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### Investment Risk-Taking by Public Pension Plans: Potential Consequences for Pension Funds, State and Local Governments, and Stakeholders in Government

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# Investment Risk-Taking by Public Pension Plans: Potential Consequences for Pension Funds, State and Local Governments, and Stakeholders in Government

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## Summary

Public pension plans in the United States have \$3.8 trillion of invested assets, more than two-thirds of which are in equities and similar assets. Unlike private pension funds, public pension funds have increased their equity allocations dramatically over the last two decades, making their investment returns and unexpected investment gains and losses far more volatile than before. This means that plan funded status and contributions requested of governments also are more volatile than before, increasing the risks to taxpayers, stakeholders in government services and investments, and workers and retirees.

One important way to examine the impact of investment-return volatility upon plan funded status and contributions is with a stochastic simulation model that draws investment returns from a probability distribution. We have constructed a pension simulation that does that, and we use it to examine the interplay between investment return volatility and funding policy, and to examine the potential consequences of different investment return environments.

### Investment risk and funding policies.

The most-common funding policies and practices reduce contribution volatility at the same time that they increase the likelihood of severe underfunding. These policies are unlikely to bring underfunded plans to full funding within 30 years, even if investment-return assumptions are met every single year and employers make full actuarially determined contributions. For example, a 75 percent funded plan using a common policy of 30-year open amortization as a constant percentage of payroll, with 5-year asset smoothing, would only reach 85 percent funding after 30 years even if it earned 7.5 percent every year. When investment returns are variable, plans and their sponsors face substantial risk of potential crises: the same plan would face a one in six chance of falling below 40 percent funding within 30 years if its investment return assumption is correct on average but has a 12 percent standard deviation. If sponsors do not pay full actuarial contributions or if reasonable expected returns are less than 7.5 percent, the risk of severe underfunding would be greater.

This raises important questions about the impact that pension contributions will have on state and local government taxes and spending, and questions about the security of pension benefits. When returns are good and contributions are driven downward, will governments resist the urge to increase benefits, or will they raise them as some have done in the past? Will they resist the urge to embark on other spending programs that may have to be cut in later years if returns are bad? When returns are bad and requested contributions are driven up sharply, will elected officials be willing to raise taxes and cut spending to support those contributions, or will many pay less than actuarially determined amounts as often has occurred previously?

In the current low-interest-rate and low-inflation environment plans are taking the risk of substantial investment income shortfalls to have reasonable chances of achieving their investment return assumptions. This means that investment earnings will be particularly volatile and funding policy takes on greater importance. In the face of earnings volatility, plans can attempt to dampen contribution volatility through the smoothing methods available to

them, but only at the expense of making funded ratios more volatile, increasing the risk that pension funds will become severely underfunded and that required contribution increases will be politically untenable.

### Investment risk-taking and the changing investment-return environment

The decline in risk-free interest rates since the 1980s and 1990s has created a very difficult investing environment for public pension plans. Before the decline, the typical plan could have achieved its investment-return assumptions while taking very little risk. As rates declined, public plans faced a choice: either reduce investment-return assumptions and request much higher contributions from governments, or maintain assumptions, avoid increasing contributions from governments, and take on much greater risk.

For the most part, public pension funds have maintained their investment-return assumptions, perhaps in the belief that interest rate declines were temporary and that in the longer run high investment returns could again be obtained at low levels of risk. But maintaining their assumptions implicitly required them to invest in riskier assets.

We modeled the implications of a sustained reduction in risk-free interest rates by examining a prototypical pension plan under three scenarios:

- *The good old days:* The pension plan can expect to earn a 7.5 percent return with very little investment-return volatility, or risk. This is similar to what plans might have been able to achieve two or three decades ago. As the name implies, pension plans no longer have this beneficial choice available.
- *Invest in riskier assets:* In response to declining risk-free rates, the pension plan maintains a 7.5 percent earnings assumption but invests in riskier assets. Even though it can expect a long-run compound return of 7.5 percent, some years will be much higher and some will be much lower. Our measure of investment-return volatility, the standard deviation, is 12 percent in this scenario. This is similar to what many public pension plans did as risk-free rates fell.
- *Lower assumed return:* In this scenario, instead of investing in riskier assets in response to declining risk-free rates, the pension plan lowers its earnings assumption to 3.5 percent and remains invested in relatively low-risk assets, with a standard deviation of 1.8 percent. This forces the plan to raise contributions from governments. For the most part, public pension plans have not done this (although they have raised contributions in response to investment shortfalls). Lowering risk and raising contributions remains an option.

Pension plans were not limited to one response or the other – they could have chosen to be in-between.

We modeled the finances of our prototypical pension fund over 30 years, assuming that employers pay full actuarially determined contributions. Our analysis shows that plans faced a fundamental trade-off: If they invested in riskier assets, the risk to the pension fund would

increase significantly but government contributions would remain low. The riskier-assets scenario resulted in a 16.9 percent probability for our prototypical plan that plan funding would fall below 40 percent sometime during the 30 years – a level that has been associated with crises in several states. If instead the plan lowered assumed investment returns, the risk to the pension fund would remain minimal, but employer contributions would have to triple, and would stay high for all 30 years of the simulation period. This dramatic increase in required contributions may go a long way toward explaining why plans have taken on increased investment risk.

We also examined what would happen if plan earnings assumptions, which are in the range of 7 to 8 percent for most plans, are too optimistic, as some professional market forecasts suggest. We simulated a scenario in which the true expected compound return is 1.5 percentage points lower than the assumed return of 7.5 percent. In that scenario the plan has a more than a one in three chance of experiencing severe underfunding at some point over the next 30 years, which is more than twice as high as when the investment earnings assumption is met. Employer contributions as a percentage of payroll would be expected to rise substantially over time, whereas if the return assumption is met they would fall over time; by the end of 30 years, the median employer contributions in this scenario are almost 50 percent higher than when investment return assumptions are met.

## Introduction

Public pension plans in the United States have \$3.8 trillion of invested assets, more than two-thirds of which are in equities and similar assets. Unlike private pension funds, public pension funds have increased their equity allocations dramatically over the last two decades, making their investment returns and unexpected investment gains and losses far more volatile than before. This means that plan funded status and contributions requested of governments also are more volatile than before, increasing the risks to taxpayers, stakeholders in government services and investments, and workers and retirees.

Relatively little has been written on public pension fund investment risk-taking and its potential consequences. The Rockefeller Institute's Pension Simulation Project is examining these issues by modeling public pension fund finances stochastically, under different investment return scenarios and different plan funding policies. We do this by modeling several different kinds of prototypical plans, and by modeling specific individual plans. We have examined and quantified how increased investment risk-taking has increased the risk of funding crises for public pension plans and the risk of large increases in employer contributions. In addition, we have examined the extent to which different funding and contribution policies chosen by plans and their sponsors cause trade-offs between risks to plan funded status and risks to employer contributions. Finally, we have examined several topics of lesser significance, including how plan demographic characteristics affect the consequences of investment risk-taking.

## Our stochastic pension simulation model

### The simulation model

To examine the interplay between stochastic investment returns and plan demographic characteristics we use a stochastic simulation model of public pension plans. The model allows us to examine the year-by-year dynamics of pension fund finances for plans with real-world characteristics, under different investment return scenarios and different funding policies. Starting from an initial position (e.g., 75 percent funded), it projects the future annual assets and cash flows, including benefit payments, employer and employee contributions, and investment income, based upon given model inputs.

The most important model inputs include:

- Retirement benefit rules, including the benefit multiplier per year of service, vesting rules, allowable retirement ages, and annual benefit percentage increase, if any (we do not call this a COLA, or cost-of-living-adjustment, because it does not depend on economic conditions).
- Plan demographics in the initial year including number of workers by age and entry age and their average salaries, number of retirees by age and their average benefit, and projected annual growth in the workforce.
- Decrement tables with mortality rates, retirement rates, and separation rates.
- Salary schedules that define how worker salaries change over time and with experience.
- Inflation and aggregate payroll growth assumptions.

- Actuarial rules and methods for determining actuarial liability, normal cost, and an actuarially determined contribution. These include the actuarial cost method (e.g., entry age normal), discount rate (which can be different from assumed and actual investment returns), asset-smoothing rules if any, and amortization rules (open or closed, level percent or level dollar, and length of amortization period).
- Information to determine employee and employer contributions. For employee contributions, this is a fixed percentage of payroll. For employer contributions, this defines whether the employer pays the actuarially determined contribution, or pays according to some other rule such as a fixed percentage of payroll.
- Rules or data specifying investment returns: Investment returns can be deterministic or stochastic.

