Online Appendix:

The Sustainability of State and Local Government Pensions: A Public Finance Approach

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This appendix includes the following:

(1) Section A provides a detailed methodology for calculating liabilities and projecting future benefits.
(2) Tables A.1 shows pension benefits as share of payroll in 2017 and 2047 by plan.
(3) Table A.2 shows the date of asset exhaustion under current policy by plan.
(4) Table A.3 show the change in contributions required to stabilize pension debt in the long run by plan.
(5) Table A.4 shows the peak and steady-state pension-to-GDP ratio under long run stabilization by plan.
(6) Table A.5 shows the steady-state funding ratio under long run stabilization by plan.
(7) Table A.6 shows the change in contributions required to stabilize pension debt in 30 years by plan.
(8) Table A.7 shows the funding ratio in 30 years under the 30-year stabilization exercise by plan.
(9) Table A.8 shows the change in contributions required to stabilize funding ratios in 30 years by plan.
(10) Table A.9 reports plans' normal costs in 2017 and 2047 under different scenarios and assumptions.
(11) Table A.10 shows percentiles of debt to GDP and assets to GDP under stochastic asset returns by plan.
(12) Section B provides detailed information on our sample.
(13) Section C shows how we used the data pulled from the plan's actuarial reports.
(14) Section D provides an accounting of our demographic assumptions.
(15) Section E provides information on our asset assumptions.

A. Projecting future benefits

Our analysis is underpinned by the replication of the stated accrued liabilities (AL) of each plan as reported in the PPD. This requires leveraging the collected plan level inputs and stated actuarial assumptions to calculate the present value of future benefits (PVFB) of vested inactive former employees (inact), current beneficiaries (ben) and the accrued liabilities (AL) of current employees (act). Due to the fact our estimated liabilities AL will not perfectly replicate the stated GASB liabilities (AL^{GASB}), we calibrate our projections of nominal future benefits B_t such that they match.

Present Value of Future Benefits

The PVFB is a liability measure which includes both obligations already accrued, as well as obligations associated with the future service of current employees. The most complex of these calculations is that of the currently active employees still accruing liability for normal retirement (ret), the possibility of quitting and claiming deferred retirement ($dret$) or refund of contributions (ref), disability (dis) and $death$. For an active employee of age x and number service years s their PVFB is decomposed as follows:

$$\text{PVFB}_{x,s}^{act} = \text{PVFB}_{x,s}^{ret} + \text{PVFB}_{x,s}^{dret} + \text{PVFB}_{x,s}^{dis} + \text{PVFB}_{x,s}^{death} + \text{PVFB}_{x,s}^{ref} \qquad (A1)$$

The total plan $PVFB^{act}$ is then calculated as a weighted sum over the lower triangular (55 x 55) age service distribution matrix Π^{act} multiplied by the number of active employees in fiscal year 2017 (N_0^{act}).

$$\text{PVFB}^{act} = N_0^{act} \sum_X \sum_S \Pi_{X,S}^{act} \, \text{PVFB}_{X,S}^{act} \qquad (A2)$$

These calculations closely follow that of (Winkelvoss 1993). Creation of the cashflows associated with normal retirement $B_{t,ret}^{act}$ and $PVFB_{x,s}^{ret}$ are detailed below:

$$PVFB_{x,s}^{ret} = \sum_{i=x}^{R} v^{i-x} \, p_{(x,s),i}^T \, q_{(x,s),i}^{ret} \, b_{ret}(x,s,i) a_i \qquad (A3)$$

$$b_{ret}(x,s,i) = \alpha(s+i-x)\left(1 - \kappa Max(r-i,0)\right)E\left[\left.\frac{\sum_{j=i-f}^{i} w_j}{f}\right| (x,s)\right] \qquad (A4)$$

$$E[w_i \mid (x,s)] = w(x,s)(1+\pi_w)^{i-x} \prod_{j=x}^{i}\left(1 + \pi_e(j, s+j-x)\right) \qquad (A5)$$

$PVFB_{x,s}^{ret}$ is calculated as a discounted probability weighted sum of single/joint[1] life annuities a_i (see eq. A24-A25) multiplied by a benefit formula $b_{ret}(x,s,i)$ conditional on age (x), service (s) and retirement age (i). All the above factors and probabilities are plan specific and obtained from

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[1] Married beneficiaries are assumed to opt for a joint life annuity where in the event of their death, their partner receives a prorated benefit.

the AVs or PPD: v is the plans discount factor $\left[\frac{1}{1+\delta}\right]$; $p_{(x,s),i}^{T}$ is the probability of remaining in employment until age i conditional on current age x and service years s; $q_{(x,s),i}^{ret}$ is the probability of retiring at age i however with the exception of workers currently older than the normal retirement age we assume workers retire with probability 1.0 at the normal retirement age; α is the benefit multiplier; κ is a penalty factor, percent per year reduction, for each year retired before the plans normal retirement age r ; w_i is the salary or expected salary at age x calculated from the recorded salary matrix by age and service and grown out under the plans general and age/service specific wage growth assumptions π_w and π_e; f is the number of years the final salary is averaged over to determine salary base for the benefit payments. Furthermore, we calculate these identities for married/unmarried (1_μ) and male/females, and weight by the plans aggregate gender ratio and assumed percent married from the AV. Similar calculations are made for the other decrements.

PVFB for deferred retirement:

$$\text{PVFB}_{x,s}^{dret} = \sum_{i=x}^{R} v^{max(r,i)-x}(1+cola)^{max(r,i)-i}p_{(x,s),i}^{T}q_{(x,s),i}^{wth}\left(1-q_{(x,s),i}^{ref}\right)b_{dret}(x,s,i)p_{i,Max(r,i)}^{m},a_{Max(r,i)} \quad (A6)$$

$$b_{dret}(x,s,i) = \alpha(s+i-x)E\left[\left.\frac{\sum_{j=i-f}^{i} w_j}{f}\right|(x,s)\right] \quad (A7)$$

Employees who do not claim a refund of contributions are assumed to retire at their normal retirement age and receive a benefit according to current service accrual and the average of their highest f salaries adjusted for the plan's COLA.

PVFB for refunds:

$$PVFB_{x,s}^{ref} = \sum_{i=x}^{R} v^{i-x}p_{(x,s),i}^{T}q_{(x,s),i}^{wth}q_{(x,s),i}^{ref} b_{ref}(x,s,i) \quad (A8)$$

$$b_{ref}(x,s,i) = \sum_{j=x-s}^{i} C_{ee}E[w_j(1+rd)^{i-j}|(x,s)] \quad (A9)$$

A certain proportion of employees who quit are assumed to claim a refund equal to the sum of previous contributions at a fixed percent of previous salaries C_{ee} adjusted for interest payments at rate rd.

PVFB for disability:

$$PVFB_{x,s}^{dis} = \sum_{i=x}^{R} v^{i-x}p_{(x,s),i}^{T}q_{(x,s),i}^{dis} b_{dis}(x,s,i)a_i \quad (A10)$$

$$b_{dis}(x, s, i) = \alpha(s + nr - x)E[w_i|(x, s)] \tag{A11}$$

Employees who become disabled immediately begin to receive an annuity calculated based on their current salary and assumed number of years' service had they worked until normal retirement age.

PVFB for early death:

$$PVFB_{x,s}^{dth} = \sum_{i=x}^{R} v^{i-x} p_{(x,s),i}^{T} q_{(x,s),i}^{dth} b_{dth}(x, s, i) a_i \tag{A12}$$

$$b_{dth}(x, s, i) = \alpha(s + i - x)E[w_i|(x, s)] \tag{A13}$$

In the event of death during employment the spouse is assumed to receive an annuity based on the current salary and service years of the decreased plan member.

Inactive members:

Similar calculations are produced for the inactive deferred plan participants and current beneficiaries.

$$PVFB^{inact} = N_0^{inact} \sum_x \sum_s \Pi_{x,s}^{inact} PVFB_{x,s}^{inact} \tag{A14}$$

$$PVFB_{x,s}^{inact} = \tilde{b}(x, s) p_{x,r}^m (1 + cola)^{r-x} v^{r-x} a_r \tag{A15}$$

The distribution of inactive members $\Pi_{x,s}^{inact}$ was calculated as the ergodic distribution produced by the age distribution of new hires in fiscal year 2017 and the termination probabilities from the AV (see appendix C). We assume, like most plans, that these members will claim their accrued benefits at the plans normal retirement age subject to surviving to that age $p_{x,r}^m$, and adjust their imputed accrued benefits for the plans cost of living adjustment.

Current beneficiaries:

$$PVFB^{ben} = N_0^{ben} \sum_x \Pi_x^{ben} PVFB_x^{ben} \tag{A16}$$

$$PVFB_x^{ben} = \bar{b}(x) a_x \tag{A17}$$

The $PVFB^{ben}$ are calculated using data recorded in the plans AVs on the age distribution of current beneficiaries Π_x^{ben} and the average benefit by age $\bar{b}(x)$. The sums of the various probability weighted life annuities a_i that go into the calculation of the $PVFBs$ for each category of plan member also produce our nominal projected cashflow vectors $B_{t=0,1....}$ and projections of future head counts $N_{t=0,1....}$.

<u>Normal costs and Accrued Liabilities</u>

Normal costs (NC) represent the annual cost of accrued benefits for active employees. It is the annual contribution that should in theory leave the plan fully funded when the experience of the plan matches expectations along every dimension[2] (Winkelvoss 1993). Normal costs therefore are used to adjust the $PVFB^{act}$ for the present value of future normal costs ($PVFNC$) to arrive at an estimated accrued liability to date for the current active population. These normal costs and accrued liabilities can be calculated using a large swathe of methods but by far the most popular[3] is the entry age normal which is illustrated below and calculates the normal cost as the level percent[4] salary contribution over the employee's career. This is calculated by dividing the present value of future benefits by the present value of future salaries $\ddot{a}_{x-s,0}$ (see eq. A26) at the employee's entry age (x-s).

$$NC_{x,s} = \frac{PVFB^{act}_{x-s,0}}{\ddot{a}_{x-s,0}} \tag{A18}$$

$$NC_t = \sum_{x,s} w_{x,s,t} \Pi_{x,s,t} NC_{x,s,t} \tag{A19}$$

The NC varies by entry age and starting salary, the plans aggregate NC at time t is therefore a payroll weighted average of each members individual normal cost. Having calculated the NC we can now calculate the plans present value of future normal costs and total stated accrued liability as follows:

$$PVFNC = N_0^{act} \sum_{x} \sum_{s} \Pi_{x,s}^{act} NC_{x,s} \ddot{a}_{x,s} \tag{A20}$$

$$AL^{act} = PVFB^{act} - PVFNC \tag{A21}$$

$$AL = AL^{act} + PVFB^{inact} + PVFB^{ben} \tag{A22}$$

where the PVFNC is a sum over the active populations present value of future salaries from their current age x multiplied by their normal cost rate.

Other accrual methods:

Three plans in the sample use the projected unit credit method whereby the accrued actuarial liability is calculated as follows:

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[2] E.g. assets achieve the assumed returns, wages grow in line with expectations, the workforce composition evolves as expected and so on.
[3] 91 percent of plans in the PPD in fiscal year 2017.
[4] In a few cases this is calculated as a level dollar contribution.

$$AL^{act} = \sum_{x,s} \Pi_{x,s}^{act} \frac{s}{r - (x - s)} PVFB_{x,s}^{act} \qquad (A23)$$

Where the present value of future benefits is pro-rated by the ratio of current service level (s) to the service level at normal retirement (r).

<u>Annuity identities</u>

Single life annuity:

$$a_x^S = \sum_{i=x}^{\infty} p_{x,i}^m v^{i-x}(1 + cola)^{i-x} \qquad (A24)$$

Where $p_{x,i}^m$ is the probability of staying alive from age x until age i; v is a discount factor, cola is a cost of living adjustment. The survival probabilities vary by gender and disability status in accordance with the stated plans assumptions. Mortality probabilities are adjusted for mortality improvement using factors from the SOA MP-2016 tables as the annuitant ages.

Joint life annuity:

$$a_x^J = \sum_{i=x}^{\infty} \left(\left(p_{x,i}^m \left(1 - p_{x,i}^{m(sp)}\right) + p_{x,i}^m p_{x,i}^{m(sp)}\right) + p_{x,i}^{m(sp)}\left(1 - p_{x,i}^m\right)\Phi \right) v^{i-x}(1 + cola)^{i-x} \qquad (A25)$$

The joint life annuity depends on two lives, the beneficiary and the spouse (sp). In the event of the beneficiary dying the annuity continues to payout at a rate reduced by a factor ϕ as long as the spouse is alive.

Temporary employer annuity:

$$a_{(x,s)}^{\cdot\cdot} = \sum_{i=x}^{R} E\left[w_i | (x,s)\right] p_{(x,s),i}^T v^{i-x} \qquad (A26)$$

The temporary employer annuity is used in calculating the present value of future salaries. It is the sum of the expected discounted future salaries of an employee aged x with service years s, adjusted for the probability of remaining in employment until age i, $p_{(x,s),i}^T$.

<u>Calibration</u>

In order to ensure our projections are as accurate as possible we calibrate our projected cashflows such that they produce each plan's stated actuarial liabilities (AL) as reported in their AV's.

The stated actuarial liability for current beneficiaries and inactive plan members (who are no longer accruing benefits) is the discounted sum (or present value) of their projected future benefits discounted using the plan's chosen discount rate (δ). The stated liabilities of current workers is the present value of their accrued normal costs.

Having calculated the liabilities for each group of members we calibrate the cash flows using calibration factors such that the following holds:

$$AL^{act,AV} \equiv v_{c,1} \, AL^{act} \tag{A27}$$

$$AL^{inact,AV} \equiv v_{c,2} AL^{inact} \tag{A28}$$

$$AL^{ben,AV} = \sum_{t=0}^{\infty} \left(\left[\frac{1}{1+\delta}\right]\right)^t (v_{c,3})^t B_t^{ben} \tag{A29}$$

Where $AL^{act,AV}$ and $AL^{inact,AV}$ are the accrued liabilities for active and inactive workers from the 2017 actuarial valuation, AL^{act} and AL^{inact} are the accrued liabilities for active and inactive workers from our calculations, B_t^{ben} is the pension cash flow for current beneficiaries from our calculations, and the $v_{c,i}$ are the calibration factors.

For current employees and current inactives, we generally found we were underestimating prospective benefit levels for current employees due to idiosyncratic factors, such as not accounting for unclaimed sick leave, that boost benefits by a roughly constant percent throughout retirement. Accordingly, we make a proportional change to their benefit streams in our projections ($v_{c,1} B_t^{act}$). We also apply the same calibration factor ($v_{c,1}$) to the new hire cash flow projections (see below). We do a similar proportional calibration for the inactive plan members.

$v_{c,3}$ is a geometric calibration factor which ensures that our estimated cash flow for current beneficiaries reproduces the AL for current beneficiaries stated in the AV report when we discount it at the plan's stated discount rate. The choice of a geometric calibration for current beneficiaries reflects that benefits at time t=0 are known with certainty and that errors are likely to reflect issues with mortality assumptions and COLAs, both of which will accumulate over time; this calibration is similar to that used in Novy-Marx and Rauh (2011) and Lutz and Sheiner (2014). Finally, we note that due to the fact our uncalibrated estimates were on average quite accurate,[5] the calibration process does not have a large effect on our analysis (see appendix B, table B3).

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[5] In addition to being on average quite accurate for the AL liability concept, our estimates are also on average accurate for the broader PVFB liability concept.

Normal Cost Calculations

Table A9 presents the pension plans' expected normal costs as a percent of plan payroll in 2017 and 2047. The first column presents the 2017 normal cost as reported in the plans AV report (and therefore calculated using the respective plan's chosen actuarial assumptions, including the discount rate). The second column presents the 2017 normal cost as calculated through use of our estimation machinery under our actuarial and economic assumptions as detailed in section IV of the paper and in this appendix. Our normal costs are significantly higher than those reported by plans in their actuarial valuations, primarily due to the fact we use a much lower discount factor of 0.5% compared to rates of 7% to 8% assumed by plans. Focusing on the aggregated U.S. values, under our baseline scenario, normal costs are expected to drift downwards over time from 51.3% in 2017 to 47.5% in 2047 due to reforms made by plans. Absent these reforms, normal costs would rise from 53.8% to 55.1%. In 2047, the reforms are estimated to lower normal costs by around 8 percentage points, equal to nearly 15% of the 55.2% normal cost that would prevail in the absence of the reforms. (Note, though, that the reforms lower normal costs both in 2017 and in 2047.) The presence of these reforms for each plan is indicated in the final 5 columns. Finally, we show that were plans to adopt COLA policies that were guaranteed to follow measured inflation, normal costs would be substantially higher both in 2017 and in 2047 and would reach 64.6% by 2047.

Our normal costs are higher than the contributions required to stabilize pension debt in our long-run stabilization exercises. This occurs for several reasons:

- In all asset return scenarios, U.S. aggregate normal costs decline over time. Thus, at a point in time prior to reaching the long run steady state, required contributions for pension debt stabilization can be lower than the normal cost at that time.
- In some asset return scenarios, the return on assets is greater than interest payments on the implicit debt (i.e. in scenarios when asset returns exceed the discount rate). This wedge allows the required contribution for stabilization to be below the normal cost.
- In all asset return scenarios using the 0.5% risk-free rate of return, the rate of interest on implicit pension debt is less than GDP growth, r<g; this constellation of growth and interest rates induces favorable debt dynamics of the type discussed in the recent literature on government debt sustainability (e.g. Blanchard 2019). Thus, even when asset returns are set equal to the discount rate, as is the case in the risk free 0.5% real asset return scenario, required contributions for pension debt stabilization can be lower than the normal cost in steady state. This can be understood intuitively by observing that in steady state, to hold pension debt fixed each year, annual contributions much cover the cost of benefits accrued that year – i.e. the normal cost – plus the cost of holding the existing stock of unfunded pension liabilities fixed as a share of GDP. See equation (1) in the main text. With r<g, annual GDP growth exceeds the annual growth in the unfunded liabilities – i.e. each year economic growth retires a portion of the pension debt as a share of the economy. Accordingly, the required contribution to maintain pension debt as a share of the economy can be lower than the normal cost in steady state, even with asset returns and the discount rate harmonized.

o   Table A3 shows that the required contribution for long-run pension debt stabilization under the 0.5% real risk free asset return, act now scenario is 37 percent of payroll (equal to the 24 percent current contribution in 2017 plus a 13 percent required increase). Table A9 shows the normal cost for the U.S. aggregate plan in 2047 in our baseline results (which use the 0.5% real discount rate) of 47.5 percent of payroll. Thus, the required contribution for stabilization is 10.5 percentage points below the normal cost in 2047. This wedge is explained by the favorable debt dynamics present under very low interest rates. Referencing equation (1) in the main text, debt stabilization in steady requires the following annual contribution: $nc + \frac{(r-g)}{(1+g)}d$. As a share of payroll, unfunded liabilities, d, equal 920 percent of payroll and 37 percent of GDP in 2047. Nominal GDP and nominal payroll growth, g, equal 3.9 percent, reflecting real growth of 1.7 percent and 2.2 percent CPI inflation; this GDP growth rate is based on assumptions in the long run CBO projection. (In steady state, payroll and GDP rise in lock step.) The nominal interest rate, r, equals 2.7 percent, reflecting a real rate of 0.5 percent. As a result, favorable debt dynamics reduce the required annual contribution for long run debt stabilization by around 11 percentage points of payroll: $\frac{(2.7\% - 3.9\%)}{(1+3.9\%)} * 920\%. \sim = 11\%$. Thus, the favorable debt dynamics are roughly equal to the difference between the required contribution and the normal cost in 2047. (Note that the steady state, upon which equation (1) is based, has not been fully reached in 2047.)

