods: Projected Benefit Obligation (PBO), Entry Age Normal (EAN), Accrued Benefit Obligation (ABO), and Projected Unit Credit (PUC). 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, as detailed in Appendix Table IV. 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.

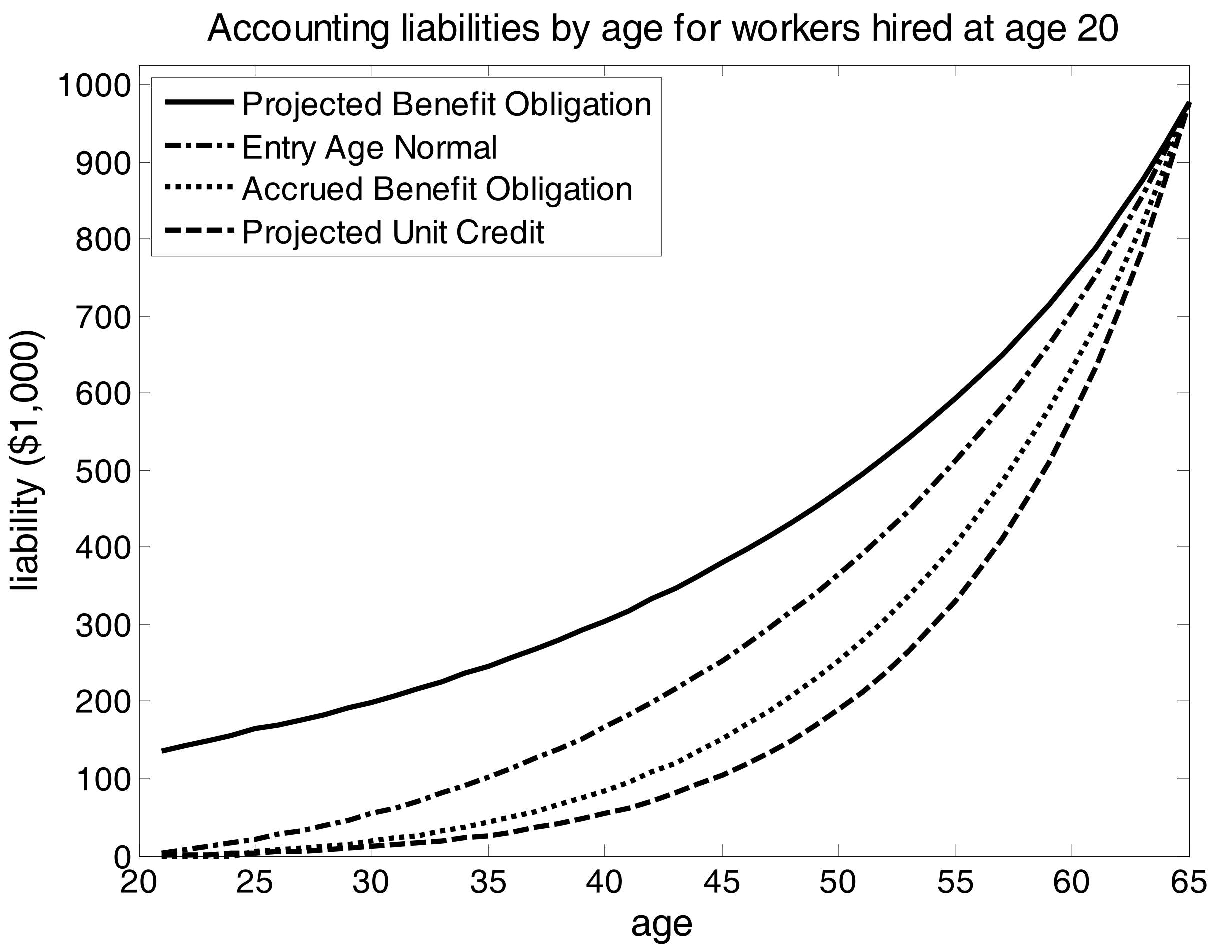
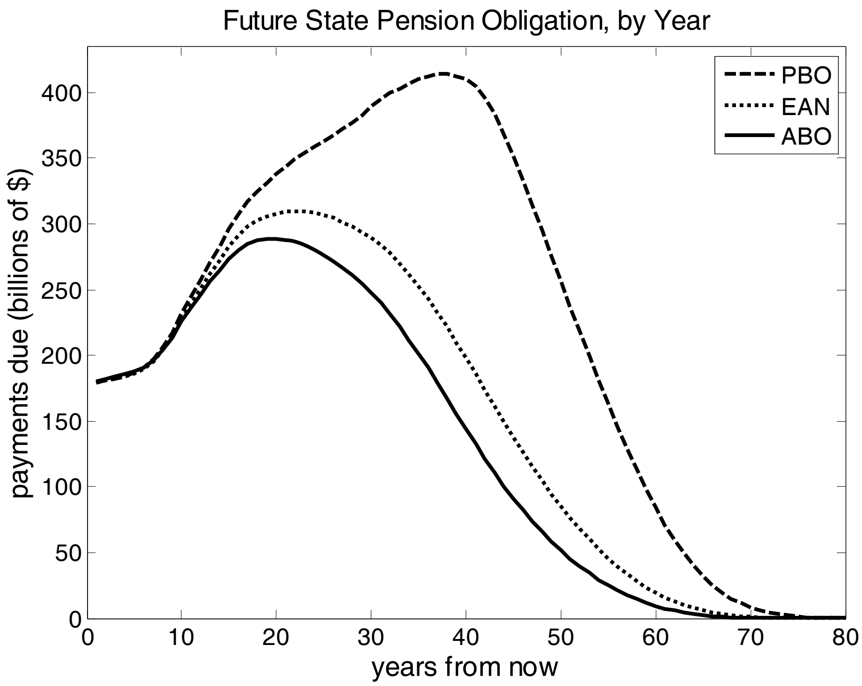


**Figure 2: Projected Aggregate Cash Flows for Public Pension Promises**

These figures show 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, as detailed in Appendix Table II. 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).



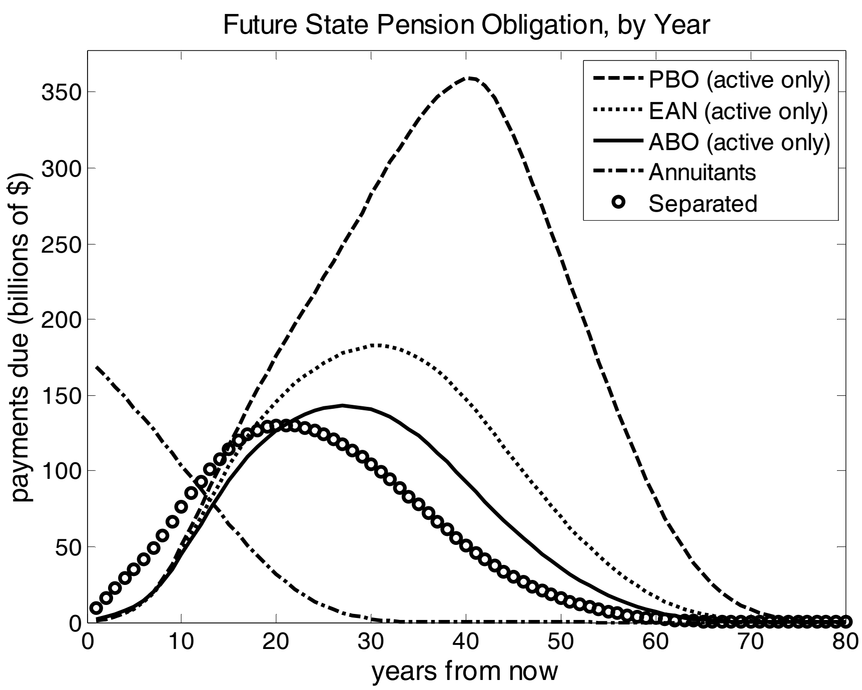



**Figure 3: Zero-Coupon Yield Curves for Treasuries and Municipal Bonds**

This graph shows zero-coupon yield curves for Treasuries, as well as municipal bonds of various ratings, as of January 30, 2009. Yields on coupon bonds were collected from Bloomberg for AAA, AA+, AA-, A+, and A- rated state municipal bonds. The zero-coupon yields were calculated from strip prices, which we obtained 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.