A deterministic run might have a single investment return applicable to all years (e.g., 7.5 percent per year) or it might have a set of deterministic returns, one per year (e.g., 10 percent for each of the first 20 years, followed by 5 percent for each of the next 20 years). When investment returns are deterministic, we only run a single simulation since results will not vary from run to run.

A stochastic run generally will draw investment returns randomly each year from a probability distribution – for example, from a normal distribution with an 8.22 percent mean return and a 12 percent standard deviation.<sup>1</sup> (More complex investment return scenarios are possible, too.) When we run the model with stochastic investment returns, typically we conduct 1,000 simulations for a given set of inputs, so that we can examine the distribution of results. The model can be used to examine prototypical pension funds, or can be used with data for actual pension funds.

We assume that investment returns follow the normal distribution, with a mean long-run compound return of 7.5 percent and a standard deviation of 12 percent. The mean is consistent with what the typical plan assumes today. The standard deviation is broadly consistent with our review of simulations and investment return analyses performed elsewhere: CalPERS used a 12.96 percent standard deviation,<sup>2</sup> Biggs assumed a 14 percent standard deviation,<sup>3</sup> and Bonafede et al. has estimated a 12.5 percent standard deviation.<sup>4</sup> A normal distribution with a standard deviation of 12 percent means that in a typical year, the pension fund has a one in six chance of falling at least 12 percentage points short of its investment return assumption and a one in six chance of exceeding its investment return assumption by at least 12 percentage points – the chance of rolling any single number with a fair six-sided die. With approximately \$3.8 trillion of public pension defined benefit plan assets under investment, a 12 percent single-year investment return shortfall is equivalent to more than \$425 billion for the United States as a whole.

Investment returns are assumed to be independent of each other from year to year – bad investment years are not necessarily followed by good investment years, and vice versa. Because investment returns are random in the model, we might obtain virtually any sequence of returns in a single run of the model (which we call an individual simulation), but if we run



enough simulations, on average the results will reflect our assumed distribution of returns (i.e., a mean compound annual return of 7.5 percent and a standard deviation of 12 percent). We run the model 1,000 times to gain insight into the likely distribution of outcomes.

### Measures we use to evaluate results

We are primarily concerned about two kinds of risks:

- Extremely low funded ratios, which create a risk to pension plans and their beneficiaries, and create political risks that could lead to benefit cuts, and
- Extremely high contributions, or large increases in contributions in short periods of time, which pose direct risks to governments and their stakeholders, and in turn could pose risks to pension plans and their beneficiaries.

There usually are trade-offs between these two kinds of risks. If a pension plan has a contribution policy designed to pay down unfunded liabilities very quickly, it is unlikely to have low funded ratios but it may have high contributions. If a pension plan has a contribution policy designed to keep contributions stable and low, there is greater risk that funded ratios may become very low because contributions may not increase rapidly in response to adverse experience.

We use three primary measures to evaluate these risks: The

#### Probability that the funded ratio will fall below 40% during the first 30 years

When returns are stochastic, many outcomes are possible, including very extreme outcomes, so it does not make sense to focus on the worst outcomes or the best outcomes. We are particularly concerned about the risk of bad outcomes, and one useful measure is the probability that the funded ratio, using the market value of assets, will fall below 40 percent in a given time period.

We choose 40 percent because it is a good indicator of a deeply troubled pension fund. In 2013, only four plans out of 160 in the Center for Retirement Research's Public Plans Database had a funded ratio below 40 percent – the Chicago Municipal Employees and Chicago Police plans, the Illinois State Employees Retirement System, and the Kentucky Employees Retirement System. Each plan is widely recognized as being in deep trouble, with the likelihood of either substantial tax increases, service cuts, or benefit cuts yet to come.

In the first year, this probability is near zero. In the scenarios that follow, plans start out with a 75 percent funded ratio. Falling to 40 percent funded would require an investment shortfall of well over 40 percent, which is not likely in a single year. But as the time period extends, there is a chance of an extended period of low returns, leading to severe underfunding. This measure evaluates the likelihood of this occurring.

Probability that employer contributions will rise above 30% of payroll during the first 30 years

Extremely high contributions can create great political and financial pressure on plan sponsors and may lead to benefit cuts, tax increases and crowding out of expenditures on other public services. We use the probability that the employer contribution will rise above 30 percent of payroll as of a given year to evaluate how likely it is that the plan sponsor may face the pressure of high contributions. As the time period extends and the chance of a long period of low returns rises, the probability of having a high employer contribution anytime in that period will increase.

Probability that employer contributions will rise by more than 10% of payroll in a 5-year period

Making contributions stable and predictable is one of the most important goals of funding policies from the perspective of the employer. Sharp increases in employer contributions, even if not large enough to threaten affordability, can cause trouble in budget planning. We use the probability that the employer contribution will rise by more than 10 percentage points of payroll in a 5-year period to measure this possibility. In some of the policies we examine, extremely low returns in a very short time period as may occur in a severe financial crisis may push up the required contribution considerably even after being dampened by asset smoothing and amortization policies.

## Investment risk and funding policy

Public defined benefit pension funds provide retirement income for nearly 10 million Americans. Although the sharp stock market declines of the Great Recession are more than seven years in the past, public pension plans remain underfunded by approximately \$1.7 trillion despite contribution increases,<sup>5 6</sup> in part because the methods state and local governments use to address funding shortfalls typically stretch repayments out over long periods of time. Defined benefit pensions are deferred compensation: an employee provides services now, and the employer promises to pay compensation during retirement. Pre-funding these promises by setting aside funds in the present that, together with investment earnings, will be sufficient to pay benefits when due helps achieve intergenerational equity. It ensures that current taxpayers pay the full cost of current services, and it helps achieve benefit security by ensuring that funds will be available for promised pensions at the time benefits must be paid.<sup>7</sup> Although some economists argue that 100 percent funding may not be an optimal goal because governments may enhance benefits when plans become overfunded, we assume that full funding is the proper goal.<sup>8</sup>

Pre-funding requires the sponsoring government to make contributions each year, and funding policy is the set of methods and rules used to determine those contributions. As we use the term, “funding policy” is broader than the cost method used to allocate benefits to past and future service. It also includes when and how shortfalls and gains are recognized and reflected in contributions. Several organizations have proposed principles for funding policy. Recently, a panel commissioned by the Society of Actuaries (SOA) set out the following principles:<sup>9</sup>

- Adequacy: Contributions, together with investment income, should be sufficient to pay promised benefits as they come due, under a range of economic conditions.
- Intergenerational equity: Achieving intergenerational equity requires paying the costs of pension benefits over employees' working lifetimes.
- Cost stability and predictability: All else equal, government officials generally prefer predictable contributions that fit well into state and local budgets.

In practice, funding methods and rules consist of a discount rate used to value liabilities, amortization rules for taking unexpected gains and losses into account, and asset smoothing rules to determine when and how swings in the market values of assets are reflected in the calculations. These are the main elements needed to calculate actuarially determined contributions. In addition, the contribution behavior of governments – the choice about whether to pay actuarially determined contributions and the extent to which they will be paid – is often considered part of funding policy.

Each of these elements affects the goals of adequacy, intergenerational equity, and cost stability. If investment returns are highly variable, a plan's funded status and the employer's contributions may be subject to large swings that depend in part on these elements of funding policy. Large investment shortfalls can lead to severe underfunding, and to large but lagged increases in actuarially determined contributions. Underfunding and contribution increases can stress the political system, leading to cuts in public services, tax increases, budget gimmicks, and calls for benefit cuts. Sharp investment gains can lead to the opposite.

In this section, we examine how investment return variability interacts with funding policy to create the risk of severe underfunding and large increases in employer contributions, using our stochastic simulation model, under different funding policies.

We discuss the major elements of funding policy below.