B. Data
See Tables B1, B2, and B3 for details. Figures B1 and B2 show additional detail.

C. Plan matrices and imputations
This section summarizes the plan matrices key to the creation of the cashflows and liabilities and any imputation steps required to take the values reported in each plans AV to the standardized form illustrated below.

As discussed in the main text, the plan AVs and CAFRs while generally similar, present information in a non-standardized format. To overcome this, we developed a set of standardized procedures to take the data we extracted from the AVs/CAFRs and put it into the format we required. A complicated example is the provision of average salary information for active members along the age dimension only. (In a few cases no distributional information was provided at all.) In this case we leveraged the wage growth matrix by age and service to back out a reasonable estimate of implied salary relativities by age and service. These imputed relativities by age and service could then be combined with the plan's active member age service distribution and plan level average salary to obtain imputed average salaries by age and service. Another common issue was that of multiple categories of employees, actuarial assumptions and

benefits provisions within consolidated plans. For example, the Los Angeles County Retirement Association is composed of 8 different tiers, 5 for the general population and 3 for safety workers such as police and firefighters. Each tier contained different plan provisions e.g. benefit factors, and actuarial assumptions like retirement rates or pay growth also varied between safety and non-safety members. In cases such as this we aggregated the assumptions into one plan input using appropriate weightings wherever possible, usually the number of active employees or payroll by tier.

We now present each of the matrices, with discussion of imputation procedures where appropriate.

See Figure C1.

Figure C2 was nearly always entirely available. In a few instances average salaries were only provided by age. In this instance we used the wage growth assumptions to grow out wages along each diagonal and then used the relativities by age, age service distribution matrix and average plan salary to impute a matrix.

When benefit distributions or relativities were not available by age, as shown in Figure C3, we imputed with the average from the other plans and adjusted such that the average age and benefit level matched the AV. The benefit relativity is the relativity to the average benefit reported in the AV.

The matrix shown in Figure C4 was imputed using the withdrawal matrix and distribution of new hires implied by the age service matrix. The matrix describes the current age and number of years service at withdrawal. The imputed matrix is the steady state solution to the following dynamic system of equations:

$$\Pi_t^{inact} = D\Pi_{t-1}^{inact} + D\left(\Pi_{t-1}^{act} \circ Q^{wth}(1 - Q^{ref})\right) \qquad (C1)$$

$$\Pi_t^{act} = \Pi_{nh} + D\left(\Pi_{t-1}^{act} \circ (1 - Q^{wth})\right)R \qquad (C2)$$

Where Π_t are the inactive and active time t distributions of employees, D shifts the distributions down by one row (ages the population) and R shifts the distributions right by one (increases service level), Q are the refund and withdrawal probability matrices and $\circ$ is the Hadamard product (element wise multiplication). Π_{nh} are the new hires added to the active distribution with an age distribution that matches the current distribution of new hires and adjusted such that the overall distribution Π_t^{act} sum to one i.e. a steady headcount is maintained.

We decided not to use the salary increases by age and years of service in the AV reports because they were not always available in sufficient detail and, when they were, they produced estimated salary increases that seemed far too low in the first few years and that would have greatly affected the relative salaries by age and service. Given that our exercise stabilizes contributions

as a share of GDP, and GDP is determined by overall productivity growth (which we obtain from CBO) and labor force growth, this would have led to smaller increases in required contributions as a result of the divergent increases in state and local payroll and GDP. Rather than possibly biasing our estimated required contributions downward, we chose to maintain the relative salaries by age and service over time, and simply boost all state and local salaries by productivity growth and inflation. We do this both for the calibration and the stabilization exercises. If salaries of state and local employees do indeed grow more slowly over time, then the required contribution increases to stabilize the implicit debt would be smaller.

$$q_{a,s}^{wth} = \beta_0 + \beta_1 1_{s<5} + +\beta_2 s + \beta_3 s^2 + \beta_4 s^3 + \beta_5 a + \beta_6 a^2 + \beta_7 a^3 + \epsilon_{a,s} \qquad (C4)$$

The matrix in Figure C5 was constructed by taking the withdrawal assumptions by age and/or service and using a linear regression to bring the data into our standardized format. We censored the predicted values below zero. Typically, assumptions were provided in similar form to that of Figure C6, in instances where this was not the case, we adjusted equation C4 accordingly.

See Figure C6.

Retirement probabilities

We assume workers retire at the normal retirement age with probability 1.0. For those aged above the normal retirement age in the initial population we assume they retire with a probability of 0.20 in each until age 75 where they retire with probability 1.0. The 0.20 probability was chosen based on the average post normal retirement age probability reported in the AV's. In previous editions of this work we had implemented retirement matrices with varying probabilities by age and service but this was difficult to maintain in tandem with the rich treatment of plan tiers and reforms.

D. Demographic projection
To project the growth of the working-age population in each state, we use a variant of the methodology used by the Demographic Group at the Weldon Cooper Center for Public Service (www.demographics.coopercenter.org). The basic approach is to begin with the population by age group and state in 2010 from the U.S. Census and then to age that population going forward using historical state and national trends.

In particular, using the 1990, 2000, and 2010 censuses, we perform the following calculations for each state and for the country as a whole:

For children younger than 10 in state j: We calculate a "fertility rate" that captures the ratio of kids to women of childbearing age:

$$Fertility_{0-4,j} = \frac{Kids_{0-4,2010,j}}{Women_{15-44,2010,j}} \qquad (22)$$

$$Fertility_{5-9,j} = \frac{Kids_{5-9,2010,j}}{Women_{20-49,2010,j}} \qquad (23)$$

For individuals ages 10 to 65, we create a "survival" rate that captures both mortality and in- and out-migration in five year age groups. To better capture long-run trends, we use the average survival rates from the 2010 and 2000 censuses.

For example, for 20-24 year olds in state j, we calculate:

$$Survival_{20-24,j} = .5 * \frac{Population_{20-24,2010,j}}{Population_{10-14,2000,j}} + .5 * \frac{Population_{20-24,2000,j}}{Population_{10-14,1990,j}} \qquad (24)$$

For states that are losing population to out-migration, there will be fewer 20-24 year olds in 2010 than there were 10-14 year olds in 2000, and survival will be less than one. For states that are gaining population because of in-migration, survival may be greater than one (depending on whether in-migration is large enough to offset losses due to mortality).

To project the population in 2030, for example, we take the population by 5-year age group by state in 2020 and multiply that by the survival rate for that age group to get an estimate of the population 10 years older in the next decade. Once we have aged the existing population so that we have projections of the population 10-65 in a given year, we then use the fertility rates described above to populate the states with children younger than 10.

Relative trends in population growth across states are assumed to have persistence, but are not permanent. Thus, we don't assume that states that have experienced out- or in-migration, experience it forever. We also assume that state fertility and survival rates converge to national averages over time. In particular, we assume that the future fertility and survival rates are a weighted average of the past rates for a particular state and the overall national average. For 2020, we put a weight of 80% on the state's historical rates and a weight of 20% on the national average, for 2030, we use weights of 50% each, and for 2040, we put a weight of 80% on the national average and 20% on the state.

E. Asset Assumptions

As discussed in the text, we update the market value of plan assets from our 2017 jump off point using the plan's most recent financial report (fiscal year 2019 for most plans and fiscal year 2020 for some plans). Then, to calculate rates of return since the last observed asset valuation to the present (February 12, 2021), we use the asset allocations in the financial reports matched to market rates of return on appropriate indexes. We use eight asset classes (and accompanying indexes): Cash, Commodities (Bloomberg Commodity Index), Domestic Equities (Russell 3000 Index), International Equities (MSCI All Country World Ex-US Index), Fixed Income

(Bloomberg Barclays Aggregate Bond Index), Hedge Funds (HFRI Fund of Funds Composite Index), Private Equities (State Street Private Equity Index), and Real Estate (NCREIF Property Index). Indexes were chosen based on the most popular index targets reported in the Boston College PPD for our sample of pension plans.

Table A1
Benefit Payments as a Share of Payroll

	2017	2047		
	Baseline	Baseline	No Reforms	No Reforms and COLA = Inflation
US Aggregate	39.5%	37.5%	40.5%	46.1%
Arizona SRS	30.5%	31.2%	31.6%	41.3%
Arizona State Corrections Officers	22.5%	37.4%	39.1%	38.8%
California Teachers	45.3%	55.4%	57.2%	60.7%
University of California	24.5%	32.8%	36.5%	36.5%
San Diego City ERS	104.9%	72.2%	87.7%	93.0%
LA County ERS	40.7%	51.0%	53.6%	53.6%
San Diego County	53.1%	53.3%	64.8%	64.8%
San Francisco City & County	41.1%	39.2%	42.9%	42.9%
DC Teachers	15.9%	26.4%	24.9%	24.9%
Florida RS	40.8%	35.2%	38.7%	33.8%
Georgia ERS	52.8%	18.1%	23.9%	34.3%
Georgia Teachers	40.0%	46.7%	46.7%	46.7%
Illinois Municipal	28.4%	25.9%	30.6%	29.8%
Illinois SERS	56.4%	44.5%	53.3%	46.7%
Illinois Teachers	62.8%	61.0%	68.6%	60.6%
Indiana Teachers	27.0%	24.9%	24.9%	29.9%
Louisiana Municipal Police	47.6%	57.0%	64.5%	90.3%
Baton Rouge City Parish RS	66.9%	67.9%	68.8%	71.0%
Louisiana SERS	68.5%	44.9%	47.6%	70.0%
Massachusetts SRS	35.4%	41.0%	43.0%	50.0%
Massachusetts Teachers	43.1%	46.8%	50.1%	59.2%
Maine State and Teacher	41.4%	38.6%	40.8%	47.6%
Michigan Public Schools	58.9%	37.6%	44.2%	43.1%
Kansas City Missouri ERS	37.0%	39.4%	44.2%	42.8%
Missouri Teachers	51.8%	62.0%	62.0%	63.7%
North Dakota Teachers	30.6%	30.4%	32.5%	43.6%
New Jersey PERS	29.1%	22.1%	30.1%	40.8%
New Jersey Teachers	39.3%	24.2%	34.5%	46.8%
New Mexico PERA	49.5%	47.2%	54.9%	56.6%
New York State Teachers	37.0%	27.6%	32.9%	42.5%
NY State & Local ERS	35.5%	28.2%	32.3%	39.0%
Ohio Teachers	73.2%	47.1%	53.5%	75.0%
Oklahoma Police	36.1%	50.0%	50.0%	69.9%
Oregon PERS	45.7%	37.4%	41.5%	42.9%
Pennsylvania School Employees	44.6%	49.4%	53.5%	72.2%
Pennsylvania State ERS	48.6%	46.7%	47.5%	64.8%
Rhode Island Municipal	27.4%	26.2%	35.6%	36.1%
South Carolina RS	34.4%	28.9%	31.6%	37.6%
South Carolina Police	29.8%	31.5%	36.8%	44.4%
Texas Teachers	23.5%	28.8%	26.6%	35.4%

Note: The table displays benefit payments as a share of payroll by plan in 2017 and 2047 for different assumptions. All assumptions have the same level of benefit payments as a share of payroll in the starting year, 2017.

Table A2
Plan Exhaustion Dates

	Years until exhaustion		
Pension Plan	0.5% real return	2.5% real return	4.5% real return
Arizona SRS	36	63	Never
Arizona State Corrections Officers	22	26	33
California Teachers	31	41	78
University of California	76	Never	Never
San Diego City ERS	Never	Never	Never
LA County ERS	31	42	Never
San Diego County	55	Never	Never
San Francisco City & County	50	96	Never
DC Teachers	60	Never	Never
Florida RS	23	32	Never
Georgia ERS	Never	Never	Never
Georgia Teachers	26	35	69
Illinois Municipal	Never	Never	Never
Illinois SERS	Never	Never	Never
Illinois Teachers	Never	Never	Never
Indiana Teachers	Never	Never	Never
Louisiana Municipal Police	Never	Never	Never
Baton Rouge City Parish RS	23	32	Never
Louisiana SERS	Never	Never	Never
Massachusetts SRS	54	Never	Never
Massachusetts Teachers	Never	Never	Never
Maine State and Teacher	Never	Never	Never
Michigan Public Schools	Never	Never	Never
Kansas City Missouri ERS	23	32	Never
Missouri Teachers	29	39	80
North Dakota Teachers	Never	Never	Never
New Jersey PERS	21	37	93
New Jersey Teachers	9	9	10
New Mexico PERA	22	29	63
New York State Teachers	23	31	55
NY State & Local ERS	49	Never	Never
Ohio Teachers	26	42	Never
Oklahoma Police	48	90	Never
Oregon PERS	19	23	34
Pennsylvania School Employees	Never	Never	Never
Pennsylvania State ERS	40	Never	Never
Rhode Island Municipal	26	46	Never
South Carolina RS	26	44	Never
South Carolina Police	Never	Never	Never
Texas Teachers	27	35	54

Note: Table displays asset exhaustion dates for plans in the estimation sample assuming current contributions as a share of payroll are maintained in perpetuity.

Table A3

Change in Contributions that Stabilizes Ratio of Implicit Pension Debt to GDP, Depending on when Adjustment is Made

	Current Contribution	0.5% real rate of return Make changes:				2.5% real rate of return Make changes:				4.5% real rate of return Make changes:			
		Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years
US Aggregate	24%	13%	11%	10%	9%	7%	7%	8%	9%	-2%	-2%	-3%	-3%
Arizona SRS	22%	10%	9%	8%	7%	4%	4%	5%	5%	-2%	-3%	-4%	-5%
Arizona State Corrections Officers	22%	17%	15%	13%	12%	12%	13%	14%	15%	6%	8%	11%	14%
California Teachers	32%	37%	32%	29%	26%	20%	21%	23%	25%	4%	5%	6%	8%
University of California	31%	15%	13%	12%	10%	1%	1%	1%	1%	-12%	-16%	-20%	-26%
San Diego City ERS	75%	-15%	-13%	-11%	-10%	-21%	-22%	-23%	-26%	-41%	-52%	-67%	-88%
LA County ERS	27%	34%	30%	27%	24%	18%	19%	21%	22%	2%	2%	3%	4%
San Diego County	49%	18%	16%	14%	12%	3%	4%	4%	4%	-15%	-20%	-25%	-33%
San Francisco City & County	28%	20%	18%	16%	14%	6%	6%	7%	7%	-10%	-13%	-16%	-22%
DC Teachers	21%	15%	13%	11%	10%	2%	3%	3%	3%	-11%	-15%	-20%	-26%
Florida RS	13%	0%	0%	0%	0%	4%	5%	5%	6%	-1%	-1%	-2%	-2%
Georgia ERS	20%	-13%	-12%	-11%	-9%	-9%	-10%	-11%	-12%	-11%	-14%	-18%	-24%
Georgia Teachers	21%	26%	24%	22%	19%	16%	18%	19%	21%	3%	5%	6%	8%
Illinois Municipal	18%	2%	2%	2%	1%	-2%	-2%	-2%	-2%	-10%	-14%	-18%	-23%
Illinois SERS	49%	-36%	-32%	-28%	-25%	-21%	-23%	-24%	-26%	-18%	-24%	-31%	-40%
Illinois Teachers	51%	-29%	-25%	-23%	-20%	-11%	-12%	-14%	-14%	-10%	-14%	-18%	-23%
Indiana Teachers	28%	-9%	-8%	-7%	-6%	-9%	-10%	-11%	-12%	-11%	-15%	-20%	-26%
Louisiana Municipal Police	49%	-4%	-4%	-3%	-3%	-8%	-8%	-9%	-10%	-17%	-23%	-30%	-39%
Baton Rouge City Parish RS	41%	4%	3%	3%	3%	5%	6%	6%	7%	-2%	-2%	-3%	-4%
Louisiana SERS	45%	-16%	-15%	-13%	-12%	-13%	-14%	-15%	-16%	-15%	-20%	-27%	-34%
Massachusetts SRS	32%	5%	5%	4%	4%	1%	1%	1%	1%	-8%	-10%	-13%	-17%
Massachusetts Teachers	40%	5%	4%	4%	3%	-2%	-2%	-2%	-3%	-12%	-15%	-21%	-27%
Maine State and Teacher	26%	-5%	-5%	-4%	-4%	-5%	-6%	-7%	-7%	-14%	-19%	-26%	-34%
Michigan Public Schools	36%	-15%	-13%	-12%	-10%	-8%	-9%	-9%	-10%	-10%	-14%	-18%	-23%
Kansas City Missouri ERS	19%	-1%	-1%	-1%	-1%	3%	3%	3%	4%	-2%	-3%	-4%	-5%
Missouri Teachers	30%	38%	34%	31%	28%	21%	23%	26%	28%	3%	5%	6%	8%
North Dakota Teachers	27%	5%	4%	4%	3%	-1%	-1%	-1%	-1%	-8%	-10%	-14%	-18%
New Jersey PERS	21%	4%	3%	3%	2%	3%	3%	3%	3%	0%	0%	0%	1%
New Jersey Teachers	18%	4%	4%	3%	3%	8%	9%	9%	10%	8%	11%	14%	18%
New Mexico PERA	27%	14%	12%	11%	10%	10%	11%	12%	12%	2%	3%	4%	5%
New York State Teachers	7%	20%	18%	16%	14%	14%	15%	17%	17%	4%	5%	7%	9%
NY State & Local ERS	18%	10%	9%	8%	7%	3%	3%	3%	3%	-9%	-12%	-15%	-19%
Ohio Teachers	26%	9%	8%	7%	7%	6%	6%	7%	8%	-3%	-3%	-5%	-6%
Oklahoma Police	31%	24%	21%	19%	17%	7%	8%	8%	9%	-10%	-13%	-17%	-23%
Oregon PERS	10%	20%	18%	16%	14%	17%	18%	20%	21%	9%	11%	15%	19%
Pennsylvania School Employees	37%	-10%	-9%	-8%	-7%	-6%	-7%	-8%	-8%	-10%	-13%	-18%	-24%
Pennsylvania State ERS	37%	2%	2%	2%	1%	1%	1%	1%	1%	-6%	-8%	-11%	-14%
Rhode Island Municipal	15%	4%	3%	3%	3%	3%	3%	4%	4%	-3%	-3%	-4%	-6%
South Carolina RS	23%	5%	5%	4%	4%	3%	3%	4%	4%	-1%	-1%	-1%	-2%
South Carolina Police	25%	-3%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-6%	-7%	-10%	-13%
Texas Teachers	15%	26%	23%	21%	19%	14%	15%	16%	17%	5%	6%	8%	10%

Note: Table displays the percentage point change in contributions as a share of payroll required to stabilize implicit pension debt as a share of GDP for the plans in the estimation sample.