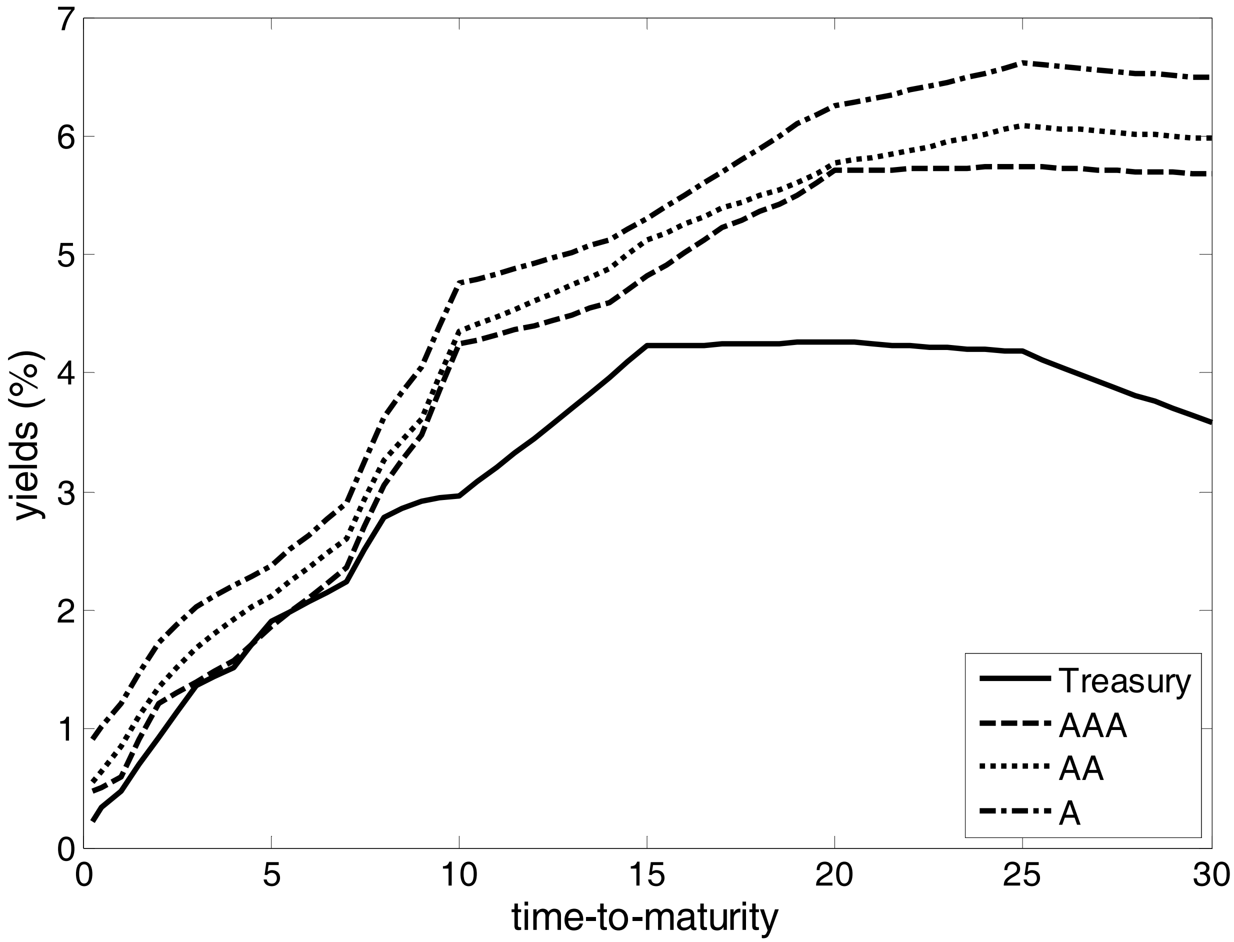


**Figure 4: Funding of State Public Pension Plans, Taxpayer Obligation Measure**

The funding levels (assets – liabilities) of 116 state-sponsored DB pension plans are calculated and aggregated to the state level. Liabilities are harmonized to an ABO basis, and it is assumed that benefits have the same default probability as GO bonds. Liabilities are therefore discounted using the municipal bond rates shown in Figure 3, excluding the tax preference as explained in the text. The distribution of the funding level in the 50 states is shown scaled by state DB pension plan liabilities in the upper left, on an unscaled basis in the upper right, scaled by state debt in the lower left, and scaled by state revenue in the lower right.