## Elements of funding policy

### Discount rate

At what rate should future benefits be discounted – that is, converted to present day dollars? Economists have concluded that benefits should be discounted at rates that reflect the riskiness (or intended riskiness) of their cash flows; if pension benefits almost certainly will be paid, that suggests using rates based upon risk-free or nearly risk-free assets.<sup>10</sup> There are some minor disagreements among economists about how, exactly, to translate this into specific market-related rates, but there is broad agreement on the larger issue. Valuing liabilities at risk-free rates does not mean funds should invest only in risk-free assets; that is an entirely separate decision. By contrast, actuaries discount benefits based on the rate they assume will be earned on the pension fund's asset portfolio, and that assumption is often based on historical returns rather than current market conditions.<sup>11</sup>

Risk-free returns have fallen substantially over the past three decades. They are lower than expected returns on a diversified portfolio of investments, and are far lower than the earnings assumed by the median pension fund, currently about 7.6 percent.<sup>12</sup> While public pension funds have lowered earnings assumptions slightly, they have not come down as much as risk-free returns have declined

The choice of discount rate is a technical issue with large consequences. The lower the discount rate, the higher the estimate of liability. One paper concluded that liabilities of state-run pension plans for the U.S. as a whole were more than \$2 trillion higher when discounted using risk-free rates.<sup>13</sup>

Estimated annual costs are higher, too, when discount rates are lower. In one simple example, the annual “normal cost” of benefits is nearly twice as great when valued at a 6 percent discount rate rather than at 8 percent, and nearly four times as great when valued at a 4 percent rate.<sup>14</sup> If benefits were valued using risk-free or nearly risk-free rates, normal costs would be several multiples of actuaries’ current estimates. The Bureau of Economic Analysis has estimated that *annual* normal costs calculated at a 5 percent discount rate were \$89 billion higher than actual employer contributions in 2013.<sup>15</sup> Funding these costs at risk-free rates, which are lower than 5 percent, would have required contributions to be higher still.<sup>16</sup> The higher contributions that governments would have to pay if benefits were discounted at risk-free rates can be thought of in two ways: as an indication of how much money plans believe they can save their governments through successful investing, and as an indication of the magnitude of risk that pension fund investments entail.

To fund benefits with complete security – that is, with no risk of shortfalls and with no chance of pushing costs off to the future - a pension fund would calculate contributions using a risk-free rate. Given the huge increases in government contributions that would be required, that certainly will not happen anytime soon.

#### Amortization methods and periods

In addition to the discount rate, funding policies must take into account amortization, or how to “stretch out” repayment. Common amortization methods vary primarily along three dimensions:

1. **Closed or open:** Closed methods use a fixed period over which to amortize liabilities – for example, 30 years – after which the liability is completely paid off. By contrast, open methods continually reset the length of the period. Under an open 30-year amortization method, the first payment would be calculated based on a 30-year period, but the second payment would be based on a new 30-year period (rather than 29 years), after adjusting the unpaid balance to take into account the prior payment. Closed methods pay off liabilities more quickly than open methods. In fact, open methods never completely pay down a liability, although the liability may be reduced substantially.
2. **Level dollar or level percent of payroll:** Level dollar methods calculate a fixed annual dollar payment, similar to a home mortgage and to the way that governments ordinarily repay bonds issued to finance infrastructure. By contrast level percent methods

calculate a fixed percentage of each year's payroll. Under the level percent method, the initial payment is lower than later payments, and payments are expected to grow each year at the same rate as payroll grows. (Payments could decline if payroll were expected to decline, but in practice payroll usually is assumed to grow.) Level dollar methods pay off liabilities more quickly than level percent methods.

3. ***Length of amortization period:*** The longer the amortization period, the lower the annual payments and the longer it will take to pay off the liability.

Neither the Governmental Accounting Standards Board (GASB) nor the Actuarial Standards Board (ASB) has authority to mandate amortization methods, but their standards and pronouncements do have influence. Until recently, GASB Statement 25 governed accounting for public pension funds and it established a maximum amortization period of 30 years for accounting.<sup>17 18</sup> The successor to GASB 25, GASB 67, requires an amortization period for financial reporting purposes that is based on the remaining service life of all employees, although plans are not required to use this for funding purposes.<sup>19</sup> In many cases this is much shorter than 30 years.

Table 1 shows the distribution in 2013 of major public pension plans along these three dimensions, based upon amortization methods described in pension plan financial reports as entered into the Center for Retirement Research's Public Plans Database; these financial-report methods are likely to correspond quite well to methods used for funding purposes.<sup>20</sup> The table summarizes data for the 138 out of 160 plans for which there was sufficient data to classify amortization methods.

*Nearly 40 percent of the plans that could be classified used open methods, with their infinite repayment periods, and about 60 percent used closed methods.* This table may overstate the use of closed methods because some hybrid methods are difficult to classify. For example, for 2012 the Missouri Local Government Employees Retirement system is classified in the Public Plans Database as using closed amortization. However, according to its comprehensive annual financial report, "upon attainment of 15 years liabilities are amortized over an open 15-year period by level percent of payroll contribution."<sup>21</sup> Its amortization method behaves like an open method and the liability is never fully paid down. Additionally, many plans using closed amortization reset the amortization period about halfway through, when payments are rising.<sup>22</sup> Because of these classification difficulties, pure closed amortization is not as common as the table suggests.

Table 1 Prevalence of amortization methods among major public pension plans

**Amortization methods and periods, 2013**

Amortization method	Number of plans	% of plans	% of unfunded liability	Remaining amortization periods for plans with data			
				Number of plans with available data	Up to 15 years	16 to 29 years	30 or more years
<i>Open methods (longer repayment)</i>	54	39%	57%	51	1	12	38
Level percent - open	41	30%	46%	38	0	10	28
Level dollar - open	13	9%	11%	13	1	2	10
<i>Closed methods (shorter repayment)</i>	84	61%	43%	78	12	46	20
Level percent - closed	56	41%	26%	54	7	33	14
Level dollar - closed	28	20%	16%	24	5	13	6
Total for plans with detailed data	138	100%	100%	129	13	58	58

Note: Details may not add to totals due to rounding.

Source: Rockefeller Institute analysis of the Public Plans Database, Center for Retirement Research, Boston College

*Level percent amortization methods, which have lower early payments and higher later payments than level dollar methods, were more common than the level dollar methods.* Seventy-one percent of plans, with 72 percent of unfunded liability used level percent methods. Those using the longest repayment method, level percent open, accounted for the greatest share of unfunded liability (46 percent).

*Most plans have long remaining amortization periods.* In total, 45 percent of plans had remaining amortization periods of 30 years or more, while 36 percent used periods of 20 to 29 years.<sup>23</sup> According to separate calculations not shown in the table, about 60 percent of the unfunded liability of public pension funds is being repaid using methods that stretch repayments out for 30 years or more. Amortization periods were the longest for the open methods, where 75 percent of plans used periods of 30 or more years (in most cases they used exactly 30 years). Put differently, the method that generally takes the longest to pay down an unfunded liability (open) tended to be combined with the longest amortization periods, extending the period to pay down liability.