Table A4.1
Peak and Long Run Stabilized Debt to GDP, Depending on When Stabilization is Started
0.5 Percent Rate of Return

	Current Debt to GDP Ratio	Start Now		Start in 10 Years		Start in 20 Years		Start in 30 Years	
		Peak	Steady-State	Peak	Steady-State	Peak	Steady-State	Peak	Steady-State
US Aggregate	34%	37%	37%	42%	42%	46%	46%	50%	50%
Arizona SRS	36%	41%	32%	41%	37%	43%	41%	46%	45%
Arizona State Corrections Officers	81%	83%	78%	92%	88%	102%	98%	109%	107%
California Teachers	41%	44%	42%	55%	55%	67%	67%	77%	77%
University of California	47%	53%	46%	55%	55%	63%	63%	70%	70%
San Diego City ERS	30%	37%	30%	37%	28%	37%	26%	37%	25%
LA County ERS	39%	42%	39%	52%	52%	64%	64%	74%	74%
San Diego County	35%	40%	36%	41%	41%	46%	46%	50%	50%
San Francisco City & County	26%	31%	28%	35%	35%	42%	42%	48%	48%
DC Teachers	32%	44%	44%	62%	62%	77%	77%	89%	89%
Florida RS	30%	38%	38%	38%	38%	38%	38%	38%	38%
Georgia ERS	16%	22%	16%	22%	12%	22%	9%	22%	6%
Georgia Teachers	36%	42%	37%	46%	46%	55%	55%	63%	63%
Illinois Municipal	23%	30%	27%	30%	28%	30%	29%	30%	30%
Illinois SERS	44%	51%	51%	49%	41%	49%	32%	49%	25%
Illinois Teachers	56%	65%	65%	58%	57%	58%	51%	58%	45%
Indiana Teachers	42%	46%	43%	46%	39%	46%	34%	46%	31%
Louisiana Municipal Police	42%	47%	46%	46%	45%	45%	44%	45%	43%
Baton Rouge City Parish RS	35%	39%	37%	39%	38%	40%	39%	40%	40%
Louisiana SERS	29%	33%	30%	33%	27%	33%	23%	33%	21%
Massachusetts SRS	34%	41%	41%	44%	44%	46%	46%	48%	48%
Massachusetts Teachers	37%	44%	44%	46%	46%	48%	48%	49%	49%
Maine State and Teacher	25%	36%	36%	33%	33%	32%	32%	31%	30%
Michigan Public Schools	27%	33%	33%	32%	29%	32%	26%	32%	23%
Kansas City Missouri ERS	36%	44%	44%	44%	44%	43%	43%	43%	43%
Missouri Teachers	38%	42%	42%	54%	53%	64%	64%	73%	72%
North Dakota Teachers	38%	42%	41%	44%	44%	46%	46%	48%	48%
New Jersey PERS	35%	38%	38%	40%	40%	42%	42%	43%	43%
New Jersey Teachers	40%	44%	44%	46%	46%	48%	48%	49%	49%
New Mexico PERA	40%	43%	41%	47%	45%	51%	49%	54%	52%
New York State Teachers	19%	26%	26%	36%	36%	44%	44%	50%	50%
NY State & Local ERS	21%	29%	25%	30%	30%	34%	34%	38%	38%
Ohio Teachers	21%	25%	24%	26%	26%	28%	28%	29%	29%
Oklahoma Police	26%	33%	26%	36%	35%	44%	43%	51%	50%
Oregon PERS	29%	33%	32%	39%	39%	45%	45%	51%	50%
Pennsylvania School Employees	37%	49%	49%	46%	46%	43%	43%	41%	40%
Pennsylvania State ERS	33%	42%	42%	43%	43%	43%	43%	44%	44%
Rhode Island Municipal	30%	40%	40%	42%	42%	44%	44%	46%	46%
South Carolina RS	37%	40%	39%	41%	41%	43%	43%	45%	45%
South Carolina Police	45%	52%	52%	50%	50%	49%	49%	49%	48%
Texas Teachers	40%	42%	34%	53%	49%	66%	63%	78%	76%

Note: Table displays the starting debt to GDP ratio, peak debt to GDP ratio along the stabilization path, and the steady-state debt to GDP ratios for long-run stabilization exercizes depending on when the stabilization begins with CBO asset returns.

Table A4.2
Peak and Long Run Stabilized Debt to GDP, Depending on When Stabilization is Started
2.5 Percent Rate of Return

	Current Debt to GDP Ratio	Start Now		Start in 10 Years		Start in 20 Years		Start in 30 Years	
		Peak	Steady-State	Peak	Steady-State	Peak	Steady-State	Peak	Steady-State
US Aggregate	34%	37%	33%	37%	36%	40%	39%	43%	42%
Arizona SRS	36%	41%	33%	41%	35%	41%	37%	41%	39%
Arizona State Corrections Officers	81%	83%	76%	89%	84%	97%	93%	106%	104%
California Teachers	41%	44%	43%	51%	51%	59%	59%	68%	68%
University of California	47%	53%	49%	53%	49%	53%	50%	53%	50%
San Diego City ERS	30%	37%	24%	37%	20%	37%	17%	37%	13%
LA County ERS	39%	42%	39%	47%	47%	55%	55%	63%	63%
San Diego County	35%	40%	31%	40%	32%	40%	33%	40%	35%
San Francisco City & County	26%	31%	26%	31%	28%	31%	31%	34%	34%
DC Teachers	32%	41%	38%	44%	41%	47%	44%	50%	47%
Florida RS	30%	36%	24%	36%	25%	36%	27%	36%	29%
Georgia ERS	16%	22%	11%	22%	8%	22%	5%	22%	2%
Georgia Teachers	36%	42%	34%	42%	40%	48%	47%	55%	55%
Illinois Municipal	23%	30%	19%	30%	18%	30%	17%	30%	15%
Illinois SERS	44%	49%	38%	49%	32%	49%	25%	49%	18%
Illinois Teachers	56%	58%	48%	58%	45%	58%	42%	58%	38%
Indiana Teachers	42%	46%	40%	46%	34%	46%	28%	46%	22%
Louisiana Municipal Police	42%	45%	39%	45%	36%	45%	34%	45%	31%
Baton Rouge City Parish RS	35%	39%	31%	39%	32%	39%	33%	39%	35%
Louisiana SERS	29%	33%	25%	33%	22%	33%	19%	33%	16%
Massachusetts SRS	34%	37%	35%	37%	35%	37%	36%	37%	36%
Massachusetts Teachers	37%	40%	40%	40%	39%	40%	38%	40%	37%
Maine State and Teacher	25%	31%	24%	31%	22%	31%	20%	31%	17%
Michigan Public Schools	27%	32%	25%	32%	22%	32%	20%	32%	17%
Kansas City Missouri ERS	36%	40%	31%	40%	32%	40%	33%	40%	35%
Missouri Teachers	38%	41%	40%	48%	47%	56%	55%	64%	63%
North Dakota Teachers	38%	42%	39%	42%	39%	42%	38%	42%	37%
New Jersey PERS	35%	37%	35%	37%	37%	38%	38%	40%	40%
New Jersey Teachers	40%	41%	39%	43%	43%	47%	46%	51%	50%
New Mexico PERA	40%	42%	37%	43%	40%	46%	44%	49%	48%
New York State Teachers	19%	22%	20%	27%	27%	35%	34%	42%	42%
NY State & Local ERS	21%	29%	20%	29%	21%	29%	22%	29%	24%
Ohio Teachers	21%	25%	20%	25%	21%	25%	23%	25%	24%
Oklahoma Police	26%	33%	26%	33%	28%	33%	31%	35%	35%
Oregon PERS	29%	33%	26%	33%	32%	39%	39%	46%	46%
Pennsylvania School Employees	37%	40%	39%	38%	37%	38%	34%	38%	31%
Pennsylvania State ERS	33%	36%	35%	36%	35%	36%	35%	36%	36%
Rhode Island Municipal	30%	35%	29%	35%	31%	35%	33%	36%	36%
South Carolina RS	37%	40%	36%	40%	37%	40%	39%	41%	41%
South Carolina Police	45%	49%	43%	49%	41%	49%	40%	49%	39%
Texas Teachers	40%	42%	40%	50%	50%	60%	60%	71%	71%

Note: Table displays the starting debt to GDP ratio, peak debt to GDP ratio along the stabilization path, and the steady-state debt to GDP ratios for long-run stabilization exercizes depending on when the stabilization begins with an asset return of 2.5%.

Table A4.3

Peak and Long Run Stabilized Debt to GDP, Depending on When Stabilization is Started

4.5 Percent Rate of Return

	Current Debt to GDP Ratio	Start Now		Start in 10 Years		Start in 20 Years		Start in 30 Years	
		Peak	Steady-State	Peak	Steady-State	Peak	Steady-State	Peak	Steady-State
US Aggregate	34%	37%	31%	37%	30%	37%	29%	37%	28%
Arizona SRS	36%	41%	32%	41%	31%	41%	29%	41%	27%
Arizona State Corrections Officers	81%	83%	75%	85%	80%	91%	86%	97%	95%
California Teachers	41%	45%	44%	46%	46%	48%	48%	50%	50%
University of California	47%	53%	50%	53%	41%	53%	30%	53%	15%
San Diego City ERS	30%	37%	19%	37%	12%	37%	4%	37%	-8%
LA County ERS	39%	42%	39%	42%	40%	42%	41%	43%	42%
San Diego County	35%	40%	29%	40%	23%	40%	17%	40%	8%
San Francisco City & County	26%	31%	25%	31%	21%	31%	15%	31%	8%
DC Teachers	32%	45%	40%	37%	26%	37%	7%	37%	-17%
Florida RS	30%	36%	16%	36%	15%	36%	15%	36%	14%
Georgia ERS	16%	22%	7%	22%	4%	22%	-1%	22%	-7%
Georgia Teachers	36%	42%	32%	42%	34%	42%	36%	42%	38%
Illinois Municipal	23%	30%	13%	30%	7%	30%	-2%	30%	-12%
Illinois SERS	44%	49%	31%	49%	25%	49%	17%	49%	7%
Illinois Teachers	56%	58%	40%	58%	36%	58%	32%	58%	27%
Indiana Teachers	42%	46%	37%	46%	29%	46%	19%	46%	7%
Louisiana Municipal Police	42%	45%	34%	45%	28%	45%	19%	45%	8%
Baton Rouge City Parish RS	35%	39%	26%	39%	26%	39%	25%	39%	24%
Louisiana SERS	29%	33%	22%	33%	18%	33%	13%	33%	6%
Massachusetts SRS	34%	37%	32%	37%	28%	37%	22%	37%	15%
Massachusetts Teachers	37%	40%	37%	40%	32%	40%	25%	40%	16%
Maine State and Teacher	25%	31%	18%	31%	12%	31%	4%	31%	-6%
Michigan Public Schools	27%	32%	19%	32%	16%	32%	12%	32%	7%
Kansas City Missouri ERS	36%	40%	22%	40%	21%	40%	20%	40%	19%
Missouri Teachers	38%	41%	40%	42%	41%	44%	43%	46%	45%
North Dakota Teachers	38%	42%	38%	42%	33%	42%	27%	42%	18%
New Jersey PERS	35%	37%	33%	37%	33%	37%	34%	37%	34%
New Jersey Teachers	40%	41%	36%	42%	40%	47%	46%	53%	52%
New Mexico PERA	40%	42%	34%	42%	35%	42%	36%	42%	37%
New York State Teachers	19%	22%	17%	22%	19%	23%	22%	27%	26%
NY State & Local ERS	21%	29%	17%	29%	12%	29%	6%	29%	-2%
Ohio Teachers	21%	25%	17%	25%	16%	25%	15%	25%	14%
Oklahoma Police	26%	33%	25%	33%	20%	33%	14%	33%	6%
Oregon PERS	29%	33%	22%	33%	26%	33%	30%	37%	36%
Pennsylvania School Employees	37%	38%	34%	38%	30%	38%	24%	38%	17%
Pennsylvania State ERS	33%	36%	31%	36%	28%	36%	25%	36%	21%
Rhode Island Municipal	30%	35%	23%	35%	21%	35%	19%	35%	16%
South Carolina RS	37%	40%	34%	40%	34%	40%	33%	40%	32%
South Carolina Police	45%	49%	37%	49%	34%	49%	29%	49%	24%
Texas Teachers	40%	44%	44%	47%	47%	52%	52%	57%	57%

Note: Table displays the starting debt to GDP ratio, peak debt to GDP ratio along the stabilization path, and the steady-state debt to GDP ratios for long-run stabilization exercizes depending on when the stabilization begins with an asset return of 4.5%.

Table A5

Long Run Stabilized Funding Ratio, Depending on When Stabilization is Started

	Current Funding Ratio	0.5% real rate of return				2.5% real rate of return				4.5% real rate of return			
		Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years
US Aggregate	39%	22%	11%	2%	-6%	30%	24%	17%	10%	35%	37%	39%	41%
Arizona SRS	36%	34%	24%	15%	7%	33%	29%	24%	19%	34%	37%	40%	45%
Arizona State Corrections Officers	18%	18%	7%	-4%	-13%	20%	12%	2%	-9%	22%	16%	9%	0%
California Teachers	38%	44%	27%	11%	-2%	43%	33%	22%	10%	41%	40%	37%	34%
University of California	45%	51%	41%	32%	25%	48%	47%	47%	46%	46%	56%	68%	84%
San Diego City ERS	48%	5%	12%	17%	22%	27%	37%	47%	58%	41%	62%	89%	124%
LA County ERS	43%	46%	28%	12%	-2%	46%	36%	25%	13%	46%	45%	43%	41%
San Diego County	47%	37%	28%	20%	13%	46%	44%	42%	39%	50%	59%	71%	86%
San Francisco City & County	56%	51%	38%	26%	15%	54%	49%	45%	40%	55%	63%	73%	86%
DC Teachers	62%	60%	43%	29%	18%	65%	62%	59%	56%	64%	76%	93%	116%
Florida RS	46%	-61%	-60%	-60%	-60%	-1%	-8%	-16%	-25%	32%	34%	37%	40%
Georgia ERS	50%	-100%	-54%	-14%	22%	-35%	0%	37%	77%	10%	53%	110%	184%
Georgia Teachers	44%	36%	19%	4%	-10%	40%	29%	17%	4%	43%	40%	37%	33%
Illinois Municipal	60%	21%	18%	16%	13%	46%	49%	52%	56%	61%	80%	104%	136%
Illinois SERS	23%	-113%	-70%	-34%	-3%	-59%	-33%	-4%	25%	-28%	-3%	29%	71%
Illinois Teachers	20%	-86%	-64%	-46%	-30%	-38%	-29%	-19%	-9%	-14%	-4%	7%	23%
Indiana Teachers	26%	-1%	11%	20%	29%	8%	21%	35%	49%	15%	32%	55%	85%
Louisiana Municipal Police	38%	6%	8%	11%	13%	21%	26%	32%	38%	30%	43%	61%	83%
Baton Rouge City Parish RS	34%	-14%	-17%	-19%	-21%	7%	3%	-1%	-6%	20%	22%	24%	26%
Louisiana SERS	33%	-27%	-12%	1%	13%	-7%	6%	20%	34%	8%	25%	46%	74%
Massachusetts SRS	40%	18%	13%	8%	5%	30%	29%	29%	28%	36%	44%	55%	69%
Massachusetts Teachers	32%	20%	16%	13%	11%	28%	30%	32%	33%	32%	42%	55%	71%
Maine State and Teacher	51%	-14%	-7%	-1%	4%	22%	30%	38%	46%	41%	62%	88%	121%
Michigan Public Schools	37%	-62%	-42%	-26%	-11%	-21%	-9%	3%	16%	5%	21%	41%	67%
Kansas City Missouri ERS	44%	-49%	-47%	-45%	-44%	-3%	-7%	-12%	-17%	24%	28%	32%	37%
Missouri Teachers	41%	40%	22%	7%	-6%	41%	31%	20%	8%	42%	40%	38%	35%
North Dakota Teachers	36%	27%	23%	19%	15%	31%	32%	33%	34%	33%	42%	53%	68%
New Jersey PERS	26%	3%	-2%	-6%	-10%	11%	7%	2%	-2%	15%	15%	14%	13%
New Jersey Teachers	15%	-28%	-33%	-37%	-41%	-13%	-23%	-34%	-45%	-5%	-16%	-31%	-50%
New Mexico PERA	34%	10%	1%	-7%	-14%	19%	12%	4%	-4%	25%	24%	21%	18%
New York State Teachers	59%	32%	7%	-14%	-31%	48%	29%	11%	-9%	56%	50%	43%	33%
NY State & Local ERS	62%	39%	27%	17%	9%	52%	49%	46%	42%	59%	71%	85%	104%
Ohio Teachers	45%	7%	-1%	-8%	-13%	24%	18%	12%	6%	34%	37%	41%	45%
Oklahoma Police	59%	58%	43%	30%	18%	58%	53%	48%	43%	59%	67%	77%	89%
Oregon PERS	45%	9%	-10%	-27%	-42%	27%	9%	-10%	-29%	37%	28%	15%	-1%
Pennsylvania School Employees	30%	-29%	-19%	-11%	-4%	-2%	4%	11%	18%	12%	23%	37%	55%
Pennsylvania State ERS	34%	-1%	-3%	-5%	-6%	16%	15%	15%	14%	25%	31%	39%	49%
Rhode Island Municipal	49%	-3%	-10%	-16%	-21%	24%	19%	13%	7%	40%	44%	51%	59%
South Carolina RS	28%	10%	4%	-1%	-5%	16%	13%	9%	5%	21%	21%	23%	24%
South Carolina Police	31%	-13%	-10%	-7%	-5%	7%	10%	12%	15%	18%	26%	36%	48%
Texas Teachers	38%	57%	37%	19%	2%	48%	37%	24%	10%	44%	40%	34%	27%

Note: Table displays the starting funding ratio by plan and steady-state final funding ratios for long-run stabilization exercizes depending on rate of return and when the stabilization begins.