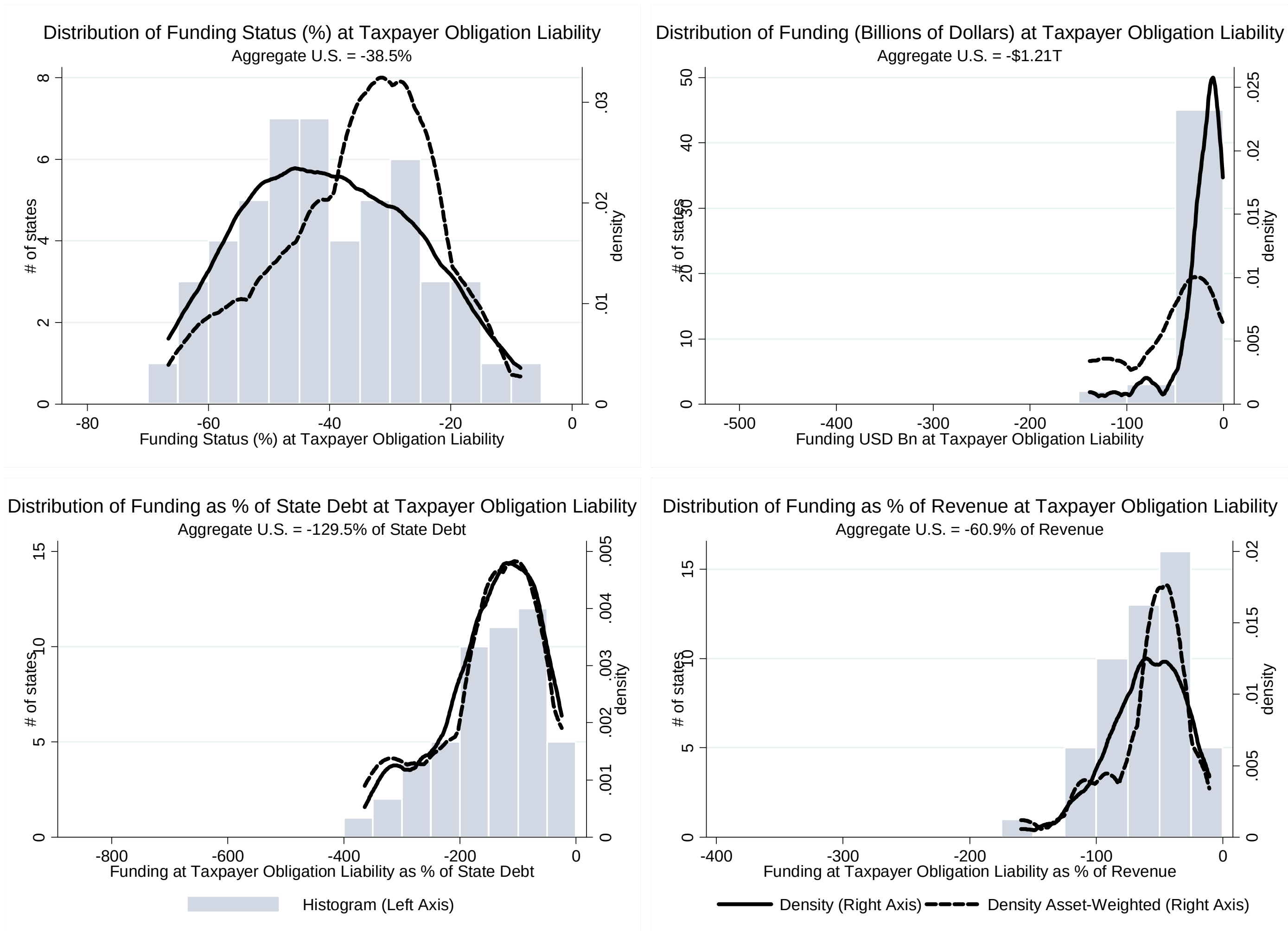


**Figure 5: Funding of State Public Pension Plans, Funding Adequacy Measure**

These figures are parallel to those in Figure 4. However, liabilities are harmonized to an accumulated benefit obligation (ABO) basis and it is assumed that the state cannot default on these liabilities. All payments are discounted using the Treasury yield curve in Figure 3.

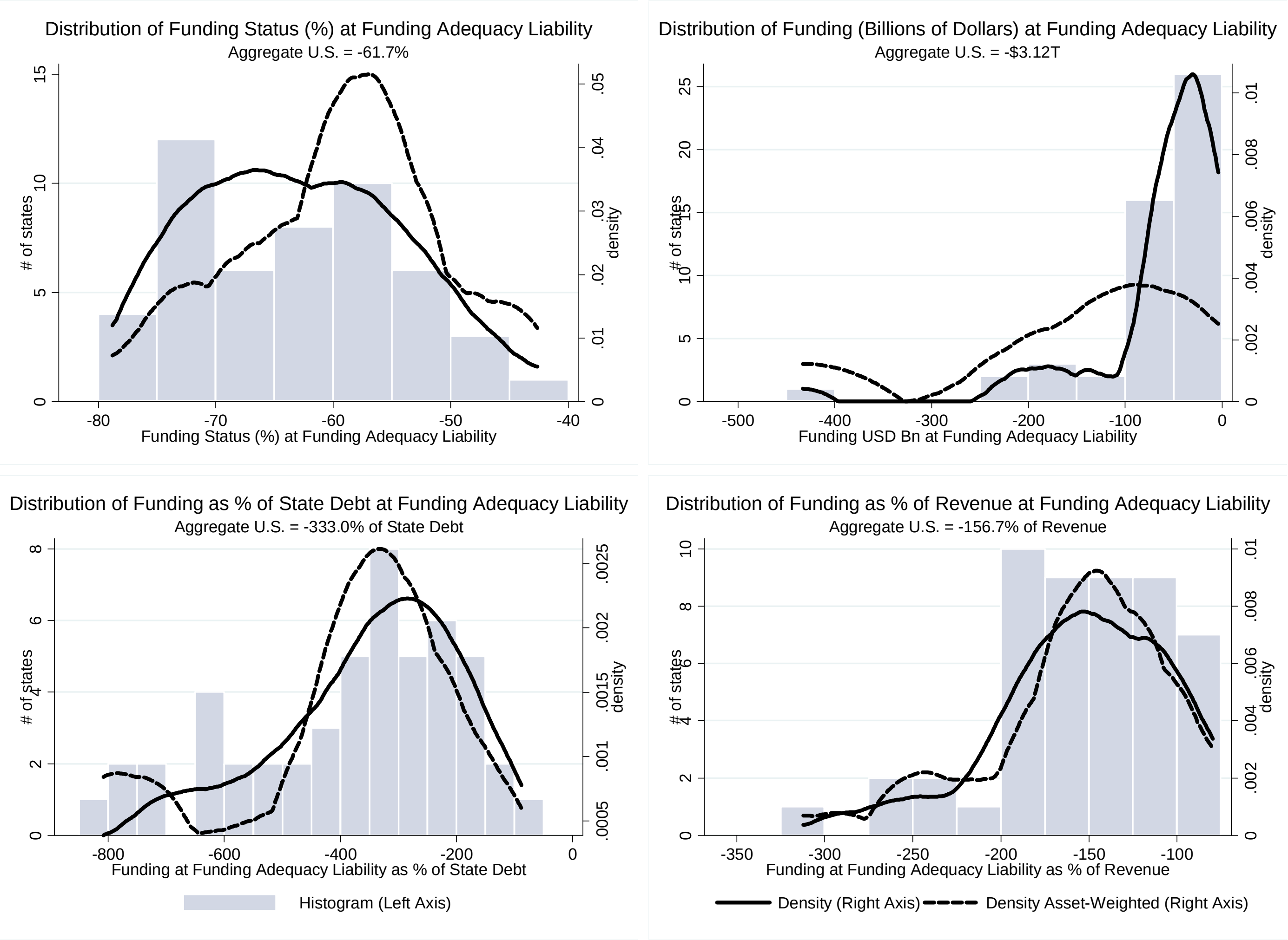


**Figure 6: Implied Durations of Public Pension Liabilities**

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, *i.e.*, the duration of the liabilities posed individually by the active, separated and retired workers (dashed, dotted and dash-dotted lines, respectively).