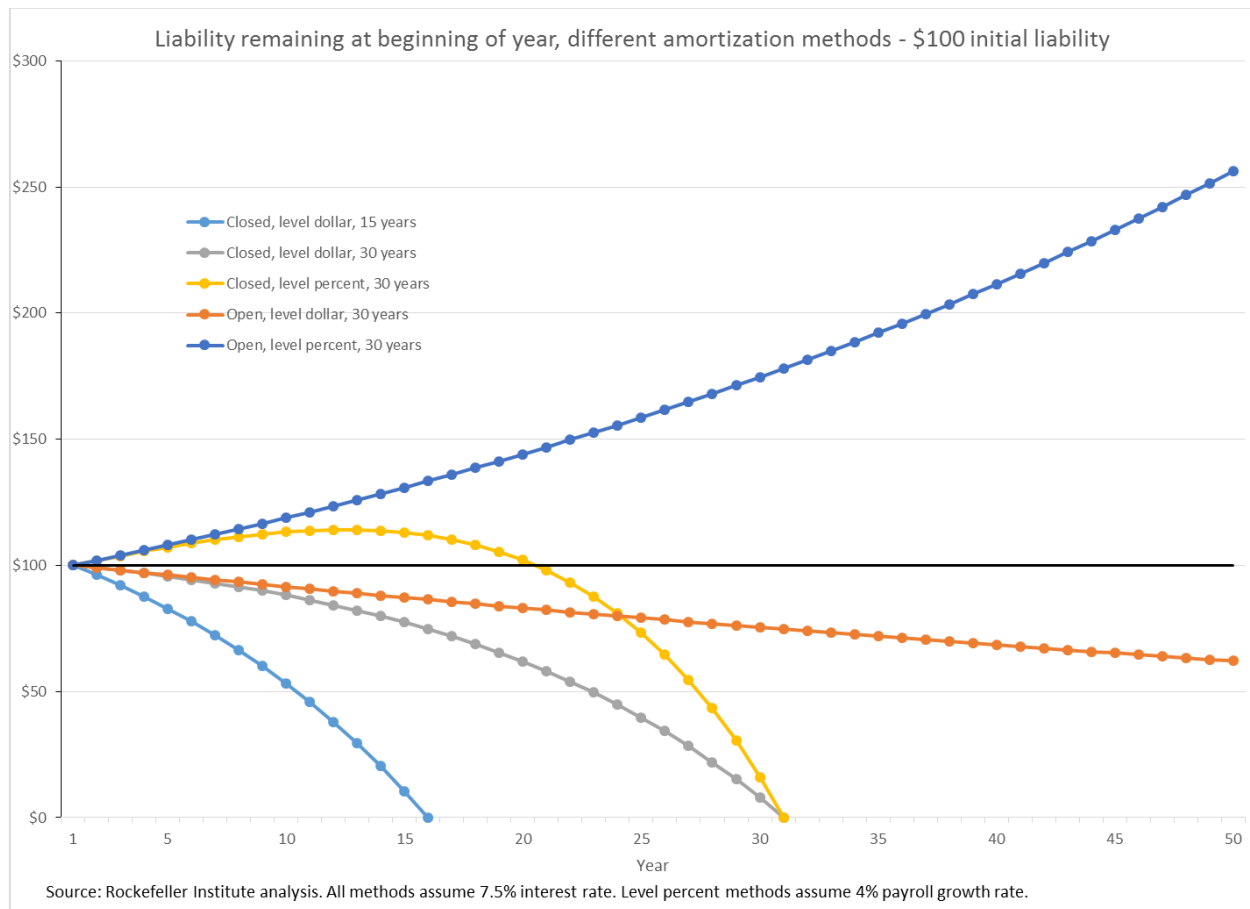
In the last decade, plans have adopted slightly more aggressive repayment schedules. However, most pension funds, and those with the largest unfunded liabilities, still use methods that stretch repayments out substantially. Fifteen-year closed level-dollar amortization is about the most conservative amortization method used by large plans, and it is very rare. In 2013 only six of the 38 plans in the Public Plans Database that used level-dollar amortization used an amortization period of 15 years or less. At the other extreme, 30-year open level-percent amortization is quite common. In 2013, 28 large plans accounting for 42 percent of the unfunded liability of plans with available data used open level-percent with an amortization period of 30 or more years.

Level percent methods, with their lower initial payments, are attractive to governments that sponsor public pension plans. The lower initial payments allow them to keep taxes lower or services higher in early years after investment shortfalls. However, low *initial* payments come at the expense of greater contribution payments later and greater tax and service trade-offs later. The same is true when investment returns or other actuarial factors work out better than expected: level percent methods defer more of the good news than do other methods.

Figure 1 illustrates the amortization of an unfunded liability of \$100 under five combinations of amortization elements, ranging from fast-amortizing 15-year closed level dollar to never-fully-amortizing 30-year open level percent. The three closed methods pay off the liability eventually and thus each crosses the horizontal axis after the 15<sup>th</sup> or 30<sup>th</sup> year, respectively.

There is a horizontal line at the one hundred dollar mark. If a line for a particular method goes above this level then the liability has actually *risen* above the original liability, which happens for both the closed and open level percent methods. Rising above the original liability, known as negative amortization, has been widely criticized. With closed level-percent amortization the liability is eventually paid off. However, under open level percent amortization, not only is the liability never paid off, it rises forever in nominal dollars under typical assumptions. The accounting standard that allowed negative amortization was adopted over the dissent of the GASB chair, who argued that this was not an amortization method at all.<sup>24</sup>

Figure 1 Open amortization methods pay down liabilities very slowly, or not at all



Although nominal payments and liability can rise forever under 30-year open level-percent amortization, liabilities shrink as a share of payroll as the time horizon lengthens, if payroll grows faster than liability and other assumptions are met. After 50 years, nominal liability under 30-year open level-percent amortization is more than twice its initial value and continues to rise, but relative to payroll it is approximately 40 percent of its original level. Contributions as a percentage of payroll also decline. Although the burden of amortization contributions falls, it continues forever – long after working careers and even retirement years have ended for the people for whom that liability was incurred.

### Asset smoothing

The third major element of funding policy is asset smoothing, or when and how to recognize investment gains and losses. As with amortization of unfunded liability, asset smoothing imposes greater stability on pension contributions in light of investment return volatility. Asset smoothing works by recognizing recent investment gains or losses incrementally over several years. Actuaries construct the “actuarial value of assets,” which reflects the extent to which investment gains and losses have been recognized. One simple form of asset smoothing phases in unexpected gains or losses over 5 years: for example, if a pension plan expected to earn \$900 in a given year but only earned \$400, it would spread the \$500 shortfall over five years, only



recognizing \$100 in the first year, and \$200 in the second year, and so on. Actuarial assets can be less than or greater than the market value of assets.

Almost all plans use some form of asset smoothing – between 2001 and 2013, out of 150 plans in the Public Plans Database all but a handful (between 5 and 9 in any year), used some form of asset smoothing. The vast majority used 5-year averaging of asset values. Seven plans used 10-year smoothing in 2012. Asset smoothing often is accompanied by caps and collars, which limit the divergence between actuarial value of assets and market value of assets.

Asset smoothing has a very different effect than amortization: It forestalls sharp contribution increases or decreases in the first few years after investment losses or gains by simply not recognizing those gains or losses immediately and fully. By contrast, amortization spreads actuarial gains or losses, once recognized, over relatively long time periods.

After an investment shortfall, initial amortization payments under asset smoothing are much lower than they otherwise would be because only a portion of the loss is recognized initially, but payments ramp up after 5 years. With closed amortization, payments stay higher than they otherwise would be until the end of the amortization period, after which contributions fall sharply for five years.

Asset smoothing can be attractive to elected officials or others focused on the near term. By creating a ramp to a new level of contributions, it provides time for financial and political planning. If government tax revenue is cyclical in a way that coincides with investment return cycles, asset smoothing could defer contribution increases to periods when government tax revenues have recovered from cyclical declines. However, by insulating elected officials with short time horizons from the near-term consequences of investment risk – risk that their successors may have to bear – asset smoothing creates what economists call a moral hazard, where one party takes risks and another bears the costs.

### Adjustments to contribution policies

Governments and pension plans use many variants of the smoothing methods described above. One approach that is potentially damaging to pension funding and pension benefit security is statutory rules that allow or require governments to pay less than actuarially determined contributions; if contributions are below what actuaries request, the plan may never be on a path to full funding. This is the primary cause of underfunding in the most deeply underfunded plans. According to a recent analysis of 110 large state-administered plans over the 2001-2010 period, only 50 percent of the observations had fully actuarially determined contributions that were not overridden by explicit contributions in statute (e.g., a fixed percentage of payroll), or limited or capped in some way, or overridden in appropriations bills.<sup>25 26</sup>

### Results

An individual simulation entails a sequence of annual pension fund finances for a single fund, under a particular funding policy, with a single sequence of annual investment returns chosen

randomly. The advantage of examining individual simulations is that they demonstrate the volatility that a pension fund might experience over time in a way that is hard to see with summary measures. The disadvantage is that we cannot generalize from a single run because virtually any sequence of investment returns is possible if they are chosen randomly. To illustrate how the model works and the information it produces, we examine three arbitrarily chosen individual simulations in the Appendix.

Below we summarize results for different funding policies, each of which we simulated 1,000 times. In all cases, investment returns have an expected compound annual return of 7.5 percent (consistent with the typical plan assumption) and a 12 percent standard deviation.

To keep graphs understandable, we focus on just four policies that we selected from 12 simulated policies. We highlight these policies because three demonstrate the range of current practice and the fourth represents a proposed reform. The four policies and their labeling are:

- 15-year closed dollar: Gains and losses are amortized over a 15-year closed period, in level-dollar amounts (similar to a fixed-rate home mortgage). This approach repays gains and losses completely after 15 years. Ten plans used a similar approach in 2013, although they generally combined it with asset smoothing.
- 30-year closed percent: Gains and losses are amortized over a 30-year closed period, as a level percentage of payroll, with no asset smoothing. Early payments are lower than later payments, with annual payments rising at the rate of payroll growth (typically 3 to 4 percent per year). This method repays gains and losses completely at the end of 30 years, with the repayment occurring disproportionately in later years. Fourteen plans used a similar approach in 2013, generally combined with asset smoothing.
- 30-year open percent asset-5: Gains and losses are amortized over a 30-year open period as a level percentage of payroll, with 5-year asset smoothing. As discussed earlier, open amortization means that the amortization period is constantly reset so that there is always a new 30-year period. The liability therefore is never fully repaid, although it is reduced, and can decline substantially as a percentage of payroll. Twenty-eight plans accounting for well over 40 percent of the unfunded liabilities of large plans use a similar method.
- SOA Blue Ribbon: As described earlier and as detailed in the appendix, this is the contribution benchmark policy that was proposed by a panel commissioned by the Society of Actuaries. The panel proposed that pension funds compare their actuarially determined contributions with contributions determined under this approach. Plan liabilities and contributions would be calculated using a forward-looking market-based discount rate that is 5.9 percent in our simulations. The benchmark uses 15-year level-percent open amortization, with 5-year asset smoothing.