Table A6

Change in Contributions to Obtain Today's Debt to GDP Ratio in 30 Years, Depending on when Adjustment is Made

	Current Contribution	0.5% real rate of return Make changes:				2.5% real rate of return Make changes:				4.5% real rate of return Make changes:			
		Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years
US Aggregate	24%	15%	18%	21%	23%	6%	9%	11%	14%	-3%	-4%	-5%	-7%
Arizona SRS	22%	8%	10%	13%	15%	2%	4%	5%	7%	-4%	-5%	-7%	-9%
Arizona State Corrections Officers	22%	16%	19%	23%	26%	10%	14%	19%	24%	5%	8%	12%	18%
California Teachers	32%	38%	47%	56%	63%	22%	29%	37%	46%	6%	8%	10%	13%
University of California	31%	14%	18%	21%	24%	2%	2%	2%	3%	-11%	-18%	-26%	-37%
San Diego City ERS	75%	-14%	-17%	-20%	-23%	-32%	-40%	-48%	-57%	-55%	-76%	-104%	-142%
LA County ERS	27%	34%	43%	50%	57%	18%	25%	32%	40%	2%	3%	4%	6%
San Diego County	49%	18%	23%	27%	30%	0%	1%	3%	4%	-18%	-27%	-37%	-51%
San Francisco City & County	28%	22%	27%	31%	36%	6%	9%	11%	13%	-9%	-15%	-22%	-31%
DC Teachers	21%	18%	23%	28%	32%	5%	6%	7%	8%	-8%	-15%	-24%	-36%
Florida RS	13%	7%	8%	8%	8%	1%	2%	4%	5%	-7%	-9%	-10%	-11%
Georgia ERS	20%	-13%	-16%	-19%	-22%	-14%	-18%	-21%	-25%	-16%	-23%	-30%	-40%
Georgia Teachers	21%	27%	34%	41%	46%	14%	21%	28%	35%	2%	4%	6%	9%
Illinois Municipal	18%	5%	6%	6%	6%	-4%	-5%	-5%	-6%	-13%	-20%	-27%	-37%
Illinois SERS	49%	-27%	-37%	-44%	-51%	-26%	-35%	-44%	-52%	-27%	-39%	-52%	-68%
Illinois Teachers	51%	-16%	-23%	-30%	-35%	-17%	-23%	-29%	-34%	-20%	-28%	-37%	-46%
Indiana Teachers	28%	-7%	-10%	-12%	-14%	-10%	-14%	-18%	-22%	-13%	-20%	-28%	-39%
Louisiana Municipal Police	49%	2%	0%	-1%	-2%	-9%	-13%	-16%	-19%	-21%	-32%	-44%	-60%
Baton Rouge City Parish RS	41%	8%	9%	9%	10%	1%	2%	4%	7%	-8%	-11%	-12%	-14%
Louisiana SERS	45%	-14%	-19%	-23%	-26%	-16%	-22%	-27%	-33%	-21%	-31%	-42%	-56%
Massachusetts SRS	32%	10%	12%	14%	15%	1%	2%	2%	2%	-8%	-12%	-18%	-26%
Massachusetts Teachers	40%	10%	13%	14%	16%	0%	-1%	-1%	-2%	-11%	-18%	-27%	-39%
Maine State and Teacher	26%	4%	4%	3%	2%	-5%	-8%	-11%	-14%	-16%	-26%	-38%	-53%
Michigan Public Schools	36%	-7%	-11%	-14%	-17%	-10%	-14%	-18%	-21%	-15%	-22%	-30%	-40%
Kansas City Missouri ERS	19%	6%	6%	5%	5%	0%	0%	1%	3%	-8%	-10%	-12%	-13%
Missouri Teachers	30%	43%	53%	64%	71%	24%	33%	43%	52%	6%	7%	10%	13%
North Dakota Teachers	27%	8%	9%	10%	11%	0%	0%	-1%	-1%	-8%	-12%	-18%	-25%
New Jersey PERS	21%	5%	7%	7%	8%	3%	4%	5%	6%	0%	0%	0%	0%
New Jersey Teachers	18%	8%	10%	11%	11%	8%	11%	14%	17%	7%	12%	17%	24%
New Mexico PERA	27%	16%	19%	21%	24%	8%	11%	15%	19%	-1%	0%	1%	3%
New York State Teachers	7%	26%	32%	37%	40%	15%	21%	27%	32%	4%	6%	9%	12%
NY State & Local ERS	18%	14%	17%	19%	21%	2%	3%	4%	5%	-10%	-15%	-21%	-29%
Ohio Teachers	26%	14%	16%	19%	21%	4%	7%	10%	12%	-6%	-8%	-10%	-13%
Oklahoma Police	31%	24%	29%	34%	39%	7%	9%	12%	15%	-11%	-16%	-24%	-33%
Oregon PERS	10%	23%	29%	33%	37%	15%	21%	28%	35%	5%	10%	16%	24%
Pennsylvania School Employees	37%	2%	0%	-2%	-4%	-4%	-7%	-10%	-13%	-11%	-17%	-26%	-37%
Pennsylvania State ERS	37%	12%	13%	13%	14%	3%	3%	3%	4%	-6%	-10%	-15%	-21%
Rhode Island Municipal	15%	9%	11%	12%	13%	3%	4%	5%	7%	-4%	-6%	-8%	-10%
South Carolina RS	23%	6%	8%	9%	10%	2%	4%	5%	6%	-2%	-2%	-3%	-4%
South Carolina Police	25%	2%	1%	1%	0%	-3%	-4%	-5%	-5%	-8%	-12%	-16%	-21%
Texas Teachers	15%	23%	29%	34%	39%	14%	19%	25%	30%	6%	8%	11%	16%

Note: Table displays the percentage point change in contributions as a share of payroll required to obtain today's implicit pension debt as a share of GDP in 30 years for the plans in the estimation sample.

Table A7

Medium Run Funding Ratio, Depending on When Stabilization is Started

	Current Funding Ratio	0.5% real rate of return				2.5% real rate of return				4.5% real rate of return			
		Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years
US Aggregate	39%	30%	29%	28%	27%	30%	29%	28%	27%	31%	29%	28%	28%
Arizona SRS	36%	24%	25%	25%	26%	25%	25%	26%	26%	25%	25%	26%	27%
Arizona State Corrections Officers	18%	18%	16%	15%	14%	18%	16%	15%	15%	18%	16%	15%	15%
California Teachers	38%	46%	46%	46%	46%	46%	47%	46%	46%	47%	47%	47%	46%
University of California	45%	48%	50%	50%	50%	48%	50%	50%	50%	49%	50%	50%	50%
San Diego City ERS	48%	11%	8%	8%	7%	12%	9%	8%	8%	13%	9%	9%	9%
LA County ERS	43%	46%	46%	46%	46%	47%	47%	47%	47%	47%	47%	47%	47%
San Diego County	47%	42%	41%	40%	39%	42%	41%	40%	39%	42%	42%	40%	39%
San Francisco City & County	56%	55%	55%	55%	55%	56%	56%	55%	55%	56%	56%	56%	56%
DC Teachers	62%	73%	74%	73%	72%	74%	74%	73%	73%	74%	75%	74%	73%
Florida RS	46%	1%	-12%	-21%	-26%	2%	-12%	-21%	-25%	2%	-11%	-20%	-24%
Georgia ERS	50%	-74%	-91%	-95%	-95%	-72%	-89%	-93%	-94%	-71%	-88%	-92%	-92%
Georgia Teachers	44%	37%	37%	37%	37%	37%	37%	37%	37%	38%	37%	37%	37%
Illinois Municipal	60%	38%	36%	34%	33%	40%	38%	36%	35%	42%	39%	38%	37%
Illinois SERS	23%	-48%	-66%	-78%	-84%	-47%	-66%	-78%	-84%	-47%	-65%	-77%	-83%
Illinois Teachers	20%	-23%	-38%	-51%	-58%	-23%	-38%	-50%	-58%	-23%	-38%	-50%	-58%
Indiana Teachers	26%	6%	4%	4%	4%	7%	4%	4%	4%	7%	4%	4%	4%
Louisiana Municipal Police	38%	21%	17%	15%	15%	21%	17%	15%	15%	22%	18%	16%	16%
Baton Rouge City Parish RS	34%	1%	-5%	-7%	-8%	2%	-4%	-6%	-7%	2%	-3%	-5%	-6%
Louisiana SERS	33%	-17%	-21%	-22%	-22%	-17%	-21%	-22%	-22%	-16%	-20%	-21%	-21%
Massachusetts SRS	40%	35%	34%	34%	33%	35%	35%	34%	33%	35%	35%	34%	33%
Massachusetts Teachers	32%	36%	35%	34%	33%	37%	35%	35%	34%	37%	36%	36%	35%
Maine State and Teacher	51%	29%	25%	22%	21%	30%	26%	23%	22%	30%	26%	24%	22%
Michigan Public Schools	37%	-17%	-27%	-33%	-35%	-16%	-26%	-32%	-34%	-15%	-25%	-31%	-33%
Kansas City Missouri ERS	44%	-2%	-14%	-20%	-22%	-2%	-14%	-20%	-21%	-2%	-13%	-19%	-21%
Missouri Teachers	41%	46%	46%	45%	45%	47%	46%	46%	45%	47%	46%	46%	46%
North Dakota Teachers	36%	36%	35%	34%	34%	36%	35%	34%	34%	36%	35%	34%	34%
New Jersey PERS	26%	14%	14%	12%	10%	14%	14%	12%	11%	15%	14%	12%	11%
New Jersey Teachers	15%	-5%	-7%	-12%	-15%	-5%	-7%	-12%	-15%	-5%	-7%	-12%	-14%
New Mexico PERA	34%	15%	13%	11%	11%	15%	13%	12%	12%	16%	13%	12%	12%
New York State Teachers	59%	54%	53%	51%	50%	55%	53%	52%	51%	55%	54%	53%	52%
NY State & Local ERS	62%	52%	52%	51%	50%	52%	52%	51%	50%	52%	52%	51%	50%
Ohio Teachers	45%	22%	19%	18%	18%	23%	19%	19%	18%	23%	20%	19%	19%
Oklahoma Police	59%	56%	56%	56%	56%	57%	56%	57%	57%	57%	57%	57%	57%
Oregon PERS	45%	24%	21%	19%	18%	24%	22%	20%	19%	25%	22%	20%	19%
Pennsylvania School Employees	30%	14%	9%	6%	4%	14%	9%	6%	5%	15%	10%	6%	5%
Pennsylvania State ERS	34%	28%	25%	22%	21%	28%	25%	23%	22%	29%	26%	23%	22%
Rhode Island Municipal	49%	27%	25%	24%	23%	27%	25%	24%	23%	28%	26%	25%	24%
South Carolina RS	28%	15%	14%	14%	14%	15%	15%	14%	14%	15%	15%	14%	14%
South Carolina Police	31%	11%	6%	3%	2%	11%	6%	4%	3%	12%	7%	4%	3%
Texas Teachers	38%	46%	47%	48%	48%	46%	47%	48%	49%	47%	48%	49%	49%

Note: Table displays the starting funding ratio by plan and funding ratio in the year the plan returns to its starting debt to GDP ratio for the medium-run stabilization exercizes depending on when the stabilization begins.

Table A8

Change in Contributions to Obtain Today's Funding Ratio in 30 Years, Depending on when Adjustment is Made

	Current Contribution	0.5% real rate of return Make changes:				2.5% real rate of return Make changes:				4.5% real rate of return Make changes:			
		Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years	Now	In 10 years	In 20 years	In 30 years
US Aggregate	24%	19%	23%	26%	29%	9%	12%	15%	18%	-1%	-1%	-2%	-4%
Arizona SRS	22%	12%	15%	17%	18%	5%	7%	8%	10%	-2%	-3%	-5%	-7%
Arizona State Corrections Officers	22%	16%	21%	24%	28%	11%	15%	20%	25%	5%	9%	13%	19%
California Teachers	32%	32%	40%	50%	57%	17%	24%	32%	41%	2%	4%	6%	10%
University of California	31%	12%	16%	19%	21%	0%	0%	0%	1%	-12%	-19%	-27%	-38%
San Diego City ERS	75%	19%	17%	14%	12%	-8%	-14%	-22%	-31%	-37%	-58%	-86%	-123%
LA County ERS	27%	32%	40%	48%	55%	16%	23%	30%	38%	1%	2%	3%	5%
San Diego County	49%	23%	28%	33%	37%	4%	5%	7%	8%	-16%	-24%	-34%	-48%
San Francisco City & County	28%	22%	27%	32%	36%	7%	9%	11%	14%	-9%	-15%	-21%	-30%
DC Teachers	21%	14%	18%	23%	27%	1%	2%	3%	5%	-11%	-17%	-26%	-38%
Florida RS	13%	20%	24%	25%	25%	10%	14%	16%	18%	0%	0%	-1%	-2%
Georgia ERS	20%	2%	-1%	-4%	-6%	-3%	-6%	-10%	-14%	-8%	-14%	-22%	-32%
Georgia Teachers	21%	31%	39%	45%	51%	18%	24%	31%	38%	4%	6%	9%	12%
Illinois Municipal	18%	11%	12%	12%	13%	1%	0%	-1%	-1%	-10%	-16%	-24%	-33%
Illinois SERS	49%	1%	-4%	-10%	-16%	-5%	-11%	-18%	-27%	-11%	-21%	-33%	-49%
Illinois Teachers	51%	12%	11%	9%	5%	4%	3%	0%	-3%	-5%	-9%	-16%	-24%
Indiana Teachers	28%	-1%	-3%	-5%	-7%	-5%	-9%	-13%	-17%	-10%	-16%	-25%	-36%
Louisiana Municipal Police	49%	12%	13%	13%	12%	-1%	-3%	-6%	-9%	-15%	-25%	-37%	-53%
Baton Rouge City Parish RS	41%	27%	31%	33%	34%	15%	19%	22%	24%	2%	1%	0%	-1%
Louisiana SERS	45%	7%	4%	0%	-3%	-1%	-5%	-10%	-16%	-10%	-18%	-29%	-43%
Massachusetts SRS	32%	12%	15%	17%	18%	3%	3%	4%	4%	-7%	-11%	-17%	-24%
Massachusetts Teachers	40%	8%	11%	14%	15%	-1%	-1%	-2%	-3%	-12%	-18%	-27%	-39%
Maine State and Teacher	26%	12%	13%	13%	13%	0%	-1%	-3%	-6%	-12%	-21%	-33%	-47%
Michigan Public Schools	36%	11%	9%	7%	4%	3%	1%	-2%	-5%	-6%	-11%	-18%	-28%
Kansas City Missouri ERS	19%	20%	23%	23%	23%	11%	13%	15%	16%	0%	0%	-2%	-3%
Missouri Teachers	30%	39%	50%	61%	68%	21%	30%	40%	50%	3%	5%	8%	11%
North Dakota Teachers	27%	8%	9%	11%	12%	0%	0%	0%	-1%	-7%	-12%	-17%	-25%
New Jersey PERS	21%	9%	10%	11%	12%	5%	6%	7%	9%	2%	2%	2%	2%
New Jersey Teachers	18%	16%	17%	19%	21%	13%	17%	20%	24%	11%	16%	22%	30%
New Mexico PERA	27%	26%	31%	33%	36%	16%	20%	24%	28%	5%	6%	8%	10%
New York State Teachers	7%	27%	34%	40%	43%	16%	22%	29%	34%	5%	7%	10%	14%
NY State & Local ERS	18%	17%	21%	23%	25%	5%	6%	7%	8%	-8%	-13%	-19%	-26%
Ohio Teachers	26%	23%	27%	32%	34%	12%	15%	19%	22%	0%	-2%	-4%	-6%
Oklahoma Police	31%	26%	31%	36%	41%	8%	11%	13%	16%	-10%	-15%	-23%	-32%
Oregon PERS	10%	32%	38%	44%	48%	21%	28%	36%	43%	10%	15%	21%	29%
Pennsylvania School Employees	37%	9%	10%	9%	7%	1%	0%	-2%	-5%	-7%	-12%	-20%	-30%
Pennsylvania State ERS	37%	15%	18%	19%	21%	6%	7%	8%	9%	-4%	-8%	-12%	-18%
Rhode Island Municipal	15%	15%	17%	18%	19%	7%	8%	10%	11%	-1%	-3%	-4%	-7%
South Carolina RS	23%	11%	13%	14%	15%	6%	7%	9%	10%	1%	0%	0%	-1%
South Carolina Police	25%	9%	10%	10%	10%	3%	3%	2%	2%	-4%	-7%	-10%	-16%
Texas Teachers	15%	19%	25%	30%	35%	12%	16%	21%	27%	4%	6%	9%	13%

Note: Table displays the percentage point change in contributions as a share of payroll required to stabilize the funding ratio for the plans in the estimation sample.

Table A9
Normal Costs Under Different Assumptions

	2017				2047			Reforms				
	Reported	Baseline	No Reforms	No Reforms/COLA = Infl.	Baseline	No Reforms	No Reforms/COLA = Infl.	Benefit Factor	COLA	Vesting	Retirement Age	Salary Averaging
US Aggregate	13.5%	51.3%	53.8%	62.7%	47.5%	55.1%	64.6%	45%	23%	43%	55%	70%
Arizona SRS	15.9%	41.4%	42.1%	57.6%	41.3%	43.0%	59.2%	0	0	0	0	1
Arizona State Corrections Officers	16.2%	60.9%	69.6%	69.0%	51.0%	73.0%	72.3%	0	1	0	0	1
California Teachers	20.3%	81.2%	81.6%	88.4%	81.8%	84.2%	91.4%	0	0	0	1	0
University of California	17.4%	52.6%	53.1%	53.1%	53.5%	55.2%	55.2%	0	0	0	1	0
San Diego City ERS	25.6%	90.0%	91.4%	97.0%	81.4%	90.8%	96.3%	1	0	0	0	1
LA County ERS	16.7%	70.5%	76.6%	76.6%	72.3%	78.8%	78.8%	1	1	0	1	1
San Diego County	26.9%	85.5%	95.8%	95.8%	70.2%	100.1%	100.1%	1	1	0	1	1
San Francisco City & County	18.6%	60.6%	63.5%	63.5%	57.6%	66.0%	66.0%	0	1	0	1	1
DC Teachers	15.2%	39.9%	37.4%	37.4%	42.7%	39.7%	39.7%	1	0	0	0	0
Florida RS	7.4%	40.3%	46.6%	40.1%	25.6%	48.0%	41.4%	0	1	1	1	1
Georgia ERS	4.7%	17.7%	24.5%	34.3%	12.8%	25.4%	35.4%	1	0	0	0	0
Georgia Teachers	13.8%	61.3%	61.3%	61.3%	61.6%	61.6%	61.6%	0	0	0	0	0
Illinois Municipal	10.1%	34.7%	38.7%	37.6%	27.2%	40.2%	39.1%	0	1	1	1	1
Illinois SERS	21.4%	56.8%	66.3%	57.7%	34.6%	68.0%	59.0%	1	1	1	1	1
Illinois Teachers	18.1%	81.4%	89.9%	77.1%	50.5%	92.3%	79.1%	0	1	1	1	1
Indiana Teachers	5.7%	29.2%	29.3%	35.6%	29.5%	29.7%	36.1%	0	0	1	0	0
Louisiana Municipal Police	18.5%	76.7%	81.4%	120.4%	62.8%	82.0%	121.1%	1	0	1	0	1
Baton Rouge City Parish RS	24.3%	68.1%	68.5%	70.8%	67.6%	70.1%	72.4%	0	0	0	0	1
Louisiana SERS	11.8%	45.4%	45.6%	64.0%	45.4%	46.3%	65.0%	0	0	1	1	1
Massachusetts SRS	13.4%	46.9%	50.4%	58.7%	48.8%	52.4%	61.2%	0	0	0	1	1
Massachusetts Teachers	13.6%	57.0%	61.9%	75.1%	59.4%	64.4%	78.6%	0	0	0	1	1
Maine State and Teacher	11.7%	36.6%	38.5%	45.2%	36.1%	39.2%	46.2%	0	0	0	1	0
Michigan Public Schools	10.6%	45.7%	54.1%	53.1%	34.9%	55.9%	55.0%	0	1	0	1	1
Kansas City Missouri ERS	13.3%	50.3%	55.5%	53.6%	30.9%	57.8%	55.9%	1	1	1	1	1
Missouri Teachers	17.0%	84.8%	84.8%	88.0%	86.1%	86.1%	89.3%	0	0	0	0	0
North Dakota Teachers	12.1%	43.4%	44.3%	61.8%	43.1%	45.1%	63.2%	0	0	1	0	1
New Jersey PERS	10.1%	35.1%	37.3%	52.7%	32.3%	38.3%	54.5%	1	0	0	1	1
New Jersey Teachers	11.2%	40.6%	43.1%	62.2%	34.8%	44.4%	64.6%	1	0	0	1	1
New Mexico PERA	15.8%	65.5%	72.5%	75.2%	55.3%	75.5%	78.3%	1	0	1	0	1
New York State Teachers	13.6%	40.7%	43.0%	59.4%	34.8%	43.0%	59.4%	1	0	1	1	1
NY State & Local ERS	16.1%	40.4%	42.9%	51.3%	36.4%	45.3%	54.7%	1	0	1	1	1
Ohio Teachers	10.7%	48.0%	57.8%	84.2%	49.3%	59.1%	85.3%	1	0	0	0	1
Oklahoma Police	21.1%	65.9%	65.9%	100.5%	65.7%	65.7%	100.3%	0	0	0	0	0
Oregon PERS	11.6%	44.6%	50.1%	52.0%	41.9%	51.9%	53.9%	0	1	0	1	0
Pennsylvania School Employees	15.2%	59.3%	62.8%	90.2%	48.3%	64.3%	93.1%	1	0	1	1	0
Pennsylvania State ERS	11.1%	63.4%	59.6%	83.7%	54.9%	60.3%	85.4%	0	0	1	1	0
Rhode Island Municipal	12.4%	31.4%	45.9%	46.6%	25.8%	47.1%	47.8%	1	0	1	0	1
South Carolina RS	10.7%	38.4%	39.1%	47.5%	38.1%	40.7%	49.6%	0	0	1	0	1
South Carolina Police	14.7%	47.4%	54.4%	69.5%	34.8%	54.5%	69.6%	1	0	1	0	1
Texas Teachers	10.1%	45.4%	42.0%	60.3%	47.1%	42.9%	61.8%	1	0	0	0	1

Note: Table reports plans expected normal costs as a percent of plan payroll in 2017 and 2048. The reported column is generally as reported in plans actuarial valuations. Baseline, no reforms and no reforms/COLA=inflation columns report the normal costs under the scenarios described in section V based on the methodology and assumptions detailed in section IV and appendix A. Across plans these scenarios use a discount rate of 0.5%, assume wage inflation of 3.4% and price inflation of 2.2%. The Baseline scenario incorporates plan reforms. The last 5 columns indicate whether the plan was subject to any of the reforms modelled in the projections. Benefit factor indicates a change to the plans final salary benefit factor. COLA, a change in COLA policy which could include a fixed change including removal of the COLA, or change to the formula relating the COLA to investment returns or realized inflation. Vesting refers to the number of years of service required to be eligible for retirement benefits. Retirement age is the normal retirement age at which full benefits can be claimed. Salary averaging indicates a change in the number of years of salary that are averaged over before applying the benefit factor.