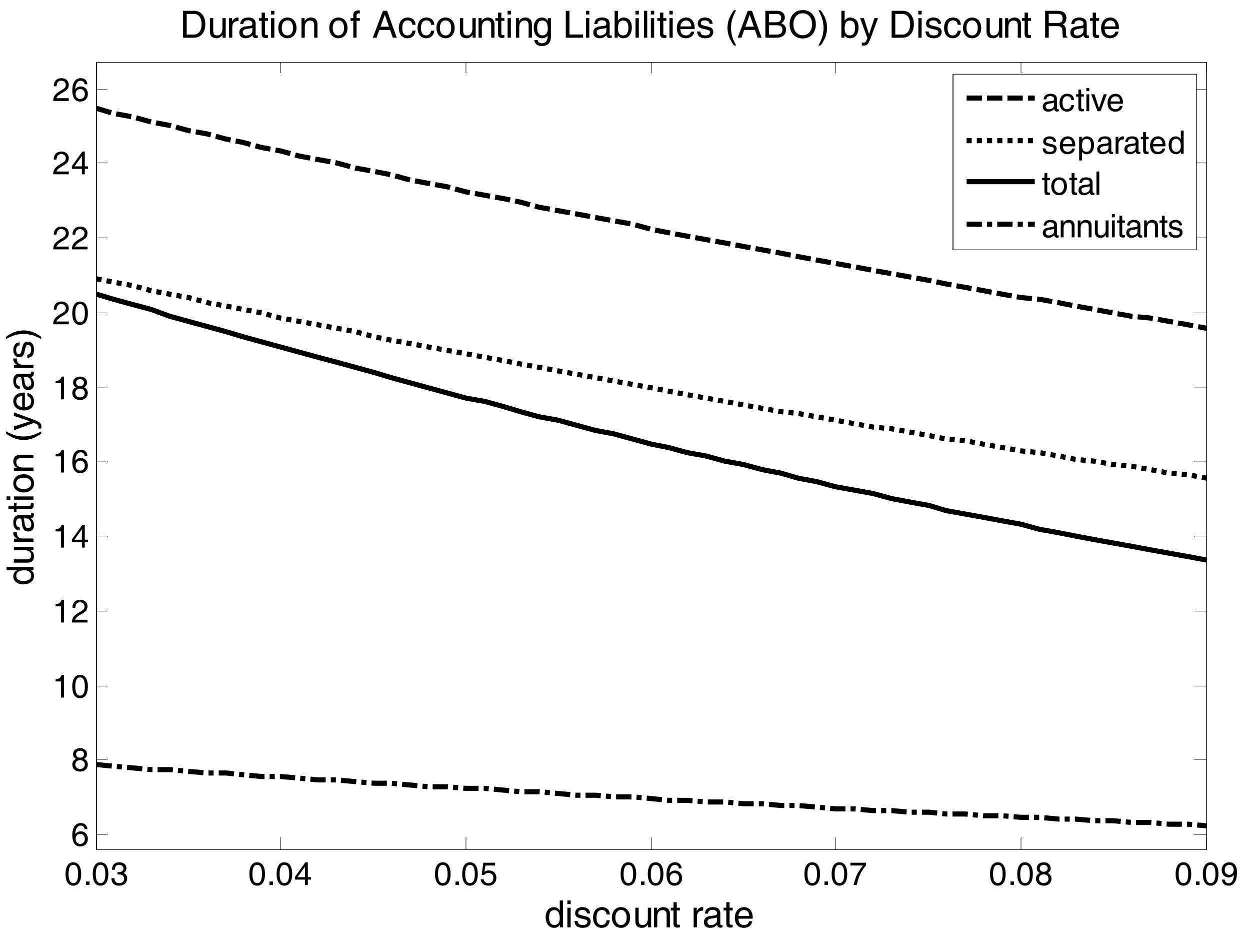


**Figure 7: Government Salary Growth and Market Returns**

This figure shows the extent of co-movement between 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 US Census for all government workers between 1962 and 2006. The wage index is deflated by Consumer Price Inflation (CPI) growth, as reported on the Bureau of Labor Statistics (BLS) website. The return on the US stock market is adjusted by the risk-free rate, and is extracted from the Kenneth R. French data.

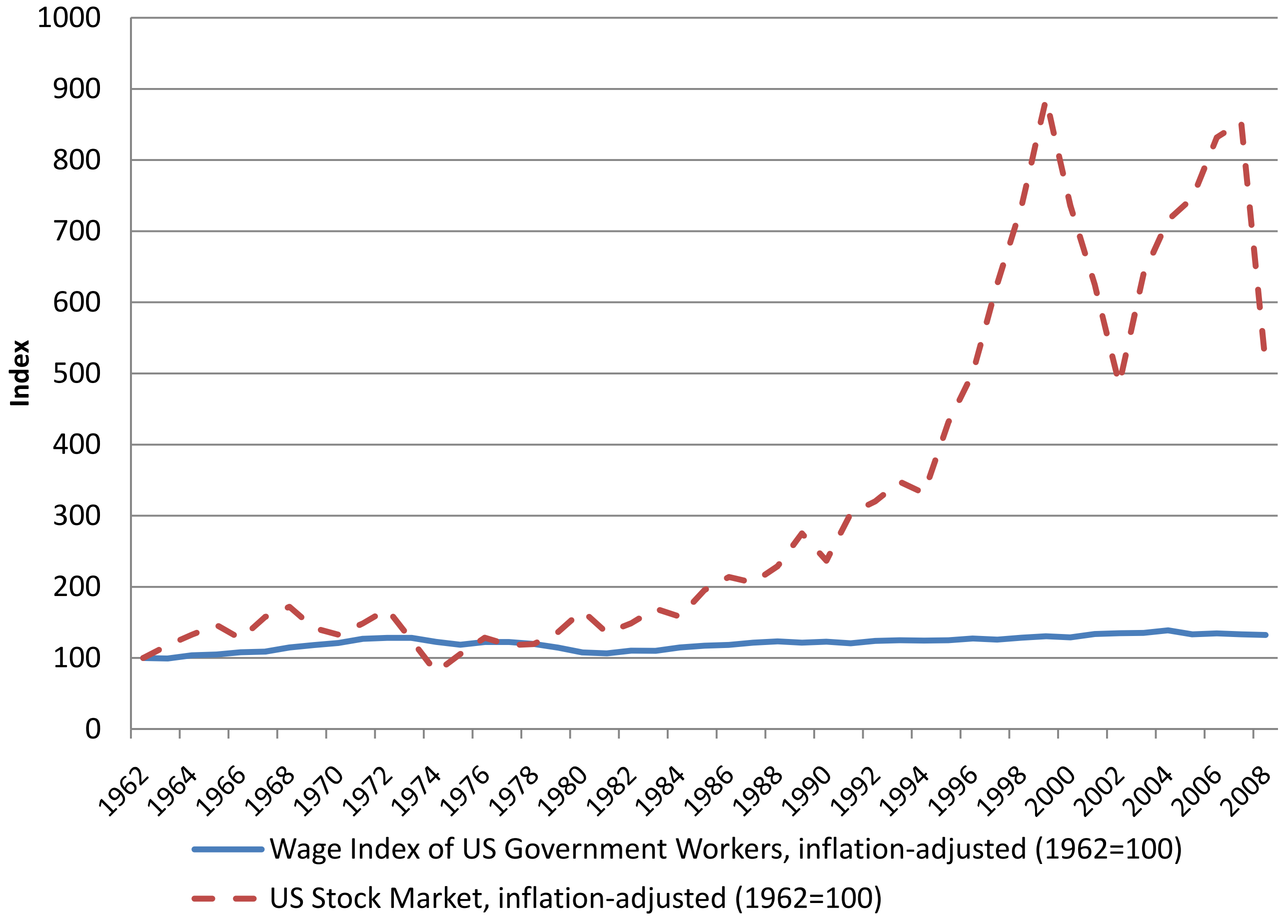


**Table I: Assets Held in State Pension Funds, in Trillions of Dollars**

This table shows assets held in the public pension funds of U.S. states, denominated in trillions of dollars. Measurements are shown from two sources: the latest Comprehensive Annual Financial Report (CAFR) published by the plan, and the *Pensions and Investments* survey of January 2009 reflecting asset allocation as of September 30, 2008. The table also shows estimates based on these two sources for state pension fund assets as of December 31, 2008. The estimates are based on the reported asset allocations for each plan from these two sources and asset class returns over the relevant time periods, all of which are summarized in Appendix Table I.