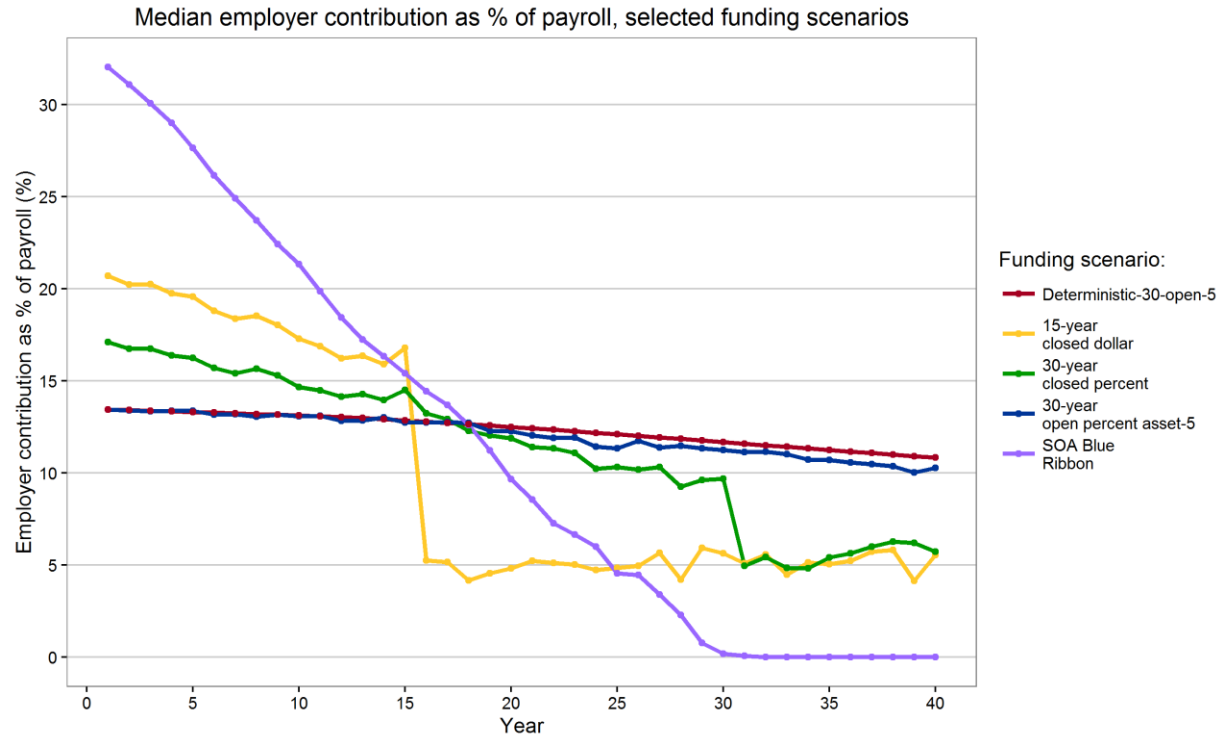
We also show the deterministic scenario (7.5 percent investment return each and every year) for the 30-year open level-percent funding policy with 5-year asset smoothing, labeled as Deterministic-30-open-5.

### Employer contributions

We begin with the median employer contribution rate across 1,000 simulations under each of the four policies (Figure 2). We show results for 40 years so that the declines in contributions after closed amortization periods end are apparent:

- The initial contribution under the Society of Actuaries (SOA) benchmark is as much as twice that of the other policies, primarily because the market-based discount rate is 5.9 percent, compared with the 7.5 percent assumed for all of the other funding policies. In the simulations the plan earns 7.5 percent on average despite the lower discount rate, and so the contribution falls steadily.<sup>27</sup> It is not surprising that the SOA Benchmark has a salutary impact on funded ratios, and that governments might prefer other methods that have much lower initial contributions.
- Employer contributions fall sharply in the 15-year and 30-year closed amortization policies, after their respective amortization periods end, because the initial 25 percent underfunding is treated as a shock that occurred in a single event and it is fully amortized at the end of the period.
- The 30-year open policy has the lowest contributions between years 2 and 15, and the highest contributions after year 30.

*Figure 2 Initial employer contribution rates are highest under the SOA Benchmark, and second-highest under 15-year level dollar closed amortization*



While medians show what happens in the typical case, they don't reveal the implications of investment return volatility. For that, we need the probabilistic measures described earlier. Figure 3 shows the probability that employer contributions will rise above 30 percent of payroll during the first 30 years. The deterministic scenario, which has an employer contribution ranging from about 14 percent of payroll to 12 percent depending on the year (see Figure 2 above), has zero chance of the employer contribution rising above 30 percent. Perhaps surprisingly, the highly smoothed policy of 30-year open funding as a level percentage of payroll, with 5-year asset smoothing, has near-zero probability of employer contributions rising above 30 percent. At the other extreme, the SOA benchmark would start out with contributions above 30 percent and so the probability is 100 percent. The two closed-period policies fall between these extremes.

Figure 3 30-year open level-percent funding has virtually no chance of an employer contribution above 30% of payroll