Table A10.1
Stochastic Exercise Results by Plan Using Contribution Rates with 0.5 Percent Real Return

	Percentiles of Debt to GDP in 2047							Percentiles of Assets to GDP in 2047						
	1st	10th	25th	50th	75th	90th	99th	1st	10th	25th	50th	75th	90th	99th
US Aggregate	-1.28%	-0.42%	-0.12%	0.09%	0.24%	0.32%	0.41%	0.08%	0.17%	0.25%	0.40%	0.61%	0.91%	1.77%
Arizona SRS	-0.90%	-0.26%	-0.03%	0.15%	0.27%	0.34%	0.41%	0.07%	0.13%	0.20%	0.32%	0.50%	0.73%	1.37%
Arizona State Corrections Officers	-0.86%	0.01%	0.31%	0.54%	0.68%	0.78%	0.87%	0.11%	0.21%	0.30%	0.45%	0.67%	0.98%	1.84%
California Teachers	-2.21%	-0.75%	-0.36%	-0.02%	0.22%	0.36%	0.52%	0.24%	0.40%	0.54%	0.78%	1.12%	1.51%	2.92%
University of California	-2.91%	-1.15%	-0.55%	-0.09%	0.21%	0.40%	0.60%	0.31%	0.51%	0.70%	1.00%	1.46%	2.06%	3.82%
San Diego City ERS	-1.18%	-0.38%	-0.09%	0.11%	0.23%	0.29%	0.36%	-0.03%	0.04%	0.11%	0.23%	0.43%	0.71%	1.51%
LA County ERS	-2.29%	-0.90%	-0.43%	-0.07%	0.18%	0.34%	0.50%	0.23%	0.39%	0.55%	0.80%	1.16%	1.63%	3.01%
San Diego County	-2.02%	-0.81%	-0.39%	-0.05%	0.17%	0.31%	0.44%	0.16%	0.29%	0.43%	0.65%	0.99%	1.41%	2.61%
San Francisco City & County	-2.34%	-0.98%	-0.51%	-0.17%	0.06%	0.21%	0.37%	0.20%	0.36%	0.51%	0.75%	1.09%	1.55%	2.89%
DC Teachers	-5.68%	-2.65%	-1.57%	-0.72%	-0.17%	0.18%	0.61%	0.56%	0.99%	1.34%	1.89%	2.75%	3.82%	6.86%
Florida RS	-1.08%	-0.30%	-0.05%	0.12%	0.24%	0.30%	0.39%	-0.09%	-0.00%	0.06%	0.18%	0.36%	0.60%	1.38%
Georgia ERS	-0.29%	-0.01%	0.07%	0.13%	0.17%	0.21%	0.31%	-0.22%	-0.12%	-0.08%	-0.04%	0.02%	0.10%	0.38%
Georgia Teachers	-1.69%	-0.64%	-0.27%	0.02%	0.21%	0.33%	0.44%	0.13%	0.25%	0.36%	0.55%	0.85%	1.21%	2.23%
Illinois Municipal	-1.99%	-0.80%	-0.40%	-0.10%	0.09%	0.21%	0.32%	0.05%	0.17%	0.28%	0.48%	0.77%	1.18%	2.36%
Illinois SERS	0.15%	0.35%	0.40%	0.45%	0.51%	0.58%	0.74%	-0.45%	-0.28%	-0.21%	-0.15%	-0.10%	-0.05%	0.14%
Illinois Teachers	0.12%	0.38%	0.47%	0.53%	0.57%	0.62%	0.72%	-0.27%	-0.17%	-0.12%	-0.07%	-0.01%	0.07%	0.33%
Indiana Teachers	-0.38%	0.05%	0.20%	0.30%	0.37%	0.41%	0.46%	-0.01%	0.03%	0.07%	0.14%	0.25%	0.40%	0.82%
Louisiana Municipal Police	-1.25%	-0.36%	-0.07%	0.16%	0.31%	0.40%	0.49%	0.04%	0.13%	0.22%	0.37%	0.60%	0.89%	1.77%
Baton Rouge City Parish RS	-0.60%	-0.06%	0.10%	0.23%	0.31%	0.36%	0.42%	-0.06%	-0.00%	0.04%	0.12%	0.25%	0.41%	0.96%
Louisiana SERS	-0.31%	0.07%	0.17%	0.24%	0.28%	0.32%	0.39%	-0.14%	-0.07%	-0.04%	0.01%	0.08%	0.18%	0.56%
Massachusetts SRS	-1.47%	-0.54%	-0.21%	0.04%	0.21%	0.31%	0.42%	0.10%	0.21%	0.31%	0.48%	0.73%	1.06%	1.99%
Massachusetts Teachers	-1.25%	-0.44%	-0.15%	0.08%	0.24%	0.34%	0.45%	0.13%	0.24%	0.34%	0.50%	0.73%	1.02%	1.81%
Maine State and Teacher	-1.62%	-0.60%	-0.27%	-0.02%	0.14%	0.23%	0.32%	0.04%	0.12%	0.21%	0.37%	0.63%	0.96%	1.98%
Michigan Public Schools	-0.40%	0.00%	0.12%	0.21%	0.26%	0.31%	0.38%	-0.15%	-0.07%	-0.03%	0.03%	0.11%	0.23%	0.63%
Kansas City Missouri ERS	-1.09%	-0.29%	-0.03%	0.16%	0.29%	0.37%	0.47%	-0.12%	-0.02%	0.06%	0.19%	0.38%	0.64%	1.44%
Missouri Teachers	-2.34%	-0.85%	-0.41%	-0.06%	0.18%	0.33%	0.48%	0.22%	0.38%	0.52%	0.76%	1.11%	1.55%	3.04%
North Dakota Teachers	-1.28%	-0.46%	-0.16%	0.08%	0.24%	0.34%	0.45%	0.14%	0.24%	0.34%	0.51%	0.75%	1.05%	1.87%
New Jersey PERS	-0.34%	0.03%	0.15%	0.25%	0.31%	0.34%	0.38%	0.03%	0.07%	0.10%	0.16%	0.26%	0.38%	0.74%
New Jersey Teachers	0.18%	0.32%	0.36%	0.39%	0.41%	0.43%	0.48%	-0.10%	-0.05%	-0.03%	-0.01%	0.02%	0.06%	0.20%
New Mexico PERA	-0.89%	-0.20%	0.05%	0.22%	0.33%	0.39%	0.45%	0.02%	0.08%	0.15%	0.26%	0.43%	0.67%	1.36%
New York State Teachers	-1.82%	-0.83%	-0.45%	-0.17%	0.04%	0.16%	0.28%	0.13%	0.26%	0.38%	0.58%	0.87%	1.24%	2.22%
NY State & Local ERS	-2.29%	-0.95%	-0.52%	-0.18%	0.04%	0.17%	0.30%	0.13%	0.26%	0.39%	0.61%	0.94%	1.38%	2.70%
Ohio Teachers	-0.81%	-0.28%	-0.09%	0.06%	0.15%	0.20%	0.25%	0.02%	0.07%	0.13%	0.21%	0.36%	0.55%	1.08%
Oklahoma Police	-2.59%	-1.16%	-0.64%	-0.23%	0.04%	0.22%	0.38%	0.22%	0.39%	0.56%	0.83%	1.24%	1.76%	3.18%
Oregon PERS	-1.23%	-0.37%	-0.11%	0.08%	0.21%	0.28%	0.35%	0.03%	0.10%	0.18%	0.31%	0.49%	0.75%	1.61%
Pennsylvania School Employees	-0.73%	-0.14%	0.06%	0.21%	0.30%	0.36%	0.41%	0.02%	0.07%	0.13%	0.23%	0.37%	0.57%	1.16%
Pennsylvania State ERS	-0.92%	-0.29%	-0.07%	0.11%	0.24%	0.31%	0.38%	0.08%	0.15%	0.22%	0.34%	0.52%	0.74%	1.37%
Rhode Island Municipal	-1.71%	-0.62%	-0.23%	0.02%	0.19%	0.28%	0.38%	0.03%	0.13%	0.22%	0.39%	0.64%	1.03%	2.11%
South Carolina RS	-0.54%	-0.05%	0.12%	0.23%	0.32%	0.36%	0.41%	0.03%	0.07%	0.12%	0.20%	0.32%	0.49%	0.96%
South Carolina Police	-0.72%	-0.09%	0.11%	0.28%	0.38%	0.44%	0.50%	0.00%	0.06%	0.12%	0.23%	0.40%	0.60%	1.23%
Texas Teachers	-1.77%	-0.73%	-0.31%	0.01%	0.22%	0.36%	0.51%	0.23%	0.39%	0.52%	0.74%	1.06%	1.47%	2.51%

Note: Table displays the debt to GDP and asset to GDP ratios for various percentiles by plan, assuming contributions to return to today's debt to GDP ratio in 30 years starting now given a 0.5% real return on assets.

Table A10.2

Stochastic Exercise Results by Plan Using Contribution Rates from 2.5 Percent Real Return

	Percentiles of Debt to GDP in 2047							Percentiles of Assets to GDP in 2047						
	1st	10th	25th	50th	75th	90th	99th	1st	10th	25th	50th	75th	90th	99th
US Aggregate	-0.88%	-0.18%	0.07%	0.24%	0.36%	0.42%	0.49%	0.00%	0.07%	0.13%	0.25%	0.43%	0.67%	1.37%
Arizona SRS	-0.65%	-0.07%	0.13%	0.27%	0.37%	0.43%	0.48%	-0.01%	0.05%	0.11%	0.20%	0.35%	0.55%	1.11%
Arizona State Corrections Officers	-0.41%	0.29%	0.52%	0.70%	0.82%	0.89%	0.96%	0.03%	0.10%	0.17%	0.29%	0.46%	0.70%	1.38%
California Teachers	-1.47%	-0.42%	-0.04%	0.24%	0.42%	0.53%	0.65%	0.11%	0.23%	0.34%	0.52%	0.80%	1.18%	2.22%
University of California	-1.99%	-0.61%	-0.11%	0.25%	0.50%	0.64%	0.79%	0.13%	0.28%	0.42%	0.66%	1.02%	1.52%	2.89%
San Diego City ERS	-1.03%	-0.20%	0.04%	0.21%	0.32%	0.38%	0.48%	-0.15%	-0.04%	0.02%	0.12%	0.29%	0.53%	1.36%
LA County ERS	-1.61%	-0.47%	-0.08%	0.21%	0.40%	0.52%	0.63%	0.10%	0.21%	0.33%	0.52%	0.81%	1.20%	2.33%
San Diego County	-1.45%	-0.43%	-0.07%	0.19%	0.37%	0.47%	0.57%	0.03%	0.13%	0.23%	0.41%	0.67%	1.03%	2.04%
San Francisco City & County	-1.58%	-0.57%	-0.19%	0.08%	0.27%	0.38%	0.50%	0.08%	0.19%	0.30%	0.49%	0.76%	1.14%	2.13%
DC Teachers	-3.89%	-1.60%	-0.74%	-0.09%	0.33%	0.60%	0.89%	0.29%	0.57%	0.84%	1.27%	1.91%	2.77%	5.02%
Florida RS	-0.85%	-0.15%	0.07%	0.23%	0.33%	0.39%	0.49%	-0.19%	-0.08%	-0.03%	0.07%	0.23%	0.45%	1.15%
Georgia ERS	-0.25%	0.00%	0.08%	0.14%	0.18%	0.23%	0.33%	-0.24%	-0.14%	-0.09%	-0.05%	0.01%	0.09%	0.34%
Georgia Teachers	-1.12%	-0.30%	0.01%	0.23%	0.38%	0.46%	0.55%	0.02%	0.11%	0.20%	0.35%	0.57%	0.87%	1.69%
Illinois Municipal	-1.61%	-0.54%	-0.18%	0.10%	0.26%	0.35%	0.45%	-0.08%	0.02%	0.12%	0.28%	0.55%	0.91%	1.96%
Illinois SERS	0.11%	0.33%	0.38%	0.43%	0.49%	0.55%	0.71%	-0.41%	-0.25%	-0.19%	-0.13%	-0.08%	-0.03%	0.19%
Illinois Teachers	0.11%	0.39%	0.48%	0.54%	0.59%	0.64%	0.76%	-0.31%	-0.18%	-0.13%	-0.09%	-0.02%	0.06%	0.34%
Indiana Teachers	-0.23%	0.15%	0.28%	0.37%	0.43%	0.46%	0.51%	-0.07%	-0.02%	0.02%	0.07%	0.17%	0.30%	0.67%
Louisiana Municipal Police	-0.96%	-0.16%	0.11%	0.31%	0.44%	0.50%	0.59%	-0.06%	0.02%	0.09%	0.22%	0.42%	0.69%	1.49%
Baton Rouge City Parish RS	-0.50%	0.01%	0.18%	0.29%	0.37%	0.42%	0.49%	-0.13%	-0.06%	-0.01%	0.06%	0.17%	0.34%	0.85%
Louisiana SERS	-0.22%	0.10%	0.20%	0.27%	0.31%	0.35%	0.44%	-0.19%	-0.10%	-0.06%	-0.02%	0.05%	0.14%	0.47%
Massachusetts SRS	-1.13%	-0.27%	0.01%	0.21%	0.35%	0.43%	0.51%	0.01%	0.09%	0.17%	0.31%	0.51%	0.79%	1.64%
Massachusetts Teachers	-1.02%	-0.20%	0.06%	0.25%	0.38%	0.45%	0.53%	0.05%	0.13%	0.20%	0.33%	0.51%	0.78%	1.58%
Maine State and Teacher	-1.38%	-0.37%	-0.07%	0.15%	0.28%	0.36%	0.44%	-0.09%	-0.00%	0.07%	0.21%	0.42%	0.72%	1.73%
Michigan Public Schools	-0.34%	0.04%	0.16%	0.24%	0.30%	0.34%	0.43%	-0.20%	-0.11%	-0.06%	-0.01%	0.08%	0.19%	0.57%
Kansas City Missouri ERS	-0.94%	-0.14%	0.10%	0.28%	0.39%	0.46%	0.59%	-0.24%	-0.11%	-0.04%	0.07%	0.25%	0.50%	1.26%
Missouri Teachers	-1.48%	-0.44%	-0.09%	0.19%	0.39%	0.50%	0.61%	0.09%	0.20%	0.32%	0.51%	0.79%	1.14%	2.17%
North Dakota Teachers	-0.96%	-0.22%	0.07%	0.27%	0.39%	0.46%	0.54%	0.05%	0.12%	0.20%	0.32%	0.52%	0.81%	1.54%
New Jersey PERS	-0.19%	0.13%	0.24%	0.31%	0.36%	0.39%	0.42%	-0.01%	0.02%	0.05%	0.10%	0.17%	0.28%	0.60%
New Jersey Teachers	0.21%	0.33%	0.36%	0.39%	0.41%	0.43%	0.48%	-0.11%	-0.05%	-0.03%	-0.01%	0.02%	0.05%	0.16%
New Mexico PERA	-0.64%	-0.01%	0.19%	0.33%	0.42%	0.47%	0.54%	-0.07%	0.00%	0.05%	0.14%	0.29%	0.48%	1.11%
New York State Teachers	-1.55%	-0.52%	-0.19%	0.05%	0.21%	0.30%	0.39%	0.03%	0.12%	0.21%	0.37%	0.61%	0.94%	1.96%
NY State & Local ERS	-1.71%	-0.59%	-0.21%	0.07%	0.24%	0.33%	0.43%	-0.01%	0.09%	0.19%	0.36%	0.64%	1.02%	2.13%
Ohio Teachers	-0.63%	-0.13%	0.03%	0.15%	0.23%	0.27%	0.32%	-0.05%	0.00%	0.04%	0.12%	0.24%	0.40%	0.89%
Oklahoma Police	-2.10%	-0.73%	-0.25%	0.07%	0.29%	0.41%	0.53%	0.07%	0.19%	0.31%	0.53%	0.85%	1.33%	2.69%
Oregon PERS	-0.92%	-0.19%	0.04%	0.21%	0.31%	0.37%	0.44%	-0.05%	0.01%	0.07%	0.18%	0.34%	0.57%	1.29%
Pennsylvania School Employees	-0.48%	0.01%	0.19%	0.31%	0.38%	0.43%	0.48%	-0.05%	0.00%	0.05%	0.12%	0.24%	0.42%	0.90%
Pennsylvania State ERS	-0.72%	-0.11%	0.09%	0.25%	0.34%	0.40%	0.45%	0.00%	0.06%	0.11%	0.21%	0.36%	0.57%	1.17%
Rhode Island Municipal	-1.33%	-0.36%	-0.03%	0.19%	0.33%	0.41%	0.50%	-0.09%	0.00%	0.09%	0.22%	0.44%	0.77%	1.73%
South Carolina RS	-0.34%	0.09%	0.22%	0.32%	0.38%	0.42%	0.46%	-0.02%	0.02%	0.05%	0.12%	0.21%	0.34%	0.77%
South Carolina Police	-0.55%	0.06%	0.24%	0.38%	0.47%	0.52%	0.58%	-0.08%	-0.01%	0.04%	0.13%	0.27%	0.45%	1.05%
Texas Teachers	-1.23%	-0.33%	-0.00%	0.24%	0.41%	0.52%	0.62%	0.12%	0.23%	0.33%	0.51%	0.75%	1.08%	1.98%

Note: Table displays the debt to GDP and asset to GDP ratios for various percentiles by plan, assuming contributions to return to today's debt to GDP ratio in 30 years starting now given a 2.5% real return on assets.