*Latest Comprehensive Annual Financial Reports (CAFR)*

| | Assets | Plans |
|---|---|---|
| June 30, 2008 Reports | $1.29 | 66 |
| December 31, 2007 Reports | $0.25 | 16 |
| June 30, 2007 Reports | $0.56 | 22 |
| Other Dates | $0.50 | 12 |
| | | |
| Raw Sum of Latest Reports | $2.61 | 116 |
| December 31, 2008 (Estimated) | $2.02 | |

*Pensions and Investments Survey*

| | Assets |
|---|---|
| September 30, 2007, All Plans | $2.66 |
| September 30, 2008, All Plans | $2.30 |
| December 31, 2008 (Estimated) | $1.94 |

**Table II: Summary of Plan Characteristics**

This table shows plan characteristics as collected for as many of our 116 sample plans as possible. The data were taken from the CAFRs and from Center for Retirement Research (2006). Where data were unavailable, these items were ultimately filled in with sample means, but the table shows the data before that step. For 28 plans, benefit factors were given as a range, for which we picked the midpoint. For Cost of Living Adjustment (COLAs), the summary statistics shown are the COLAs that we estimate are built into the states' nominal cash flow projections. The easiest case was if the COLA was fixed, in which case the COLA is just the fixed number given. If the COLAs were a CPI with a cap or Partial CPI, the given formula was applied to the state's inflation assumption. If the COLA was ad hoc, excess earning, or other, we assumed the projected COLA equaled the state's inflation assumption.

| | Benefit Factor | | Inflation | | Discount Rate | | Cost of Living Adjustment (COLA) | |
|---|---|---|---|---|---|---|---|---|
| Mean | 1.97% | | 3.54% | | 7.97% | | 3.13% | |
| Median | 2.00% | | 3.50% | | 8.00% | | 3.00% | |
| Mode | 2.00% | | 3.00% | | 8.00% | | 3.00% | |
| Standard deviation | 0.36% | | 5.71% | | 0.33% | | 0.77% | |
| Count | 94 | | 91 | | 102 | | 94 | |
| | | | | | | | | |
| Detail | <2.00% | 40 | <3.00% | 2 | 7.00% | 2 | Fixed | 19 |
| | 2.00% | 20 | 3.00% | 29 | 7.25% | 5 | CPI with Cap | 26 |
| | >2.00% | 34 | 3.25% | 5 | 7.50% | 13 | Ad hoc | 20 |
| | | 94 | 3.50% | 24 | 7.75% | 7 | Excess Earning | 5 |
| | | | 3.75% | 7 | 7.80% | 1 | Partial CPI | 11 |
| | | | 4.00% | 12 | 8.00% | 45 | Other | 13 |
| | | | 4.50% | 5 | 8.25% | 15 | | 94 |
| | | | 5.00% | 5 | 8.50% | 14 | | |
| | | | Other | 2 | | 102 | | |
| | | | | 91 | | | | |

**Table III: 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 $2.84 trillion of liabilities in the top cell, which is the unadjusted sum of liabilities as reported in the latest financial reports of the 116 plans. 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 state's liabilities and a set of actuarial assumptions based on representative plans.

| *Figures in trillions of U.S. dollars* | Liability |
|---|---|
| Total (Active + Annuitants + Separated) | |
| As Stated, Unharmonized | $2.84 |
| Accumulated Benefit Obligation (ABO) | $2.74 |
| Projected Unit Credit (PUC) | $2.70 |
| Entry Age Normal (EAN) | $2.87 |
| Projected Benefit Obligation (PBO) | $3.19 |
| Active Participants Only | |
| Accumulated Benefit Obligation (ABO) | $0.70 |
| Projected Unit Credit (PUC) | $0.65 |
| Entry Age Normal (EAN) | $0.82 |
| Projected Benefit Obligation (PBO) | $1.15 |
| Annuitants Only | $1.20 |
| Separated Not Yet Receiving Benefits Only | $0.84 |

**Table IV: 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 the *taxpayer obligation* measure, benefits are assumed to have equal priority to state general obligation (GO) bonds. They are discounted at municipal bond rates excluding the tax preference, based on the zero-coupon municipal yield curve as of January 30, 2009. In the *funding adequacy* measure, benefits are assumed to be riskless. For the funding adequacy measure, liabilities are discounted using the zero-coupon Treasury yield curve as of January 30, 2009. These yield curves are shown in Figure 3.

Taxpayer Obligation Measure

Risk Assumption: Equal Priority to General Obligation (GO) Bonds

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

| | Amount | |
|---|---|---|
| Annuitants | $1.44 | trillion |
| Separated Not Yet Receiving Benefits | $0.95 | trillion |
| Actives (Accumulated Benefit Obligation) | $0.75 | trillion |
| | | |
| Total Liabilities | $3.15 | |
| Total Assets (December 2008) | $1.94 | |
| Unfunded Liabilities | $1.21 | |

Funding Adequacy Measure

Risk Assumption: Risk-free

Discount rate: $r_f$, the Treasury rate

| | Amount | |
|---|---|---|
| Annuitants | $1.67 | trillion |
| Separated Not Yet Receiving Benefits | $1.71 | trillion |
| Actives (Accumulated Benefit Obligation) | $1.68 | trillion |
| | | |
| Total Liabilities | $5.06 | |
| Total Assets (December 2008) | $1.94 | |
| Unfunded Liabilities | $3.12 | |

**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 liability cash flows using the Treasury zero-coupon yield curve as of January 30, 2009. The second column discounts the pension payments at taxable muni rates, based on taxable municipal zero-coupon yield curves as of January 30, 2009. These yield curves are shown in Figure 3. The third column discounts to the Treasury rate plus a 51bp premium for salary risk as explained in the text, and the fourth column to the taxable muni rate plus the 51bp salary risk premium. The salary risk premium is only added to the active worker component. 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.

| *Figures in trillions of dollars* | $\frac{r_{muni(j)}}{1-\tau_B}$ | $r_f$ | $\frac{r_{muni(j)}}{1-\tau_B}$ + Wage Risk | $r_f$ + Wage Risk |
|---|---|---|---|---|
| Total (Active + Annuitants + Separated) | | | | |
| Accumulated Benefit Obligation (ABO) | $3.15 | $5.06 | $3.15 | $5.06 |
| Projected Unit Credit (PUC) | $3.10 | $4.98 | $3.03 | $4.79 |
| Entry Age Normal (EAN) | $3.27 | $5.50 | $3.18 | $5.24 |
| Projected Benefit Obligation (PBO) | $3.60 | $6.90 | $3.47 | $6.40 |
| Active Participants | | | | |
| Accumulated Benefit Obligation (ABO) | $0.75 | $1.68 | $0.75 | $1.69 |
| Projected Unit Credit (PUC) | $0.71 | $1.60 | $0.64 | $1.41 |
| Entry Age Normal (EAN) | $0.88 | $2.11 | $0.79 | $1.86 |
| Projected Benefit Obligation (PBO) | $1.20 | $3.52 | $1.08 | $3.02 |
| Annuitants | $1.44 | $1.67 | $1.44 | $1.67 |
| Separated Not Yet Receiving Benefits | $0.95 | $1.71 | $0.95 | $1.71 |