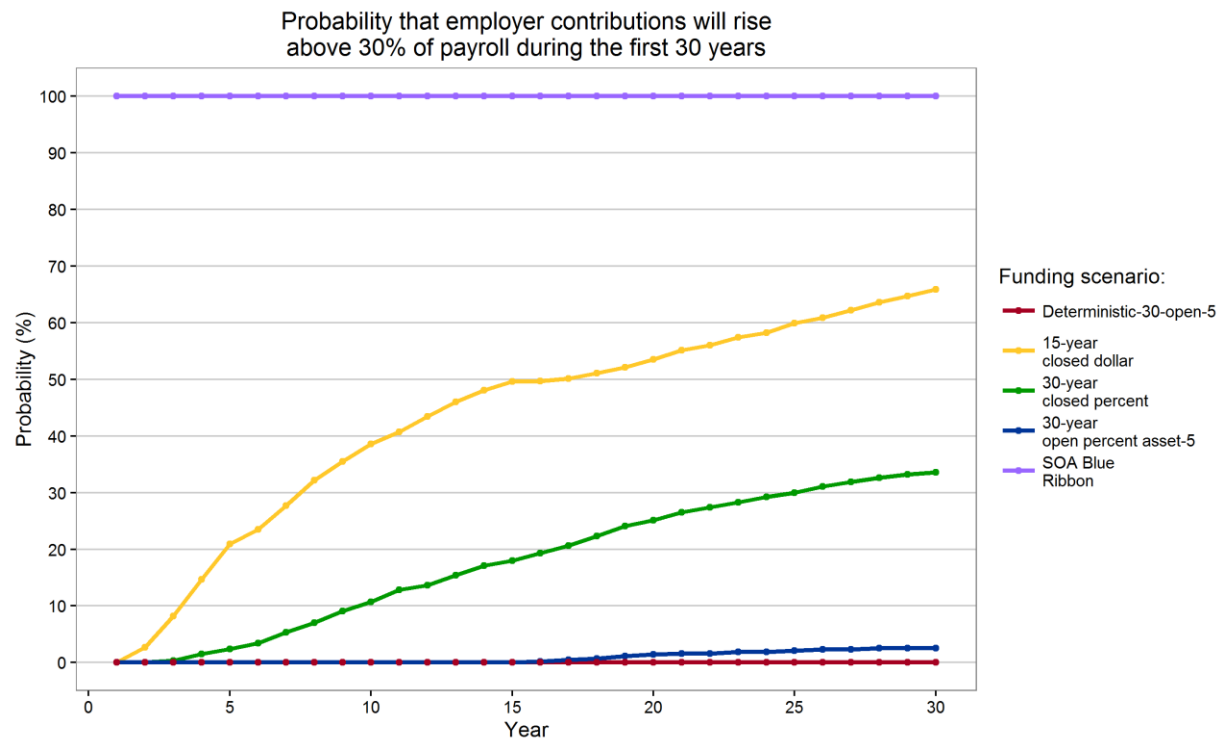
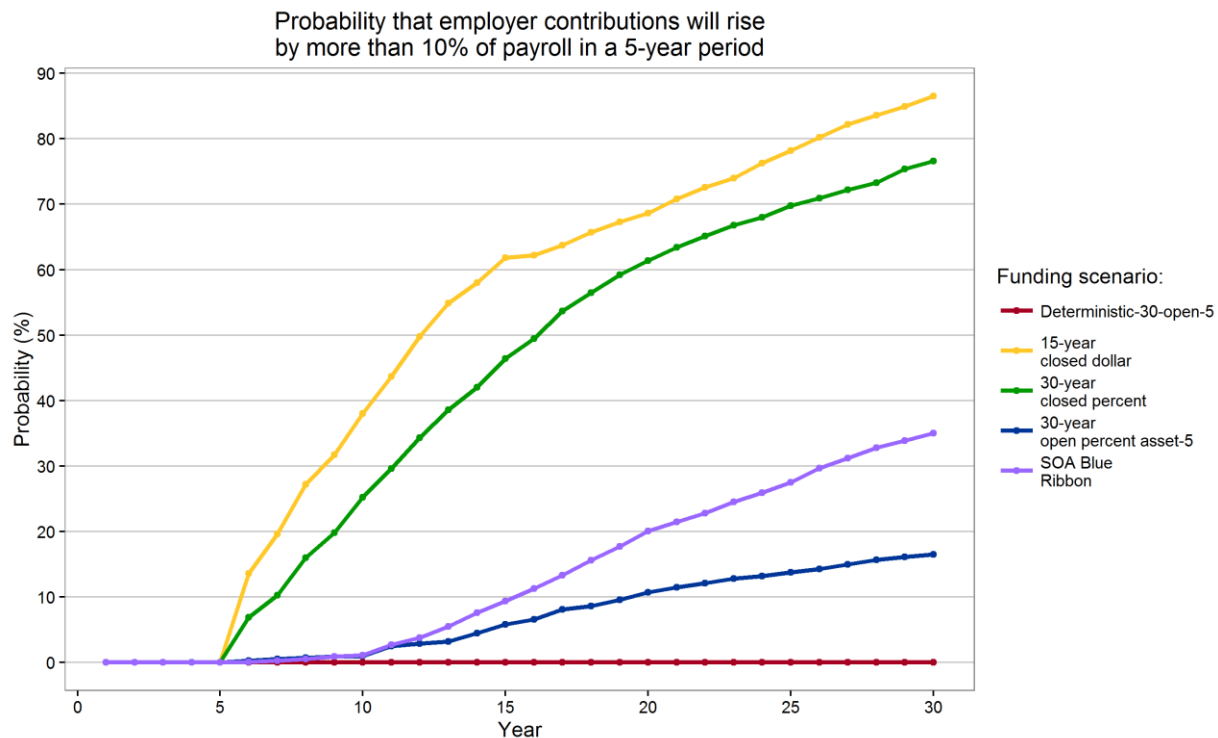


Figure 4 shows the probability that employer contributions will rise by more than 10 percent of payroll in any 5-year period within the first 30 years. There is no chance of this when investment returns are deterministic – 7.5 percent each and every year. However, it is possible when investment returns vary, in which case investment shortfalls may trigger contribution increases. The quicker and more forcefully that a funding policy responds to investment shortfalls, the greater the probability that contributions will rise by more than 10 percent. Thus, this probability is greatest for the 15-year closed period level-dollar funding policy: it repays shortfalls over a fixed relatively short period, with constant-dollar payments that are higher than under level-percent funding policies.

Figure 4 Closed funding methods have a greater chance of contribution increases of more than 10% of payroll

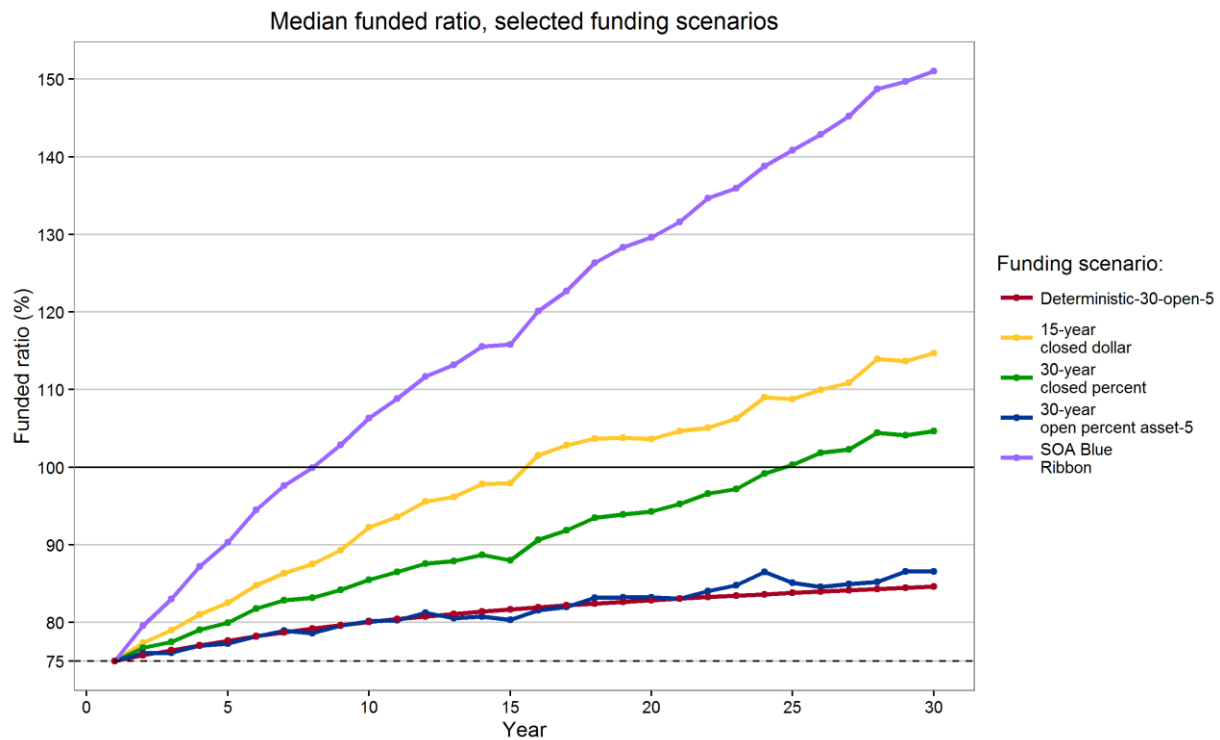


It is easy to see why the very stretched-out policy of 30-year open-period funding as a level percentage of payroll is attractive to employers. Unlike other policies currently used by funds, it has near-zero chance of employer contributions rising above 30 percent, and a very low probability that contributions will rise by more than 10 percentage points in a 5-year period. It provides stability to plan sponsors. That stability comes at a price, however: a risk of severe underfunding when investment returns vary from year to year.

#### Impact on plan funding

Figure 5 shows the median funded ratio across 1,000 simulations for each of the funding policies. Under the deterministic scenario and its stochastic counterpart (30-year open period level-percent funding with 5-year asset smoothing), the funded ratio rises from the initial 75 percent to about 87 percent after 30 years: the plan never quite achieves full funding but moves in that direction. The two closed-period methods eventually raise the funded ratio above 100 percent, in part because contributions are not allowed to become negative (the sponsor cannot withdraw money from the plan if it becomes overfunded, so there is always upward pressure on funding). The SOA benchmark as we have modeled it overfunds the plan substantially – it discounts liabilities at 5.9 percent but then achieves compound investment returns of 7.5 percent.

Figure 5 Median funded ratio can remain below 100% or rise substantially above, depending on funding policy



As with employer contributions, medians do not provide information on the risk of underfunding. Figure 6 shows the probability that the funded ratio will fall below 40 percent during the first 30 years. Here the results are the opposite of the results for employer contributions: the funding policies that repay shortfalls most aggressively and quickly have the least chance of a funded ratio falling below 40 percent. However, the relatively common funding policy of 30-year open period level-percent funding with 5-year asset smoothing has a far greater risk of severe underfunding, reaching 17 percent by the end of 30 years – a one in six chance of severe underfunding.