Table A10.3

Stochastic Exercise Results by Plan Using Contribution Rates from 4.5 Percent Real Return

	Percentiles of Debt to GDP in 2047							Percentiles of Assets to GDP in 2047						
	1st	10th	25th	50th	75th	90th	99th	1st	10th	25th	50th	75th	90th	99th
US Aggregate	-0.48%	0.09%	0.27%	0.41%	0.49%	0.54%	0.62%	-0.13%	-0.05%	0.00%	0.09%	0.22%	0.40%	0.97%
Arizona SRS	-0.44%	0.11%	0.29%	0.41%	0.48%	0.53%	0.59%	-0.12%	-0.05%	-0.01%	0.07%	0.19%	0.37%	0.91%
Arizona State Corrections Officers	0.01%	0.53%	0.73%	0.87%	0.96%	1.01%	1.07%	-0.08%	-0.02%	0.03%	0.12%	0.26%	0.45%	0.97%
California Teachers	-0.82%	-0.01%	0.28%	0.49%	0.63%	0.71%	0.79%	-0.03%	0.05%	0.13%	0.27%	0.48%	0.77%	1.58%
University of California	-1.31%	-0.11%	0.30%	0.59%	0.77%	0.88%	0.99%	-0.08%	0.04%	0.14%	0.32%	0.62%	1.02%	2.22%
San Diego City ERS	-0.64%	0.01%	0.20%	0.35%	0.44%	0.51%	0.67%	-0.34%	-0.18%	-0.10%	-0.01%	0.13%	0.32%	0.97%
LA County ERS	-1.12%	-0.05%	0.26%	0.48%	0.63%	0.71%	0.81%	-0.08%	0.02%	0.10%	0.25%	0.47%	0.78%	1.82%
San Diego County	-0.93%	-0.07%	0.22%	0.44%	0.57%	0.65%	0.76%	-0.16%	-0.05%	0.03%	0.16%	0.38%	0.67%	1.51%
San Francisco City & County	-1.23%	-0.22%	0.13%	0.35%	0.49%	0.57%	0.67%	-0.10%	0.00%	0.08%	0.23%	0.45%	0.79%	1.80%
DC Teachers	-2.57%	-0.65%	0.01%	0.50%	0.82%	1.01%	1.20%	-0.03%	0.17%	0.35%	0.67%	1.16%	1.83%	3.72%
Florida RS	-0.62%	0.02%	0.21%	0.35%	0.43%	0.50%	0.65%	-0.35%	-0.20%	-0.13%	-0.04%	0.09%	0.28%	0.92%
Georgia ERS	-0.23%	0.04%	0.11%	0.16%	0.21%	0.26%	0.38%	-0.29%	-0.17%	-0.12%	-0.07%	-0.02%	0.05%	0.31%
Georgia Teachers	-0.74%	-0.01%	0.25%	0.44%	0.56%	0.62%	0.72%	-0.14%	-0.05%	0.02%	0.13%	0.32%	0.59%	1.31%
Illinois Municipal	-1.07%	-0.21%	0.10%	0.31%	0.44%	0.53%	0.69%	-0.31%	-0.16%	-0.07%	0.06%	0.28%	0.58%	1.43%
Illinois SERS	0.11%	0.33%	0.39%	0.44%	0.50%	0.56%	0.70%	-0.41%	-0.26%	-0.20%	-0.14%	-0.09%	-0.03%	0.19%
Illinois Teachers	0.16%	0.43%	0.51%	0.56%	0.62%	0.68%	0.81%	-0.36%	-0.23%	-0.17%	-0.11%	-0.06%	0.02%	0.29%
Indiana Teachers	-0.11%	0.25%	0.36%	0.45%	0.50%	0.53%	0.61%	-0.16%	-0.09%	-0.05%	-0.00%	0.08%	0.19%	0.55%
Louisiana Municipal Police	-0.69%	0.10%	0.32%	0.48%	0.57%	0.64%	0.76%	-0.23%	-0.11%	-0.05%	0.05%	0.20%	0.43%	1.21%
Baton Rouge City Parish RS	-0.28%	0.15%	0.29%	0.38%	0.45%	0.50%	0.61%	-0.25%	-0.15%	-0.09%	-0.03%	0.07%	0.21%	0.62%
Louisiana SERS	-0.12%	0.16%	0.25%	0.31%	0.35%	0.40%	0.52%	-0.27%	-0.15%	-0.11%	-0.06%	0.00%	0.09%	0.36%
Massachusetts SRS	-0.66%	0.01%	0.24%	0.41%	0.51%	0.57%	0.67%	-0.15%	-0.05%	0.01%	0.11%	0.28%	0.51%	1.17%
Massachusetts Teachers	-0.58%	0.06%	0.28%	0.43%	0.52%	0.58%	0.64%	-0.06%	-0.00%	0.05%	0.15%	0.30%	0.51%	1.16%
Maine State and Teacher	-0.78%	-0.09%	0.16%	0.33%	0.43%	0.50%	0.66%	-0.31%	-0.15%	-0.08%	0.03%	0.20%	0.44%	1.14%
Michigan Public Schools	-0.24%	0.11%	0.22%	0.30%	0.35%	0.40%	0.52%	-0.29%	-0.17%	-0.11%	-0.06%	0.01%	0.12%	0.47%
Kansas City Missouri ERS	-0.68%	0.05%	0.26%	0.41%	0.51%	0.60%	0.80%	-0.44%	-0.24%	-0.16%	-0.06%	0.09%	0.30%	1.03%
Missouri Teachers	-0.89%	-0.06%	0.25%	0.47%	0.60%	0.68%	0.76%	-0.06%	0.02%	0.10%	0.23%	0.45%	0.76%	1.58%
North Dakota Teachers	-0.54%	0.08%	0.28%	0.44%	0.54%	0.59%	0.66%	-0.08%	-0.01%	0.05%	0.15%	0.30%	0.51%	1.12%
New Jersey PERS	-0.07%	0.22%	0.31%	0.38%	0.42%	0.44%	0.50%	-0.09%	-0.03%	-0.01%	0.03%	0.10%	0.19%	0.48%
New Jersey Teachers	0.22%	0.34%	0.38%	0.40%	0.42%	0.45%	0.51%	-0.13%	-0.07%	-0.04%	-0.02%	0.00%	0.04%	0.16%
New Mexico PERA	-0.35%	0.16%	0.33%	0.45%	0.53%	0.58%	0.67%	-0.20%	-0.10%	-0.05%	0.02%	0.14%	0.31%	0.82%
New York State Teachers	-1.05%	-0.18%	0.08%	0.28%	0.39%	0.47%	0.56%	-0.15%	-0.05%	0.02%	0.14%	0.34%	0.59%	1.45%
NY State & Local ERS	-1.17%	-0.23%	0.09%	0.30%	0.44%	0.52%	0.66%	-0.23%	-0.09%	-0.01%	0.13%	0.34%	0.66%	1.58%
Ohio Teachers	-0.36%	0.01%	0.15%	0.25%	0.31%	0.35%	0.42%	-0.15%	-0.08%	-0.04%	0.02%	0.12%	0.26%	0.63%
Oklahoma Police	-1.29%	-0.23%	0.12%	0.37%	0.54%	0.63%	0.75%	-0.14%	-0.03%	0.06%	0.23%	0.48%	0.83%	1.89%
Oregon PERS	-0.54%	0.01%	0.20%	0.34%	0.43%	0.49%	0.59%	-0.21%	-0.11%	-0.05%	0.04%	0.18%	0.37%	0.93%
Pennsylvania School Employees	-0.29%	0.16%	0.31%	0.41%	0.47%	0.51%	0.59%	-0.16%	-0.08%	-0.04%	0.02%	0.12%	0.27%	0.72%
Pennsylvania State ERS	-0.41%	0.08%	0.25%	0.37%	0.45%	0.49%	0.56%	-0.11%	-0.04%	0.00%	0.08%	0.20%	0.38%	0.86%
Rhode Island Municipal	-0.85%	-0.04%	0.20%	0.37%	0.49%	0.57%	0.70%	-0.29%	-0.15%	-0.08%	0.04%	0.22%	0.45%	1.25%
South Carolina RS	-0.20%	0.21%	0.32%	0.40%	0.45%	0.49%	0.55%	-0.12%	-0.06%	-0.02%	0.03%	0.11%	0.23%	0.63%
South Carolina Police	-0.30%	0.23%	0.38%	0.50%	0.57%	0.62%	0.71%	-0.21%	-0.11%	-0.06%	0.01%	0.12%	0.28%	0.81%
Texas Teachers	-0.67%	0.03%	0.29%	0.48%	0.61%	0.68%	0.75%	0.00%	0.07%	0.14%	0.27%	0.45%	0.72%	1.41%

Note: Table displays the debt to GDP and asset to GDP ratios for various percentiles by plan, assuming contributions to return to today's debt to GDP ratio in 30 years starting now given a 4.5% real return on assets.

Figure A1

Number of Articles on State and Local Government
Pension Crisis in Major, National Publications
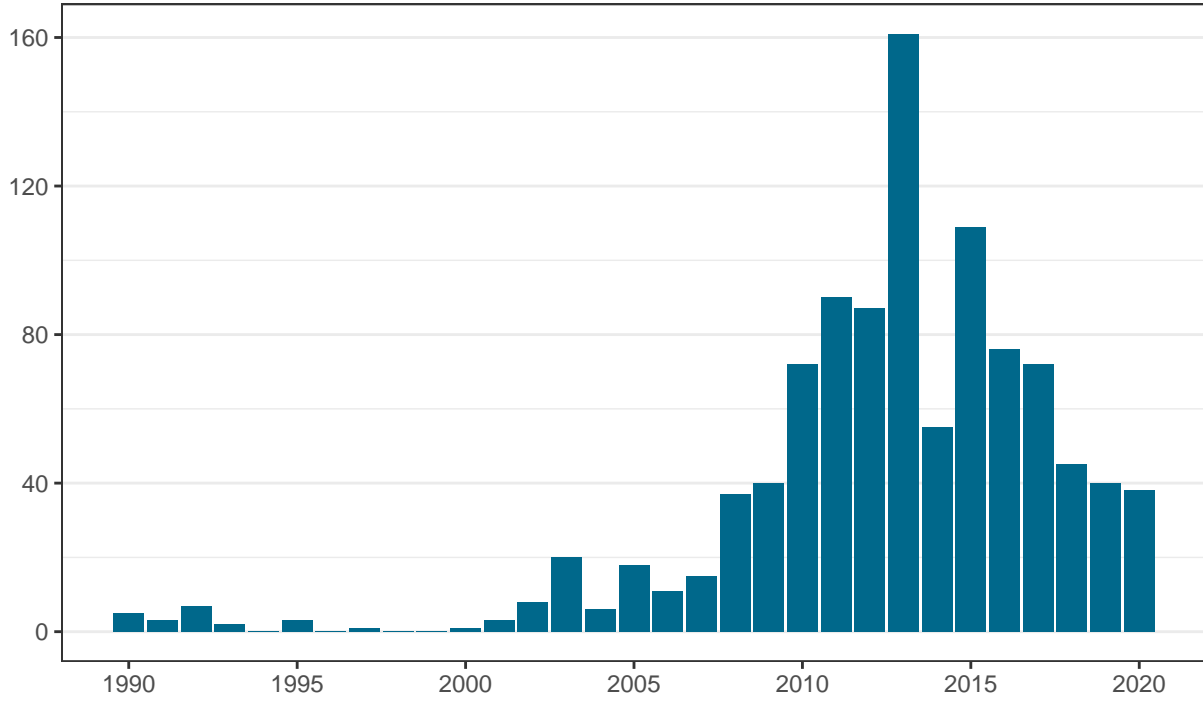
Source: Factiva search of major, national news sources.
Search terms: (state OR local) AND pension AND (crisis OR default).

Change in State and Local Government Expenditures as Share of Tax Receipts

Share of tax receipts (PP)	1998	2017
Pension Contributions	5.3	8.7
Wages and Salaries	61.2	54.9
Infrastructure	18.4	16.8

—— Pension Contributions – – Wages and Salaries · · Infrastructure
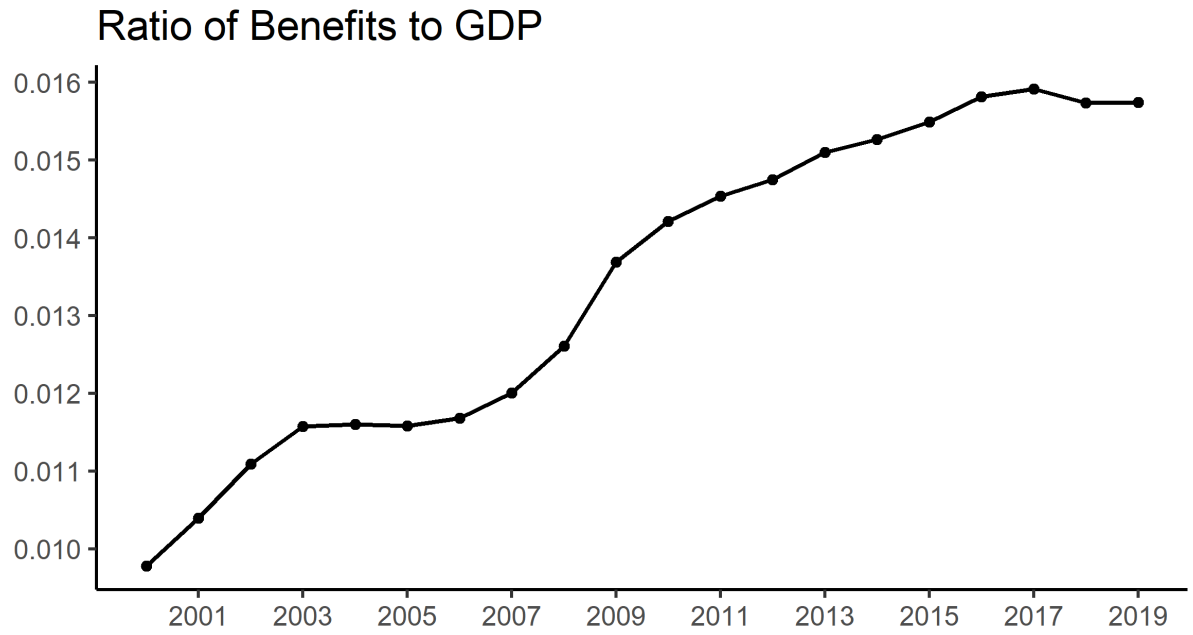
Source: BEA
Note: Graph shows changes in the ratio of State and Local employer pension contributions, wage and salary payments, and investment in infrastructure to current tax receipts.

Figure A3

State and Local Government Pension Funding Ratios Under Plan Chosen Discount Rate
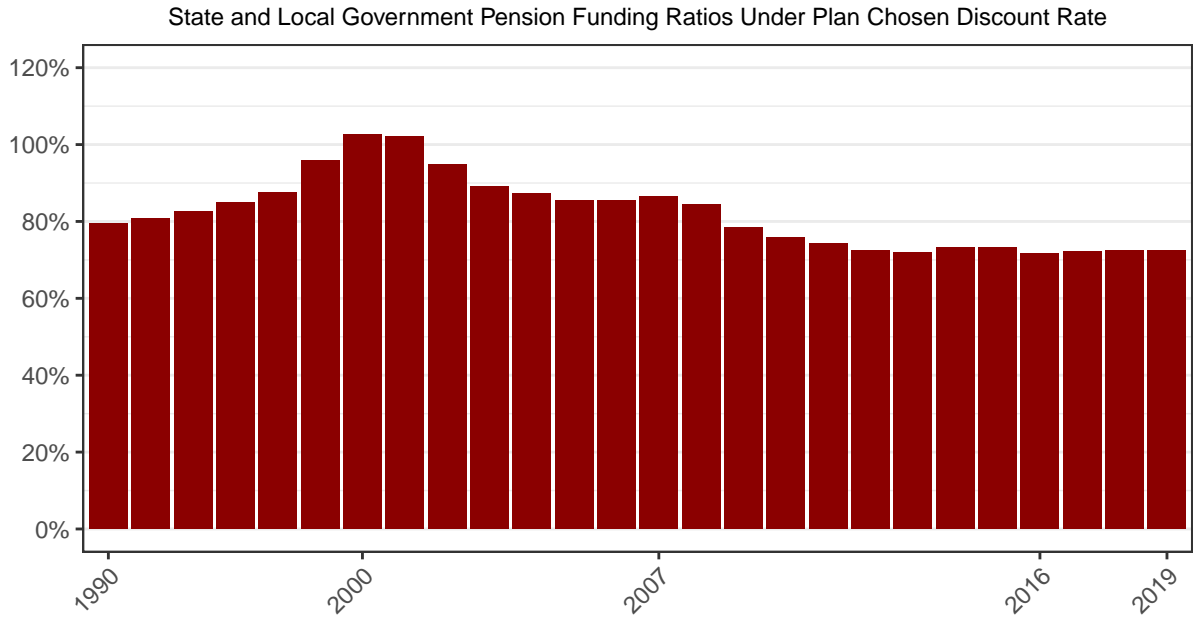
Source: Calculations and figure are from the Center for Retirement Research at Boston College; Aubry, Crawford, and Wandrei (2018).
Note: The 2017 funded ratio involves projections for 18 percent of PPD plans, representing 26 percent of liabilities.
Calculations based on 2017 actuarial valuations (AVs); Center for Retirement Research at Boston College Public Plans Database (PPD)
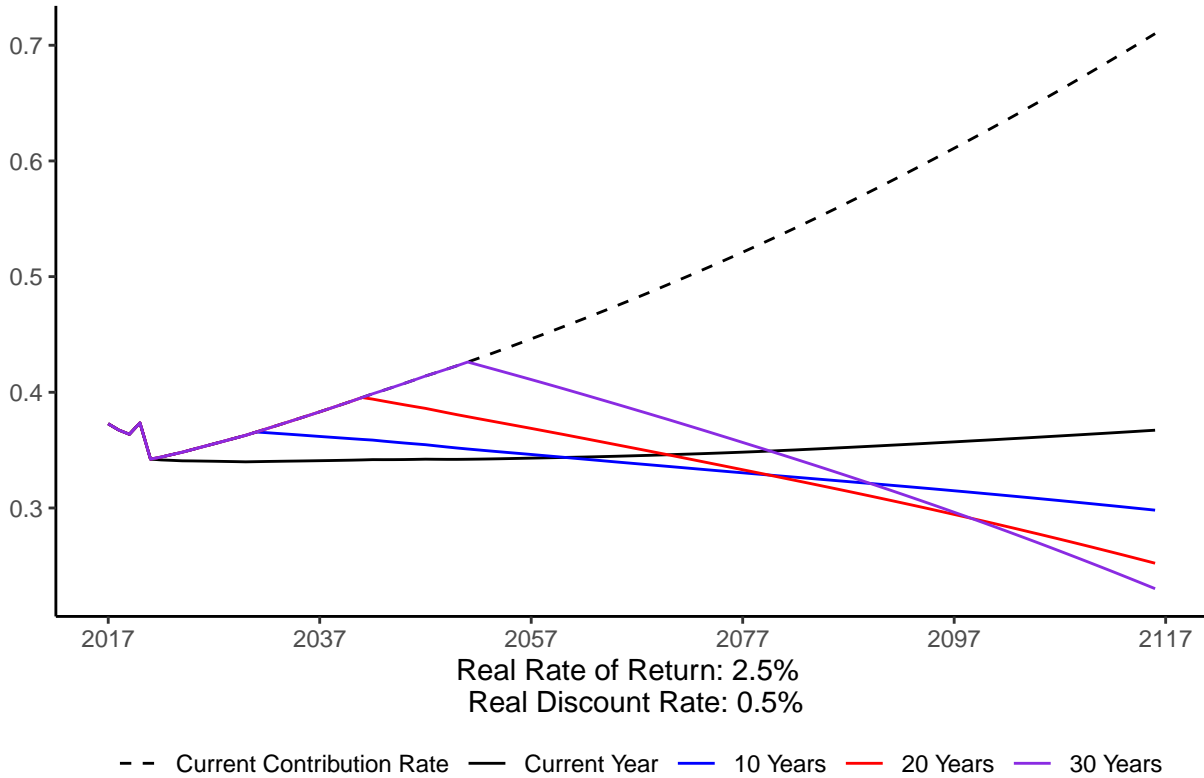(2001–2017);and Zorn(1990–2000).