**Appendix Table I: Asset Allocation and Asset Class Returns**

As a proxy for the returns to domestic stock, international stock and real estate we use the returns to Barra/MSCI Investible Indices (USA, World ex-USA and US REIT, respectively). For domestic fixed income, international fixed income, mortgages and "other" we use Barclays Capital Indices (US Government/Credit, Global Aggregate Ex USA, US MBS and Hedge Fund (Asset Weighted), respectively). We get the returns to cash and equivalents from Ken French's website (one month risk-free rate). For the return to private equity we use the mid-point of the range estimated by Steven N. Kaplan (private conversation).

| | Asset-Weighted Average Asset Allocation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Domestic Stock | International Stock | Domestic Fixed Income | International Fixed Income | Cash and Equivalents | Private Equity | Real Estate Equity | Mortgages | Other |
| Latest Annual Financial Reports | | | | | | | | | |
| June 2008 Reports (N=66) | 36.0% | 16.5% | 25.4% | 2.1% | 2.7% | 3.8% | 6.7% | 0.9% | 5.8% |
| December 2007 Reports (N=16) | 35.6% | 17.9% | 26.9% | 2.3% | 2.4% | 1.8% | 6.4% | 3.1% | 3.8% |
| June 2007 Reports (N=22) | 42.0% | 16.9% | 22.4% | 2.1% | 4.7% | 1.1% | 5.0% | 0.6% | 5.3% |
| Pensions & Investments, September 2008 | 35.1% | 17.8% | 23.7% | 2.2% | 1.5% | 8.0% | 7.3% | 0.9% | 3.4% |

| | Returns | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Domestic Stock | International Stock | Domestic Fixed Income | International Fixed Income | Cash and Equivalents | Private Equity | Real Estate Equity | Mortgages | Other |
| Returns Used to Calculate Totals | | | | | | | | | |
| September 2008 to December 2008 | -22.8% | -21.5% | 2.7% | 5.7% | 0.2% | -12.5% | -39.1% | -15.0% | -7.4% |
| June 2008 to December 2008 | -30.1% | -38.1% | 1.5% | -0.6% | 0.6% | -17.8% | -35.8% | -20.3% | -17.8% |
| December 2007 to December 2008 | -38.6% | -45.2% | 2.4% | 4.4% | 1.6% | -18.1% | -38.0% | -22.7% | -18.1% |

**Appendix Table II: Actuarial Assumptions**

This table sets out the actuarial assumptions we use to translate among different liability methods and discount rates. Panel A which simply shows member counts and average salaries for plans by actuarial method, were calculated using data from the Center for Retirement Research (2006) and the CAFRs of the 116 sample plans. For Panels B, C, and D, we examined the CAFRs of the 10 states with the largest total liabilities and took the assumptions from the reports where they were usable: New York, Illinois, Pennsylvania, Ohio, and Texas. The figures represent an average over the reports. Our model assumes that all job leavers leave with vested pension benefits, and that benefits are adjusted to be taken at a normal retirement age of 65 in an actuarially fair way. Where necessary we perform linear interpolations between age brackets.

*A. Member Counts and Average Salary by Plan Actuarial Method*

| | Member Counts (Millions of People) | | | | |
|---|---|---|---|---|---|
| | Active | Annuitants | Separated Vested | Total | Average Salary |
| All | 12.11 | 5.81 | 2.17 | 20.09 | $39,829 |
| Projected Unit Credit | 1.58 | 0.79 | 0.37 | 2.75 | $43,480 |
| Entry Age Normal and Related | 10.52 | 5.02 | 1.80 | 17.34 | $39,279 |

*B. Service Distribution of Job Leavers*

| Min Years | Max Years | Distribution |
|---|---|---|
| 5 | 10 | 8.1% |
| 11 | 15 | 10.6% |
| 16 | 20 | 11.5% |
| 21 | 25 | 15.1% |
| 26 | 30 | 18.5% |
| 30 | 100 | 36.2% |

*C. Salary Growth and Separation Rate by Age*

| Age | Salary Growth | Separation Rate |
|---|---|---|
| 21-25 | 10.0% | 19.8% |
| 26-30 | 11.2% | 9.1% |
| 31-35 | 7.6% | 6.8% |
| 36-40 | 7.0% | 6.0% |
| 41-45 | 6.1% | 4.9% |
| 46-50 | 5.6% | 4.7% |
| 51-55 | 5.0% | 4.7% |
| 56-60 | 4.7% | 21.4% |
| 61-65 | 4.2% | 23.3% |
| 66-70 | 4.0% | 26.1% |
| 71-75 | 4.1% | 54.9% |

*D. Age-Service Matrices*

i.) Age-Service Weights (share of workforce in a given age-service bracket)

| Age | | Years of Service | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | Max | 0-5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-30 | 31-35 | 36-40 | 41-45 | 46-50 | 51-55 |
| 21 | 25 | 0.033 | 0.000 | | | | | | | | | |
| 26 | 30 | 0.108 | 0.021 | 0.000 | | | | | | | | |
| 31 | 35 | 0.053 | 0.068 | 0.010 | 0.000 | | | | | | | |
| 36 | 40 | 0.038 | 0.042 | 0.044 | 0.007 | 0.000 | | | | | | |
| 41 | 45 | 0.036 | 0.027 | 0.024 | 0.027 | 0.006 | 0.000 | | | | | |
| 46 | 50 | 0.032 | 0.027 | 0.019 | 0.018 | 0.023 | 0.006 | 0.001 | | | | |
| 51 | 55 | 0.023 | 0.024 | 0.022 | 0.019 | 0.018 | 0.028 | 0.013 | 0.000 | | | |
| 56 | 60 | 0.014 | 0.015 | 0.017 | 0.020 | 0.018 | 0.016 | 0.026 | 0.004 | 0.000 | | |
| 61 | 65 | 0.007 | 0.005 | 0.006 | 0.007 | 0.007 | 0.005 | 0.004 | 0.003 | 0.000 | | |
| 66 | 70 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | |
| 71 | 75 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

ii.) Age-Service Relative Wages (as a fraction of overall average wage)

| Age | | Years of Service | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | Max | 0-5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-30 | 31-35 | 36-40 | 41-45 | 46-50 | 51-55 |
| 21 | 25 | 0.570 | 0.441 | | | | | | | | | |
| 26 | 30 | 0.698 | 0.844 | 0.767 | | | | | | | | |
| 31 | 35 | 0.718 | 0.911 | 0.882 | 0.695 | | | | | | | |
| 36 | 40 | 0.655 | 0.899 | 1.069 | 1.123 | 1.020 | | | | | | |
| 41 | 45 | 0.603 | 0.804 | 1.037 | 1.174 | 1.204 | 0.948 | | | | | |
| 46 | 50 | 0.588 | 0.746 | 0.927 | 1.125 | 1.245 | 1.253 | 0.959 | | | | |
| 51 | 55 | 0.610 | 0.761 | 0.906 | 1.056 | 1.215 | 1.325 | 1.367 | 1.344 | | | |
| 56 | 60 | 0.659 | 0.772 | 0.903 | 1.043 | 1.168 | 1.307 | 1.413 | 1.478 | 1.352 | | |
| 61 | 65 | 0.686 | 0.745 | 0.868 | 0.998 | 1.119 | 1.202 | 1.318 | 1.491 | 1.461 | | |
| 66 | 70 | 0.760 | 0.848 | 0.911 | 1.011 | 1.083 | 1.164 | 1.241 | 1.345 | 1.429 | 1.160 | |
| 71 | 75 | 0.718 | 0.722 | 0.540 | 0.764 | 0.878 | 0.880 | 1.132 | 1.301 | 1.172 | 1.358 | 1.276 |