Figure 6 30-year open level-percent funding runs far greater risks of severe underfunding than the other funding policies

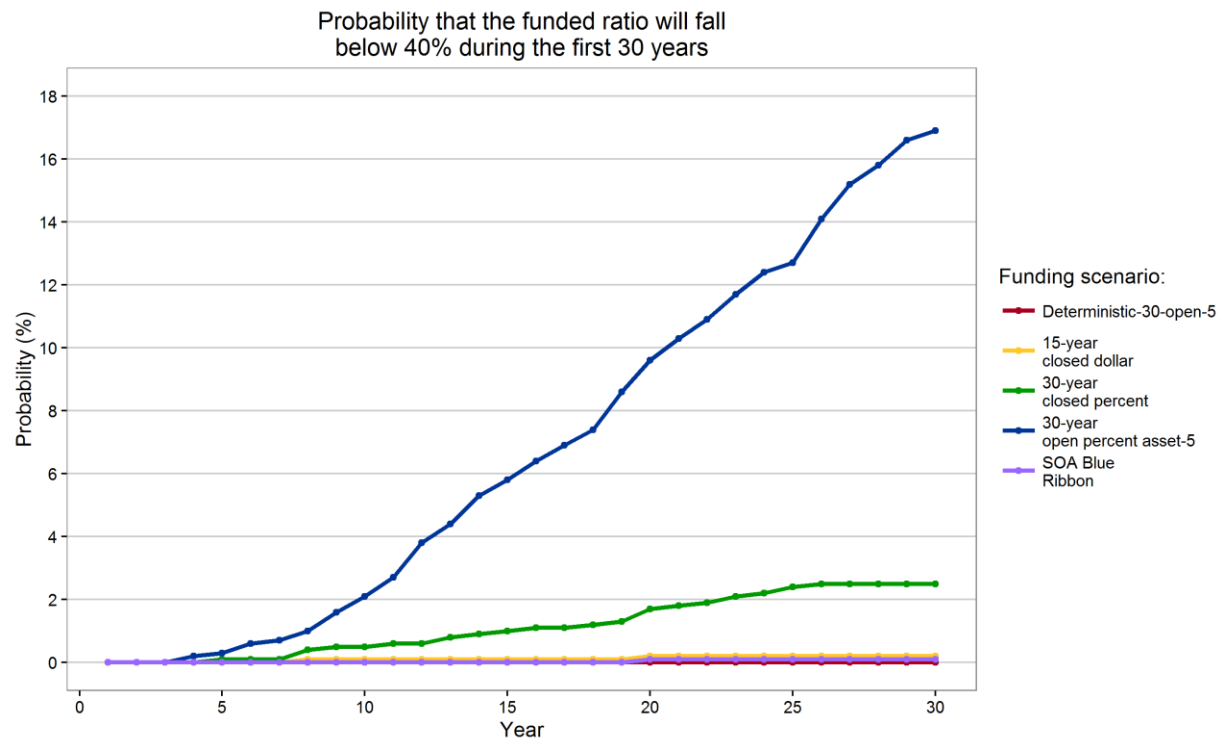
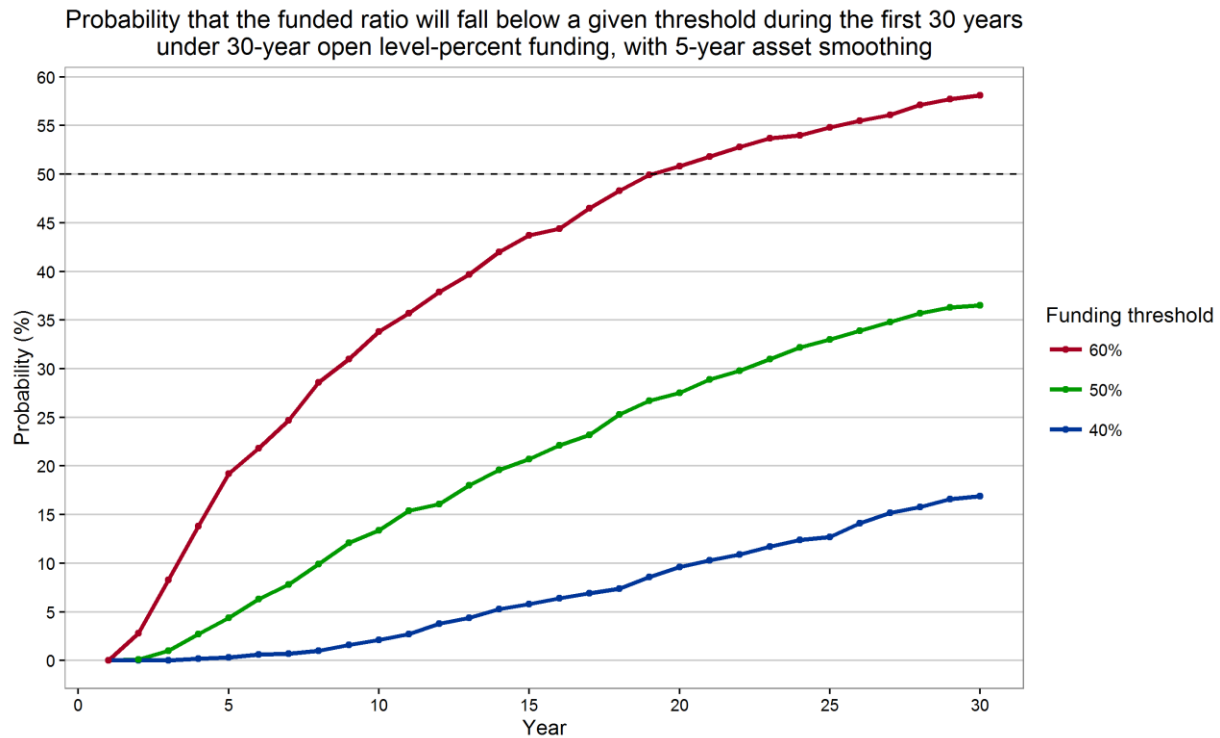


Figure 6 demonstrates a very important conclusion: When the assumed investment return is achieved each and every year and actuarial contributions are paid, as in the deterministic scenario, there is zero risk of severe underfunding. But if investment returns vary from year to year, there can be a substantial risk of severe underfunding (a one in six chance in this case), even if expected returns are correct on average and even if governments pay full actuarial contributions.

Finally, Figure 7 shows the risk of a 75-percent funded plan falling below three different funded-ratio thresholds when the common funding policy is used: 60 percent, 50 percent, and 40 percent. The red line shows the likelihood of falling below 60 percent: there is a more than 50 percent chance of falling below this level within 20 years.



Figure 7 A typical plan that starts out 75% funded and uses a common funding policy has more than a 50% chance of falling below 60 percent funding within 20 years



The three elements of the amortization method affect the degree to which costs are pushed to the future. The amortization period and the level-percent versus level-dollar choice affect each other. Extending the amortization period from 15 years to 30 years has a bigger negative impact on funded status when combined with the level percent method than when combined with the level dollar method. And switching to level percent from level dollar has a bigger negative impact on funded status when combined with 30-year amortization than with a 15-year period. Replacing open amortization with closed amortization can considerably improve the long-run funded status at the expense of higher contributions.

None of the smoothing policies can prevent sharp rises or falls in contributions over the long run. If funds are invested in risky assets, smoothing policies can alter the time it takes to reach higher contributions but does not change the long-run path markedly.

Finally, Figure 8, which shows quartiles for the funded ratio of the pension plan over time under the typical smoothing policy, illustrates a conclusion that may be surprising to some people. The risk of better than expected or worse than expected funding outcomes increases over time. That is, the gap between the 75<sup>th</sup> percentile and the 25<sup>th</sup> percentile grows over time. This results primarily because investment returns are independent from year to year. When that is true, which is often assumed in financial simulations, it is well known that the volatility of asset values rises over time. While the variability in *compound annual returns* diminishes over time, this is more than offset by compounding those returns over more years. If returns are not

independent – if, for example, bad investment years are followed by good years, and vice versa - the gap in Figure 8 might not widen so significantly, or conceivably it could even narrow. Under some investment return assumptions, the gap could widen even more.