Ratio of Benefits to GDP

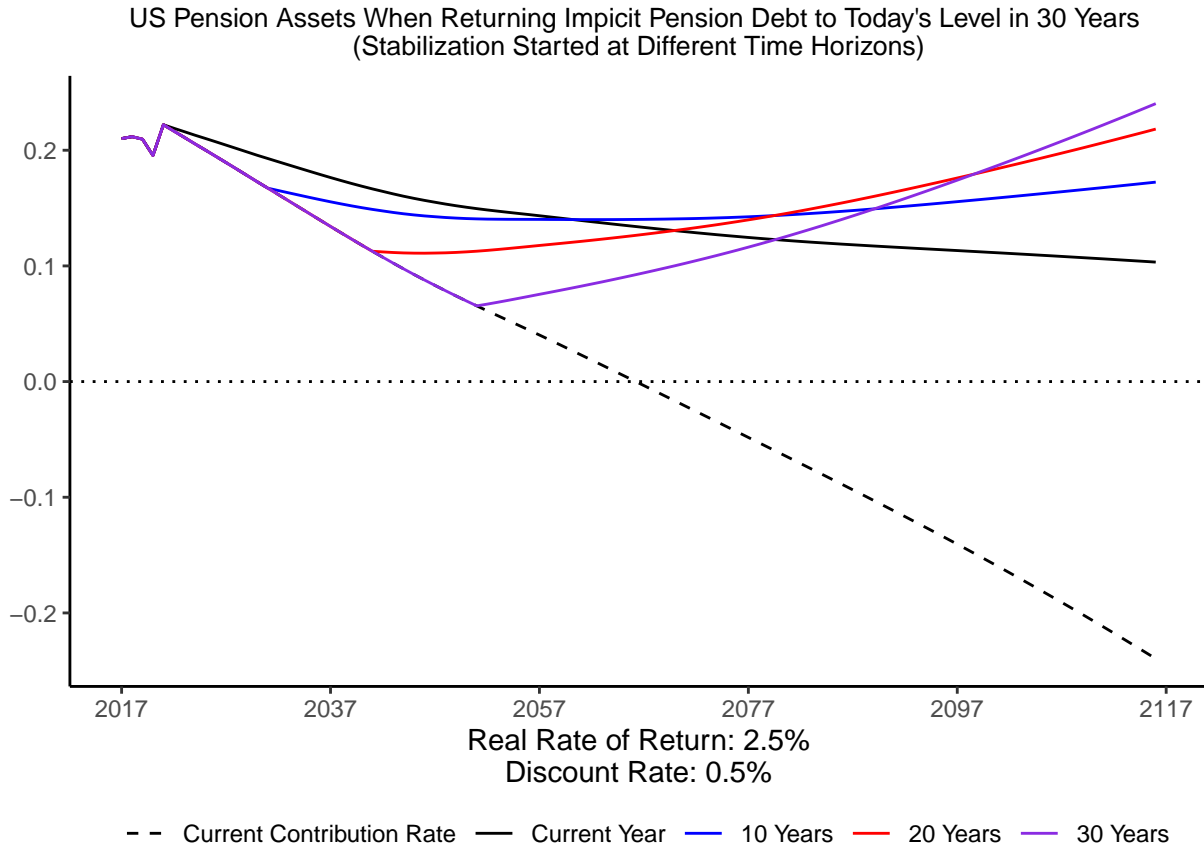*Source:* BEA Table 7.24. Transactions of State and Local Government Defined Benefit Pension Plans

Figure A5

US Implicit Pension Debt When Returning Pension Debt to Today's Level in 30 Years
(Stabilization Started at Different Time Horizons)

Real Rate of Return: 2.5%
Real Discount Rate: 0.5%

- - Current Contribution Rate — Current Year — 10 Years — 20 Years — 30 Years

Note: The dashed black line displays implicit pension debt – unfunded pension liabilities – as a share of GDP assuming that assets have a real return of 2.5 percent and that pension contributions as a share of GDP are held fixed at their 2017 value. The solid black line displays implicit pension debt – unfunded pension liabilities – as a share of GDP assuming that assets have a real return of 2.5 percent and that pension contributions as a share of payroll receive an immediate one-time, permanent change such that pension debt returns to today's level in 30 years. The blue, red, and purple solid lines are analogous to the solid black line but assume that the adjustment to pension contributions occurs in 10 years, 20 years, and 30 years, respectively, and pension debt returns to today's level in 40 years, 50 years, and 60 years, respectively.

Figure A6

US Pension Assets When Returning Impicit Pension Debt to Today's Level in 30 Years
(Stabilization Started at Different Time Horizons)

Real Rate of Return: 2.5%
Discount Rate: 0.5%

- - Current Contribution Rate — Current Year — 10 Years — 20 Years — 30 Years

Note: The dashed black line displays pension assets as a share of GDP assuming that the assets have a real return of 2.5 percent and that pension contributions as a share of GDP are held fixed at their 2017 value. The solid black line displays pension assets as a share of GDP assuming that the assets have a real return of 2.5 percent and that pension contributions as a share of payroll receive an immediate one-time, permanent change such that pension debt returns to today's level in 30 years. The blue, red, and purple solid lines are analogous to the solid black line but assume that the adjustment to pension contributions occurs in 10 years, 20 years, and 30 years, respectively, and the pension debt returns to today's level in 40 years, 50 years, and 60 years, respectively.

Stochastic Exercise: Debt to GDP Percentiles for U.S. Aggregate, Contributions as in 30-year Deterministic Stabilization with 4.5% Real Return on Assets

Stochastic Exercise: Debt to GDP Percentiles for U.S. Aggregate, Contributions as in 30-year Deterministic Stabilization with 0.5% Real Return on Assets

Stochastic Exercise: Assets to GDP Percentiles for U.S. Aggregate, Contributions as in 30-year Deterministic Stabilization with 4.5% Real Return on Assets

Stochastic Exercise: Assets to GDP Percentiles for U.S. Aggregate, Contributions as in 30-year Deterministic Stabilization with 0.5% Real Return on Assets
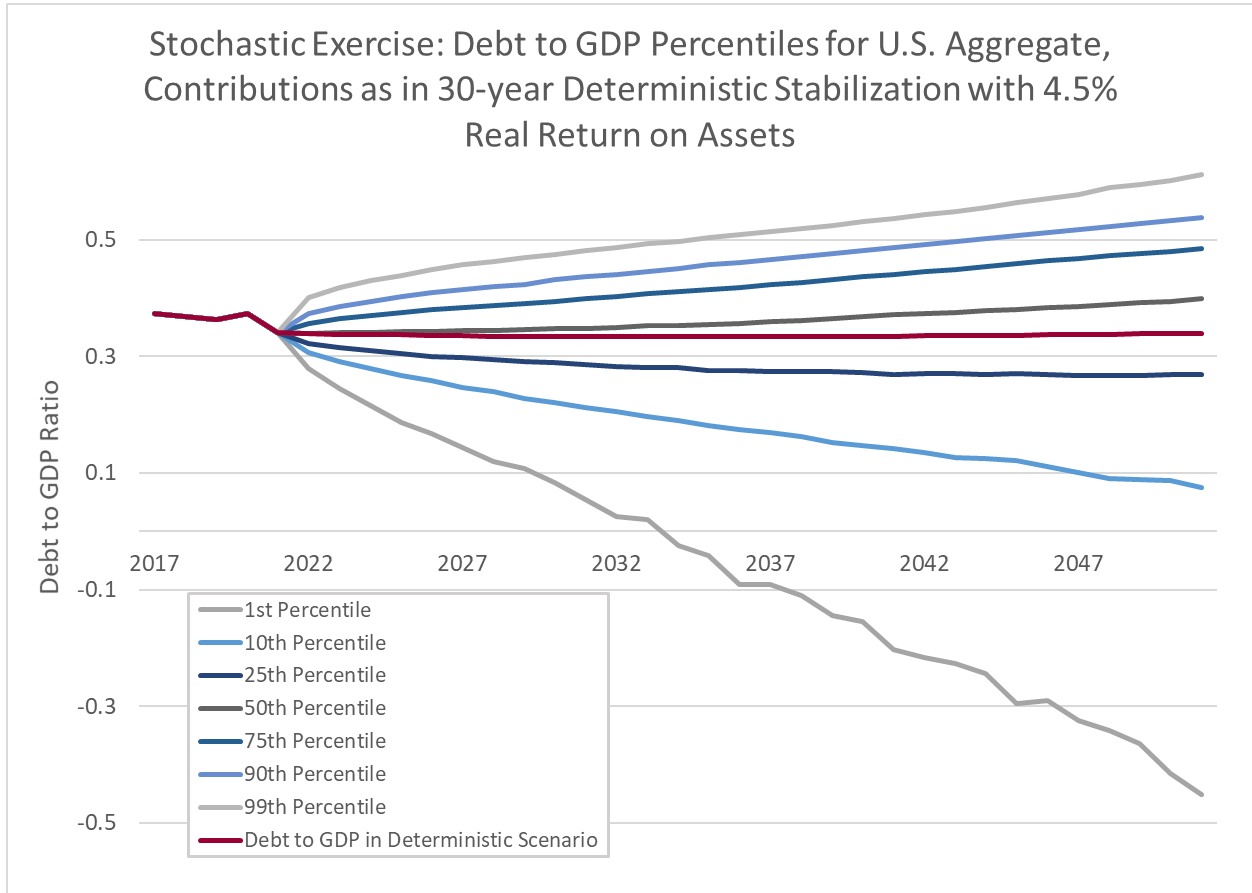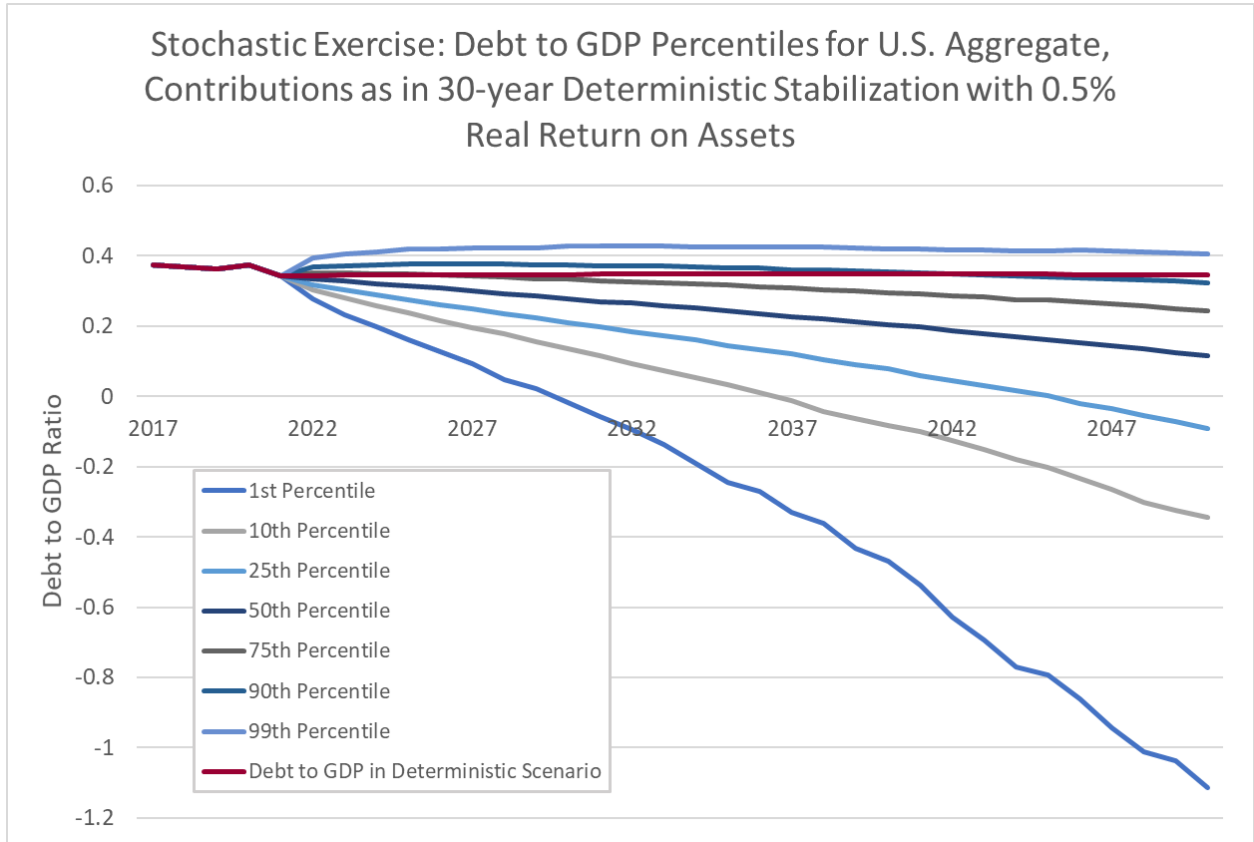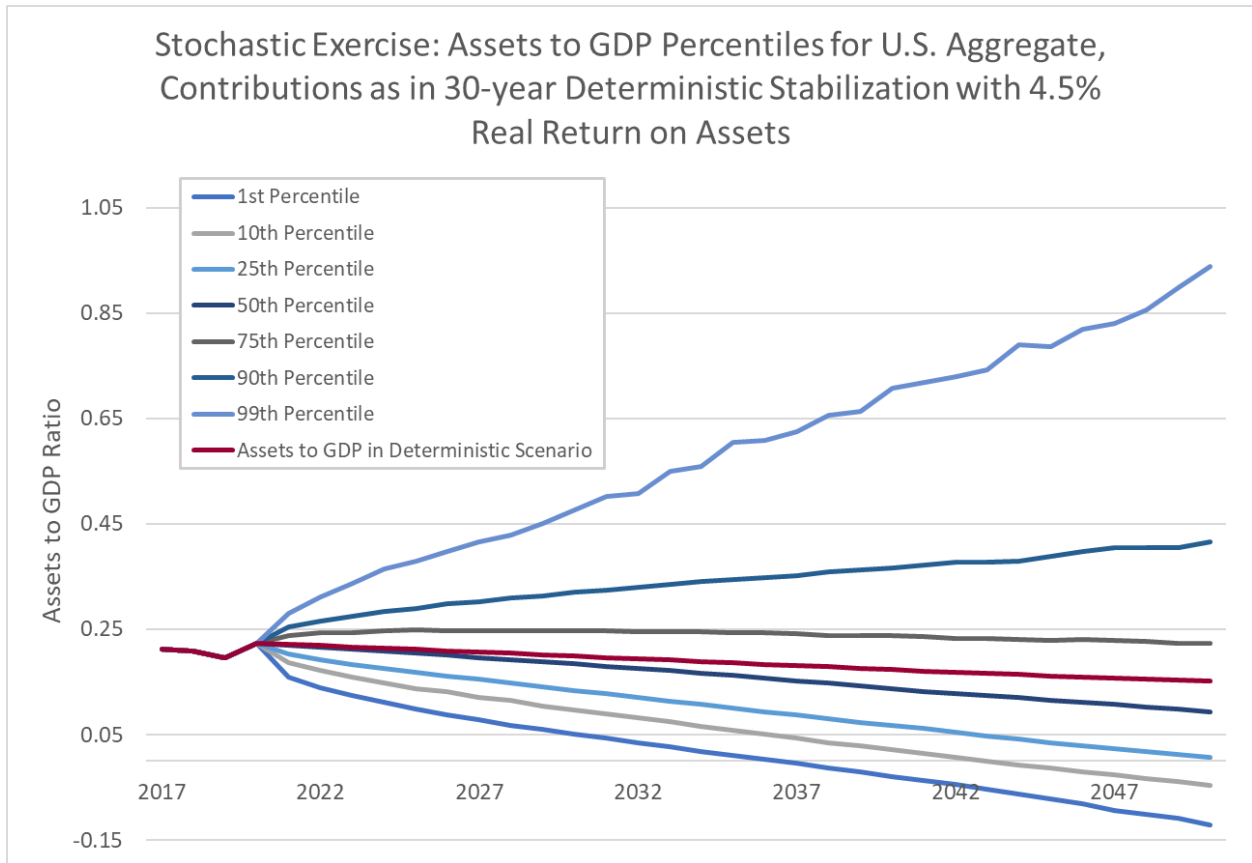
Table B1

List of State and Local Pension Plans in Estimation Sample

States	Pension Plan	Funding Ratio (%)	Unfunded Liability to Payroll	Contribution Rate (%)	Ratio of Active Employees to Beneficiaries	Employee Growth Rate (%)
AZ	Arizona SRS	69.7	1.6	22.4	1.4	0.9
AZ	Arizona State Corrections Officers	49.5	2.9	22.0	2.7	0.9
CA	California Teachers	62.6	3.4	32.4	1.5	0.6
CA	University of California	84.8	1.0	31.1	1.8	0.6
CA	San Diego City ERS	71.2	6.1	77.8	0.7	0.6
CA	LA County ERS	79.9	1.7	24.3	1.5	0.6
CA	San Diego County	77.4	2.7	44.0	1.0	0.6
CA	San Francisco City & County	86.3	1.1	26.8	1.1	0.6
DC	DC Teachers	92.5	0.4	20.4	1.3	2.0
FL	Florida RS	84.3	1.1	12.8	1.2	1.1
GA	Georgia ERS	74.7	1.7	26.0	1.2	0.6
GA	Georgia Teachers	74.2	2.2	20.9	1.8	0.6
IL	Illinois Municipal	92.9	0.4	18.2	1.4	-0.3
IL	Illinois SERS	35.5	7.2	48.9	0.8	-0.3
IL	Illinois Teachers	40.2	7.4	50.8	1.4	-0.3
IN	Indiana Teachers	48.1	3.1	30.9	1.2	0.0
LA	Louisiana Municipal Police	71.4	2.8	48.8	1.2	0.3
LA	Baton Rouge City Parish RS	67.9	3.8	40.6	0.8	0.3
LA	Louisiana SERS	63.7	3.7	45.3	0.8	0.3
MA	Massachusetts SRS	64.7	2.3	27.3	1.4	0.3
MA	Massachusetts Teachers	52.1	3.6	33.3	1.4	0.3
ME	Maine State and Teacher	80.9	1.4	25.4	1.1	-0.6
MI	Michigan Public Schools	61.6	3.6	34.4	0.9	-0.4
MO	Kansas City Missouri ERS	83.5	1.3	18.9	1.3	-0.1
MO	Missouri Teachers	84.0	1.5	30.2	1.2	-0.1
ND	North Dakota Teachers	63.7	2.1	25.9	1.3	1.1
NJ	New Jersey PERS	60.1	2.0	20.5	1.4	0.0
NJ	New Jersey Teachers	42.1	3.4	17.8	1.5	0.0
NM	New Mexico PERA	74.9	2.3	27.5	1.3	-0.2
NY	New York State Teachers	97.7	0.2	12.6	1.6	0.1
NY	NY State & Local ERS	94.4	0.4	17.5	1.2	0.1
OH	Ohio Teachers	75.1	2.1	26.1	1.1	-0.3
OK	Oklahoma Police	101.8	-0.1	31.0	1.3	0.5
OR	Oregon PERS	75.4	2.0	10.5	1.2	0.6
PA	Pennsylvania School Employees	56.3	3.4	37.2	1.1	-0.3
PA	Pennsylvania State ERS	59.4	3.1	36.4	0.8	-0.3
RI	Rhode Island Municipal	78.6	1.2	20.8	1.4	-0.4
SC	South Carolina RS	56.3	2.5	23.2	1.4	0.7
SC	South Carolina Police	63.0	2.1	25.3	1.5	0.7
TX	Texas Teachers	80.5	0.8	15.3	2.1	1.4

Note:

This table lists the pension plans in the estimation sample. Funding ratio is the ratio of GASB stated assets to liabilities. Contribution rate is the ratio of total contributions, employer and employee, to current payroll (FY2017).