## Supplemental Appendix Table I: State Pension Data for 2008 ($ billions)

| State Name (Number of Plans) | Pension Assets | Pension Liabilities, Stated | Pension Liabilities, Taxpayer Obligation | Pension Liabilities, Funding Obligation | Debt | Revenues (2007) | GDP (2007) | S&P General Obligation Rating |
|---|---|---|---|---|---|---|---|---|
| Alabama (3) | 22.3 | 38.7 | 43.4 | 74.8 | 7.1 | 27.5 | 165.8 | AA |
| Alaska (2) | 11.7 | 13.7 | 15.1 | 24.1 | 6.6 | 12.5 | 44.5 | A+ |
| Arizona (3) | 25.0 | 38.7 | 42.4 | 80.3 | 9.5 | 29.9 | 247.0 | NR |
| Arkansas (3) | 8.1 | 19.6 | 21.9 | 35.6 | 4.5 | 18.2 | 95.4 | AA |
| California (3) | 330.0 | 456.8 | 468.5 | 763.0 | 114.7 | 299.9 | 1813.0 | A |
| Colorado (1) | 29.3 | 52.5 | 56.9 | 100.9 | 14.9 | 26.9 | 236.3 | NR |
| Connecticut (3) | 20.4 | 42.7 | 51.5 | 89.2 | 23.8 | 25.5 | 216.3 | AA |
| Delaware (1) | 6.2 | 6.5 | 7.6 | 12.2 | 5.2 | 7.4 | 60.1 | AAA |
| Florida (1) | 97.2 | 124.1 | 139.7 | 215.9 | 36.3 | 95.0 | 734.5 | AAA |
| Georgia (2) | 53.7 | 70.9 | 77.4 | 123.1 | 11.4 | 45.1 | 396.5 | AAA |
| Hawaii (1) | 8.3 | 15.7 | 17.6 | 27.9 | 6.0 | 11.2 | 61.5 | AA |
| Idaho (1) | 8.1 | 11.2 | 11.1 | 19.8 | 2.8 | 9.1 | 51.1 | NR |
| Illinois (4) | 65.7 | 147.8 | 179.2 | 288.2 | 54.5 | 71.3 | 609.6 | AA |
| Indiana (2) | 15.5 | 34.3 | 37.0 | 61.1 | 19.2 | 32.4 | 246.4 | AAA |
| Iowa (1) | 18.1 | 24.5 | 23.5 | 42.5 | 6.7 | 19.1 | 129.0 | NR |
| Kansas (1) | 10.3 | 19.0 | 19.4 | 34.9 | 5.7 | 15.0 | 117.3 | NR |
| Kentucky (3) | 21.6 | 41.7 | 41.8 | 75.9 | 10.9 | 25.4 | 154.2 | NR |
| Louisiana (2) | 17.7 | 35.7 | 42.1 | 69.6 | 14.3 | 33.3 | 216.1 | A+ |
| Maine (1) | 8.3 | 13.7 | 14.8 | 25.0 | 5.3 | 9.4 | 48.1 | AA |
| Maryland (1) | 27.8 | 50.2 | 56.4 | 87.6 | 19.0 | 34.8 | 268.7 | AAA |
| Massachusetts (2) | 37.8 | 51.0 | 59.0 | 97.9 | 67.9 | 49.4 | 351.5 | AA |
| Michigan (4) | 43.4 | 66.0 | 72.9 | 119.2 | 33.7 | 63.1 | 382.0 | AA- |
| Minnesota (4) | 36.2 | 57.2 | 68.4 | 107.8 | 8.9 | 38.7 | 255.0 | AAA |
| Mississippi (3) | 15.1 | 29.3 | 32.6 | 52.2 | 5.9 | 22.4 | 88.5 | AA |
| Missouri (3) | 27.0 | 51.3 | 59.6 | 90.6 | 18.7 | 32.7 | 229.5 | AAA |
| Montana (2) | 5.9 | 8.6 | 9.9 | 15.4 | 4.6 | 7.1 | 34.3 | AA |
| Nebraska (2) | 5.4 | 7.9 | 8.1 | 13.9 | 2.2 | 10.0 | 80.1 | NR |
| Nevada (1) | 17.8 | 24.0 | 27.2 | 43.4 | 4.1 | 14.2 | 127.2 | AA+ |
| New Hampshire (1) | 4.4 | 7.8 | 9.3 | 14.9 | 7.7 | 7.2 | 57.3 | AA |
| New Jersey (4) | 60.5 | 116.4 | 140.6 | 216.3 | 51.4 | 65.5 | 465.5 | AA |
| New Mexico (2) | 16.2 | 25.9 | 29.1 | 44.5 | 7.3 | 16.8 | 76.2 | AA+ |
| New York (3) | 189.8 | 214.1 | 236.8 | 355.4 | 110.1 | 178.9 | 1103.0 | AA |
| North Carolina (2) | 59.1 | 61.1 | 64.6 | 103.0 | 19.2 | 51.8 | 399.4 | AAA |
| North Dakota (2) | 2.9 | 3.6 | 4.1 | 6.8 | 1.8 | 4.8 | 27.7 | AA |
| Ohio (5) | 115.6 | 181.8 | 205.4 | 323.7 | 26.1 | 86.4 | 466.3 | AA+ |
| Oklahoma (4) | 12.0 | 32.3 | 35.9 | 56.6 | 8.7 | 22.3 | 139.3 | AA+ |
| Oregon (1) | 46.1 | 53.4 | 62.7 | 97.7 | 11.3 | 30.6 | 158.2 | AA |
| Pennsylvania (2) | 70.9 | 98.3 | 116.3 | 185.2 | 37.1 | 83.4 | 531.1 | AA |
| Rhode Island (1) | 6.0 | 11.7 | 13.5 | 22.0 | 8.4 | 8.4 | 46.9 | AA |
| South Carolina (2) | 21.8 | 37.5 | 38.6 | 60.9 | 15.0 | 27.5 | 152.8 | AA+ |
| South Dakota (1) | 6.0 | 6.7 | 6.8 | 12.4 | 3.2 | 4.9 | 33.9 | NR |
| Tennessee (1) | 25.8 | 32.7 | 34.8 | 55.5 | 4.1 | 29.5 | 243.9 | AA+ |
| Texas (4) | 125.3 | 177.3 | 194.9 | 312.8 | 23.9 | 114.7 | 1142.0 | AA |
| Utah (3) | 18.6 | 19.3 | 22.3 | 34.3 | 5.9 | 15.9 | 105.7 | AAA |
| Vermont (3) | 2.4 | 3.8 | 4.4 | 7.0 | 3.1 | 5.4 | 24.5 | AA+ |
| Virginia (1) | 41.3 | 58.1 | 63.3 | 95.5 | 19.7 | 47.2 | 383.0 | AAA |
| Washington (7) | 44.3 | 55.6 | 62.7 | 99.2 | 21.1 | 47.0 | 311.3 | AA+ |
| West Virginia (2) | 6.6 | 11.6 | 12.0 | 19.4 | 5.6 | 11.9 | 57.7 | AA- |
| Wisconsin (1) | 62.2 | 73.7 | 80.5 | 132.8 | 21.5 | 40.2 | 232.3 | AA |
| Wyoming (4) | 4.8 | 6.6 | 7.4 | 11.8 | 1.2 | 5.8 | 31.5 | AA |
| TOTAL (116) | 1,936.7 | 2,842.9 | 3,151.2 | 5059.6 | 937.8 | 1,992.8 | 13,649.2 | |

**Supplemental Appendix Table II: Government Employee Wage Data and the Stock Market**

| CPS Year | Mean Wage Income | Standard Deviation of Wage Income | Growth in Mean Wage Income | CPI Inflation | Government Wage Growth Minus CPI Inflation | Risk free rate ($r_f$) | Stock Market Return ($r_m$) | Excess Return ($r_m$-$r_f$) |
|---|---|---|---|---|---|---|---|---|
| 1962 | 5000 | 2724 | | | | 2.7% | -10.3% | -13.1% |
| 1963 | 5033 | 2446 | 0.7% | 1.3% | -0.7% | 3.1% | 20.9% | 17.8% |
| 1964 | 5327 | 2881 | 5.8% | 1.3% | 4.5% | 3.5% | 16.3% | 12.8% |
| 1965 | 5471 | 2632 | 2.7% | 1.6% | 1.1% | 3.9% | 14.4% | 10.5% |
| 1966 | 5791 | 3159 | 5.9% | 2.9% | 3.0% | 4.8% | -8.7% | -13.4% |
| 1967 | 6023 | 2874 | 4.0% | 3.1% | 0.9% | 4.2% | 28.6% | 24.4% |
| 1968 | 6598 | 3699 | 9.6% | 4.2% | 5.4% | 5.2% | 14.2% | 9.0% |
| 1969 | 7148 | 4188 | 8.3% | 5.5% | 2.9% | 6.6% | -10.8% | -17.4% |
| 1970 | 7734 | 3686 | 8.2% | 5.7% | 2.5% | 6.5% | 0.1% | -6.4% |
| 1971 | 8446 | 4279 | 9.2% | 4.4% | 4.8% | 4.4% | 16.2% | 11.8% |
| 1972 | 8814 | 5184 | 4.4% | 3.2% | 1.2% | 3.8% | 17.3% | 13.5% |
| 1973 | 9357 | 4777 | 6.2% | 6.2% | -0.1% | 6.9% | -18.8% | -25.7% |
| 1974 | 9977 | 5379 | 6.6% | 11.0% | -4.4% | 8.0% | -27.9% | -36.0% |
| 1975 | 10556 | 5762 | 5.8% | 9.1% | -3.3% | 5.8% | 37.4% | 31.6% |
| 1976 | 11499 | 5646 | 8.9% | 5.8% | 3.2% | 5.1% | 26.8% | 21.7% |
| 1977 | 12248 | 5944 | 6.5% | 6.5% | 0.0% | 5.1% | -3.0% | -8.1% |
| 1978 | 12924 | 6336 | 5.5% | 7.6% | -2.1% | 7.2% | 8.6% | 1.4% |
| 1979 | 13829 | 7108 | 7.0% | 11.3% | -4.3% | 10.4% | 24.4% | 14.0% |
| 1980 | 14879 | 8008 | 7.6% | 13.5% | -5.9% | 11.3% | 33.2% | 22.0% |
| 1981 | 16236 | 7193 | 9.1% | 10.3% | -1.2% | 14.7% | -4.0% | -18.7% |
| 1982 | 17813 | 7941 | 9.7% | 6.2% | 3.6% | 10.5% | 20.4% | 9.9% |
| 1983 | 18333 | 9481 | 2.9% | 3.2% | -0.3% | 8.8% | 22.7% | 13.9% |
| 1984 | 19926 | 10540 | 8.7% | 4.3% | 4.4% | 9.8% | 3.2% | -6.7% |
| 1985 | 21048 | 11155 | 5.6% | 3.6% | 2.1% | 7.7% | 31.4% | 23.7% |
| 1986 | 21657 | 11127 | 2.9% | 1.9% | 1.0% | 6.2% | 15.6% | 9.4% |
| 1987 | 23038 | 11824 | 6.4% | 3.6% | 2.7% | 5.5% | 1.8% | -3.7% |
| 1988 | 24311 | 12388 | 5.5% | 4.1% | 1.4% | 6.4% | 17.6% | 11.2% |
| 1989 | 25143 | 12972 | 3.4% | 4.8% | -1.4% | 8.4% | 28.4% | 20.1% |
| 1990 | 26749 | 13631 | 6.4% | 5.4% | 1.0% | 7.8% | -6.1% | -13.9% |
| 1991 | 27400 | 13880 | 2.4% | 4.2% | -1.8% | 5.6% | 33.6% | 28.0% |
| 1992 | 29008 | 14717 | 5.9% | 3.0% | 2.9% | 3.5% | 9.1% | 5.6% |
| 1993 | 30067 | 15131 | 3.7% | 3.0% | 0.7% | 2.9% | 11.6% | 8.7% |
| 1994 | 30719 | 15738 | 2.2% | 2.6% | -0.4% | 3.9% | -0.8% | -4.7% |
| 1995 | 31699 | 16922 | 3.2% | 2.8% | 0.4% | 5.6% | 35.7% | 30.1% |
| 1996 | 33301 | 24617 | 5.1% | 3.0% | 2.1% | 5.2% | 21.2% | 16.0% |
| 1997 | 33627 | 22699 | 1.0% | 2.3% | -1.3% | 5.3% | 30.3% | 25.1% |
| 1998 | 34860 | 21563 | 3.7% | 1.6% | 2.1% | 4.9% | 22.3% | 17.4% |
| 1999 | 36204 | 21813 | 3.9% | 2.2% | 1.6% | 4.7% | 25.3% | 20.6% |
| 2000 | 37003 | 21555 | 2.2% | 3.4% | -1.2% | 5.9% | -11.1% | -16.9% |
| 2001 | 39358 | 24954 | 6.4% | 2.8% | 3.5% | 3.9% | -11.3% | -15.1% |
| 2002 | 40366 | 25560 | 2.6% | 1.6% | 1.0% | 1.6% | -20.8% | -22.5% |
| 2003 | 41402 | 28042 | 2.6% | 2.3% | 0.3% | 1.0% | 33.1% | 32.1% |
| 2004 | 43600 | 30343 | 5.3% | 2.7% | 2.6% | 1.2% | 13.0% | 11.8% |
| 2005 | 43281 | 27485 | -0.7% | 3.4% | -4.1% | 3.0% | 7.3% | 4.4% |
| 2006 | 45182 | 33045 | 4.4% | 3.2% | 1.2% | 4.8% | 16.2% | 11.4% |
| 2007 | 45969 | 30834 | 1.7% | 2.8% | -1.1% | 4.7% | 7.3% | 2.6% |
| 2008 | 47416 | 29402 | 3.1% | 3.8% | -0.7% | 1.6% | -38.3% | -40.0% |
| Mean | | | 5.0% | 4.8% | 0.6% | 5.7% | 11.0% | 5.3% |
| Volatility | | | 2.6% | 3.1% | 2.6% | 2.8% | 17.9% | 17.9% |