Table B2
Summary of Plan Inputs

Variable	Min	Mean	Max	Total
GASB liability ($bn)	1	58	287	2,314
GASB assets ($bn)	1	41	180	1,652
GASB discount rate	6.5%	7.3%	8%	–
Plan benefit factor	1.1%	2.2%	3.3%	–
Plan benefit factor for new hires	0.2%	2%	3%	–
Cost of living adjustment	0%	1.5%	3%	–
Wage inflation	1.2%	3.2%	4.2%	–
FY 2017 payroll ($bn)	0.1	8.1	43.2	325.3
Number of active employees	3,047	144,013	864,261	5,760,526
Number of deferred inactive employees	0	18,217	108,612	728,667
Number of current beneficiaries	2,400	106,716	436,243	4,268,628
Average annual salary	40,597	58,667.2	96,900	–
Average annual benefit	15,929	30,489.9	51,132	–
Actuarially required contribution rate	7.7%	22.2%	62.7%	–
Current rate of employee contributions	0%	7.3%	15.5%	–
Current rate of employer contributions	5.8%	19.6%	63.1%	–
Total contribution rate	10.5%	28.9%	77.8%	–
Percent of active employees that are male	22.4%	40.3%	76.5%	–
Average age of current beneficiaries	60.2	70.3	73.5	–
Normal retirement age	50	61	65	–
Normal retirement age (new hires)	50	63.7	68	–
Assumed percent of active employees that are married	55%	80%	100%	–
Joint annuity reduction factor	37.8%	54.3%	100%	–
Percent reduction per year for early retirement	2%	5.4%	10%	–
Growth rate of active employees (yrs 0-20)	-0.8%	0.2%	2.1%	–
Growth rate of active employees (yrs 21-30)	-0.9%	0.1%	1.7%	–
Growth rate of active employees (yrs 31-40)	-0.3%	0.4%	1.9%	–
Growth rate of active employees (yrs 40+)	0.4%	0.4%	0.8%	–
Number of years until vested in plan	1	7	12	–
Cost of living adjustment (new hires)	0%	1%	3%	–
Number of years until vested (new hires)	1	8	16	–
GASB liability ($bn) for current beneficiaries	0.8	34.4	154.3	–
Inflation percentage	1.9%	2.7%	3.5%	–
Number of years salary is averaged in final salary calculation	1	3	5	–
Number of years salary is averaged in final salary calculation (new hires)	2	4	8	–
Plan normal cost	4.7%	14.6%	26.9%	–

Note:

This table summarizes the input variables utilised in the calculation of the plan level cashflow and liability using the plans stated actuarial assumptions. The data is sourced from the AVs and the Bostong College PPD database.

Table B3
Replication Errors and Calibration Factors

State	Pension Plan	Uncalibrated Liability Error (%)	Calibration factors (v)		
			$vc1$	$vc2$	$vc3$
AZ	Arizona SRS	-2.1	1.020	0.679	1.008
AZ	Arizona State Corrections Officers	5.1	0.930	0.130	1.011
CA	California Teachers	-3.6	1.051	0.876	1.004
CA	University of California	11.2	0.776	0.785	1.009
CA	San Diego City ERS	-11.7	1.003	2.001	1.016
CA	LA County ERS	-8.5	1.121	0.491	1.012
CA	San Diego County	4.4	1.105	0.312	0.998
CA	San Francisco City & County	4.4	0.972	0.175	1.011
DC	DC Teachers	19.4	0.766	0.506	1.005
FL	Florida RS	1.6	0.939	0.640	1.004
GA	Georgia ERS	-5.8	0.954	2.255	1.012
GA	Georgia Teachers	-6.3	1.012	0.000	1.011
IL	Illinois Municipal	-2.8	0.865	0.000	1.001
IL	Illinois SERS	-1.6	1.010	0.972	1.002
IL	Illinois Teachers	-2.6	0.943	0.878	1.008
IN	Indiana Teachers	-14.3	1.070	0.000	1.026
LA	Louisiana Municipal Police	-9.0	1.061	1.618	1.014
LA	Baton Rouge City Parish RS	-7.9	0.959	0.924	1.016
LA	Louisiana SERS	-12.9	0.989	1.138	1.025
MA	Massachusetts SRS	-9.4	1.141	3.065	1.006
MA	Massachusetts Teachers	-10.4	1.258	0.000	1.004
ME	Maine State and Teacher	4.0	0.822	1.092	1.007
MI	Michigan Public Schools	-8.3	1.420	2.756	0.996
MO	Kansas City Missouri ERS	-11.5	1.033	0.000	1.023
MO	Missouri Teachers	3.9	0.911	0.145	1.003
ND	North Dakota Teachers	-3.4	1.020	0.928	1.006
NJ	New Jersey PERS	-0.1	0.896	0.055	1.016
NJ	New Jersey Teachers	-7.4	0.979	1.403	1.018
NM	New Mexico PERA	-2.7	0.972	0.595	1.008
NY	New York State Teachers	5.5	0.781	0.446	1.015
NY	NY State & Local ERS	-1.9	0.915	0.956	1.013
OH	Ohio Teachers	-5.9	0.881	0.898	1.018
OK	Oklahoma Police	-2.3	0.916	1.231	1.018
OR	Oregon PERS	-8.8	0.944	1.416	1.016
PA	Pennsylvania School Employees	-9.0	1.170	0.667	1.009
PA	Pennsylvania State ERS	-12.9	1.305	0.000	1.007
RI	Rhode Island Municipal	-5.3	1.032	0.000	1.008
SC	South Carolina RS	0.3	0.876	0.844	1.010
SC	South Carolina Police	5.5	0.866	0.916	1.001
TX	Texas Teachers	-4.9	1.005	0.735	1.016
US	Total	-3.2	0.999	0.917	1.010

Note:
This table illustrates the accuracy of our replication and cashflows for each plan. The total values are weighted by total liability, active liability, inactive liability, and retired liability respectively. vc1 is the proportional calibration factor for actives, vc2 is the proportional calibration factor for inactives, and vc3 is the geometric calibration factor for retirees.

Ratio of Benefits to GDP
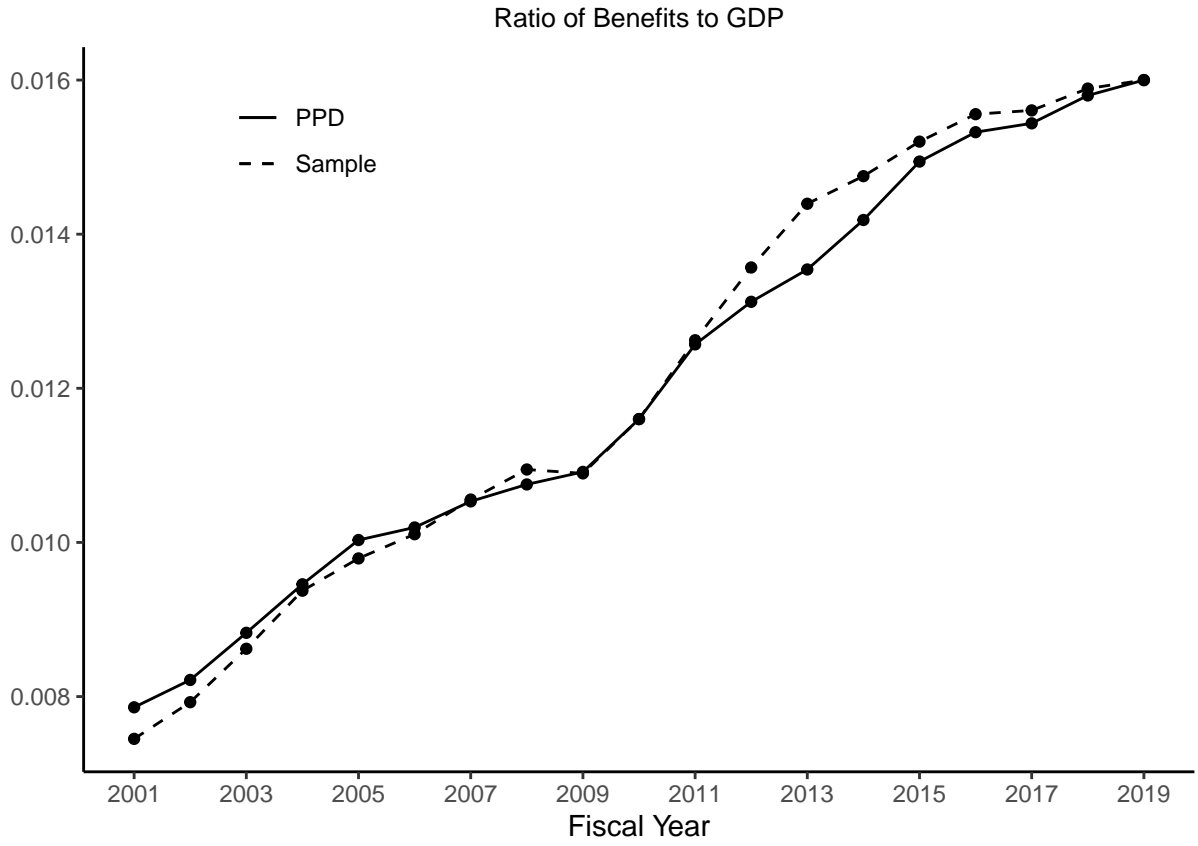
Note: The figure displays the ratio of pension benefits to GDP. Pension benefits are obtained from the PPD. The dashed line displays the ratio for the estimation sample used in the paper; the solid line displays the ratio for the entire PPD sample.

Figure B2

Panel A: Assets / Liabilities

Panel B: Unfunded Liability / Payroll

Panel C: Total Contributions / Payroll

Panel D: Active Employees / Beneficiaries
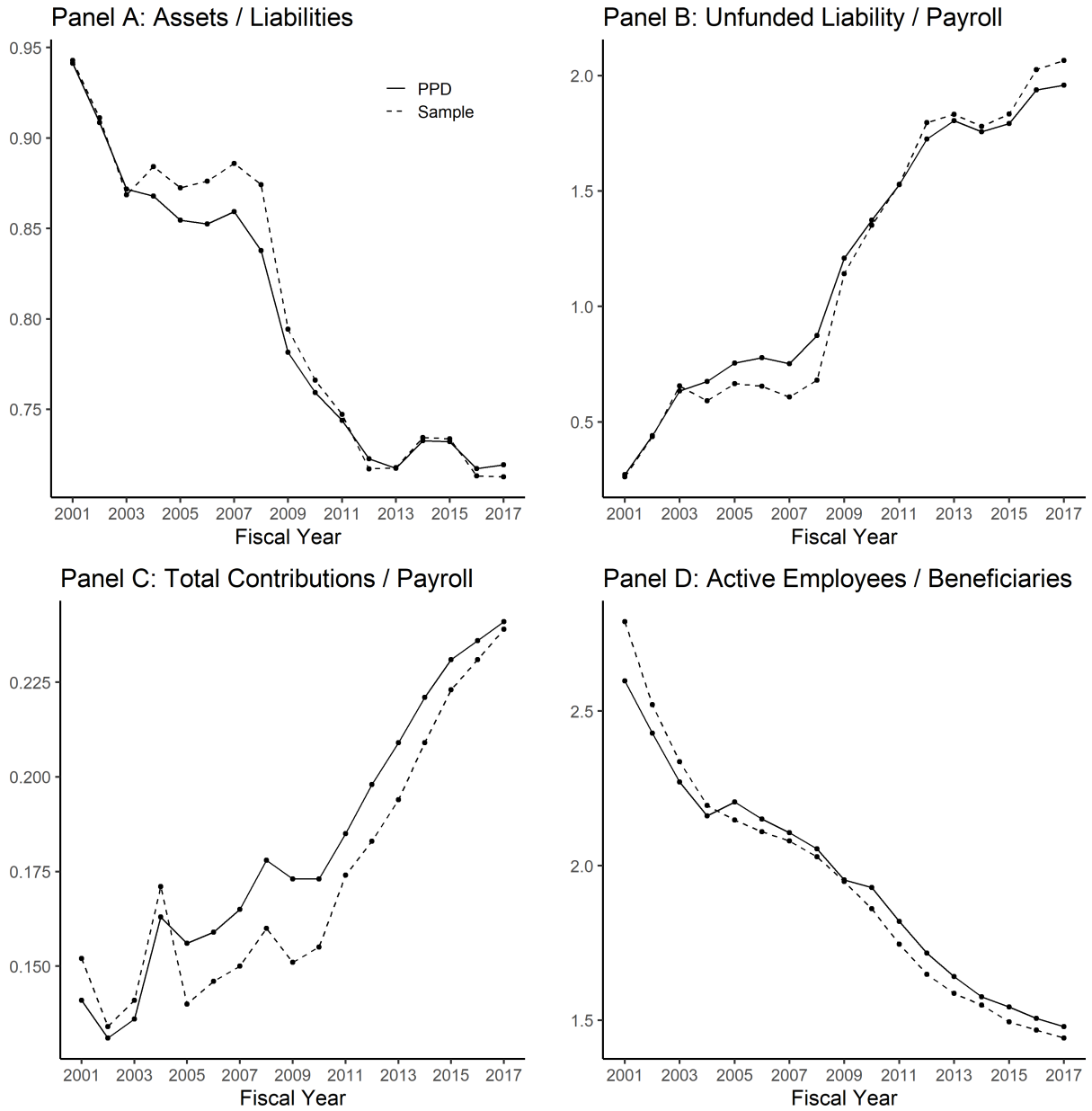
Note: The dashed lines display means for the estimation sample. The solid lines display means for the universe of the PPD.

Figure C1

age/service	Age and service distribution (percent of employees)										
	0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54
20–24	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25–29	6.9	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30–34	5.6	4.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35–39	4.1	3.0	4.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40–44	3.1	2.3	2.8	3.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0
45–49	3.0	2.3	2.6	2.9	2.8	0.8	0.0	0.0	0.0	0.0	0.0
50–54	2.3	1.9	2.3	2.3	1.9	2.0	0.6	0.0	0.0	0.0	0.0
55–59	1.9	1.6	2.5	2.2	1.7	1.5	1.2	0.1	0.0	0.0	0.0
60–64	1.1	1.2	1.5	1.6	1.2	1.0	0.7	0.2	0.0	0.0	0.0
65–69	0.5	0.4	0.5	0.5	0.3	0.3	0.2	0.1	0.0	0.0	0.0
70–74	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0

Note: Data is sourced from the various acturial valuations (FY 2017). Table is an employee weighted average over the 40 plans in sample.

Figure C2

Salary relativities

age/service	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54
20-24	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25-29	0.76	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-34	0.78	0.95	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35-39	0.80	0.98	1.10	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40-44	0.81	0.98	1.11	1.24	1.32	0.00	0.00	0.00	0.00	0.00	0.00
45-49	0.80	0.96	1.08	1.21	1.33	1.40	0.00	0.00	0.00	0.00	0.00
50-54	0.78	0.92	1.03	1.14	1.27	1.38	1.43	0.00	0.00	0.00	0.00
55-59	0.77	0.90	1.00	1.09	1.20	1.32	1.42	1.45	0.00	0.00	0.00
60-64	0.75	0.88	0.98	1.07	1.16	1.26	1.37	1.46	1.44	0.00	0.00
65-69	0.68	0.81	0.92	1.02	1.10	1.19	1.30	1.44	1.48	1.24	0.00
70-74	0.54	0.63	0.72	0.81	0.87	0.94	1.01	1.09	1.17	0.92	0.92

Note: Data is sourced from the various acturial valuations (FY 2017). Table is an employee weighted average over the 40 plans in sample.

Figure C3

	Employees (%)	Benefit Relativity
40-44	0.2	0.7
45-49	0.8	0.75
50-54	1.7	1.04
55-59	6.1	1.08
60-64	14.5	1.04
65-69	24.9	1
70-74	22.0	0.96
75-79	12.7	0.89
80-84	9.4	0.83
85-89	5.0	0.8
90-94	2.4	0.76
95-99	0.3	0.79
100+	0.0	0.81

Figure C4

Age and service distribution for inactive vested members (percent of employees)

age/service	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54
20-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34	0.0	2.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39	0.0	4.8	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-44	0.0	7.1	3.9	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
45-49	0.0	8.8	5.9	2.4	0.8	0.1	0.0	0.0	0.0	0.0	0.0
50-54	0.0	10.0	7.8	3.8	2.2	0.7	0.1	0.0	0.0	0.0	0.0
55-59	0.0	9.5	8.7	4.4	2.9	1.6	0.6	0.1	0.0	0.0	0.0
60-64	0.0	3.3	2.2	1.1	0.7	0.5	0.3	0.1	0.0	0.0	0.0
65-69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70-74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: Data is imputed using plans actuarial assumptions and current member statistics. Table is an employee weighted average over the 40 plans in sample.

Figure C5

age/service	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54
20-24	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29	11.9	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34	11.4	5.2	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39	10.9	4.7	4.3	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-44	10.6	4.4	4.0	1.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0
45-49	10.5	4.3	3.9	1.5	1.3	1.2	0.0	0.0	0.0	0.0	0.0
50-54	10.4	4.3	3.9	1.5	1.3	1.2	1.2	0.0	0.0	0.0	0.0
55-59	10.5	4.4	4.0	1.6	1.4	1.4	1.3	1.3	0.0	0.0	0.0
60-64	10.7	4.5	4.1	1.8	1.6	1.5	1.4	1.4	1.4	0.0	0.0
65-69	10.7	4.6	4.2	1.8	1.6	1.5	1.5	1.5	1.5	1.5	0.0
70-74	10.6	4.5	4.1	1.8	1.6	1.5	1.4	1.4	1.4	1.4	1.4

Withdrawal assumptions

Note: Data is sourced from the various acturial valuations (FY 2017). Table is an employee weighted average over the 40 plans in sample.

Figure C6

Proability of claiming a refund upon withdrawal

age/service	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54
20-24	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-29	100.0	61.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-34	100.0	60.3	38.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35-39	100.0	54.4	38.8	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40-44	100.0	52.9	31.9	31.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0
45-49	100.0	48.5	22.0	15.0	15.0	10.0	0.0	0.0	0.0	0.0	0.0
50-54	100.0	26.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55-59	100.0	26.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60-64	100.0	26.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65-69	100.0	26.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70-74	100.0	26.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: Data is sourced from the various acturial valuations (FY 2017). Table is an employee weighted average over the 40 plans in sample.