Figure 8 Funding risk rises over time

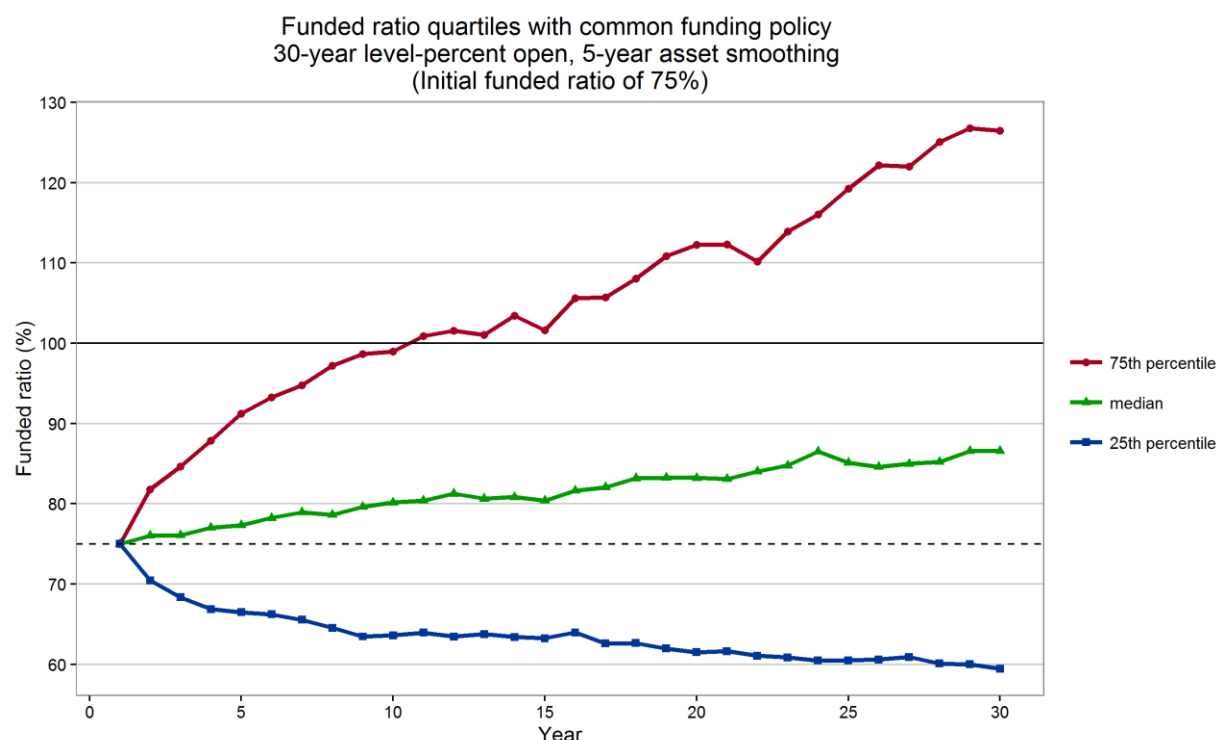


Figure 8 also shows that the risk is skewed in the sense that the best outcomes - high funded ratios - rise by more than the worst outcomes fall. The lower bound of the funded ratio is zero, but there is no limit to how high the funded ratio can rise. In addition, because the model does not allow negative contributions when the plan becomes overfunded, there is a built-in tendency for further overfunding. This is consistent with the practice of plan funding – sponsors generally are not allowed to withdraw funds if a plan becomes overfunded.

#### What happens if contributions are less than actuarially determined contributions?

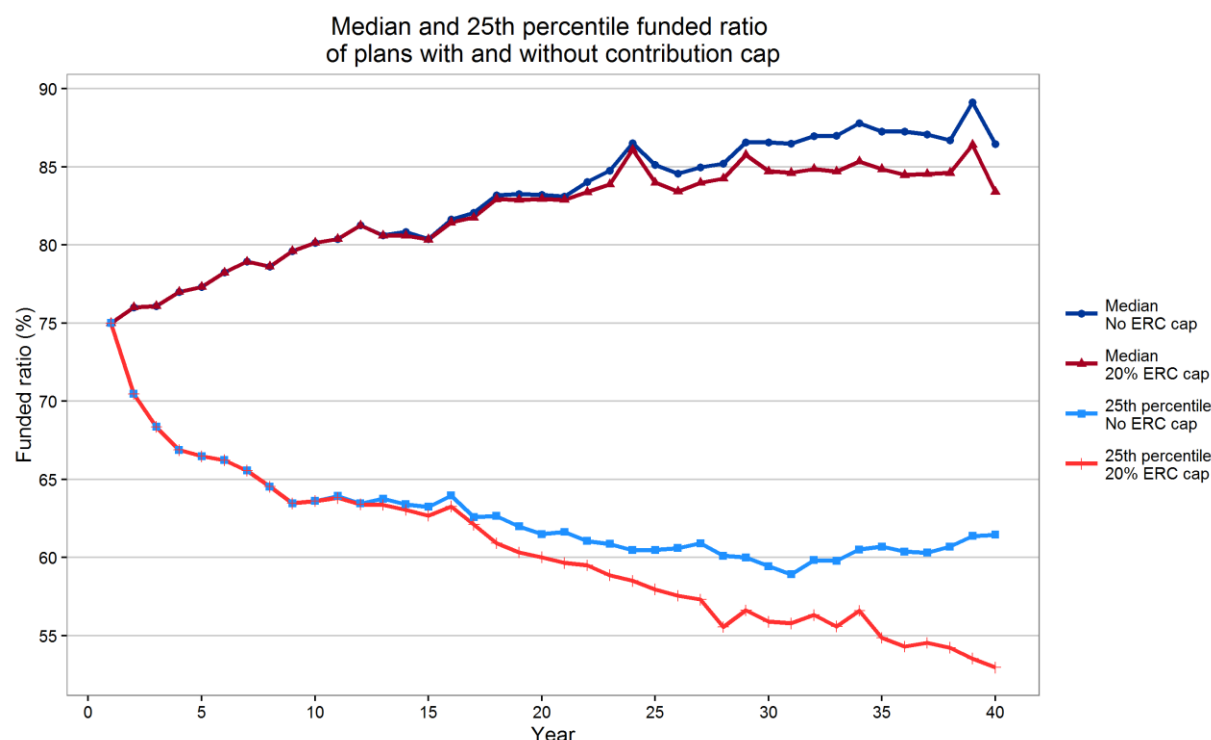
Our analysis up to this point assumes that plan sponsors always make full required contributions. In practice this often is not true, especially when the required contribution is so high that it is difficult for the sponsor to afford. Andrew Biggs of the American Enterprise Institute found that the higher the actuarially required contribution (ARC) is as a percentage of payroll, the less likely the sponsor is to pay the full ARC and the lower the percentage of ARC is paid.<sup>28</sup>

We model the consequences of a shortfall in paying the actuarially determined contribution by imposing a cap on the employer contribution as percentage of payroll, an approach similar to that used by Biggs, in essence assuming that employer underpayment occurs at this point. We

model a cap on the employer contribution rate that is approximately three times the “steady state” employer contribution rate of a fully funded plan that achieves a constant investment return equal to its assumed return. For a plan with the common funding policy of 30-year level-percent open amortization with 5-year asset smoothing and a 7.5 percent discount rate, the “steady state” employer contribution rate is around 6.7 percent, and so we model an employer contribution cap of 20 percent of payroll (about three times 6.7 percent).

Figure 9 shows the impact of this underpayment behavior on the plan’s funded status. The two lines on the upper part of the figure give the median funded ratio of the plan with and without the contribution cap. The cap has little impact on the median funded ratio until year 20, and in year 40 the funded ratio of the plan with contribution cap is about 3 percent lower than the one without the cap. The impact is relatively small because the median contribution rate is lower than 15 percent (see Figure 2), which is well below the 20 percent contribution cap. However, the effect of the contribution cap is more prominent when the plan faces bad return scenarios and the contribution cap is therefore triggered more frequently, which is represented by the 25<sup>th</sup> percentile lines of funded ratio on the lower part of the graph (25 percent of 1,000 simulations have funded ratios lower than those presented by the 25<sup>th</sup> percentile lines). In year 40, the 25<sup>th</sup> percentile funded ratio of the capped plan is almost 10 percentage points lower than the uncapped plan. In this simulation result, the contribution cap is not triggered a lot in early years because of the low initial employer contribution rate. If the initial contribution rate is higher, the cap would be triggered more frequently, leading to a larger negative impact on the plan’s long-term funded status.

Figure 9 Contribution underpayment (modeled as a cap on employer contributions) has a larger impact on funded status under bad return scenarios (e.g., at the 25th percentile) than under better scenarios (e.g., at the median)

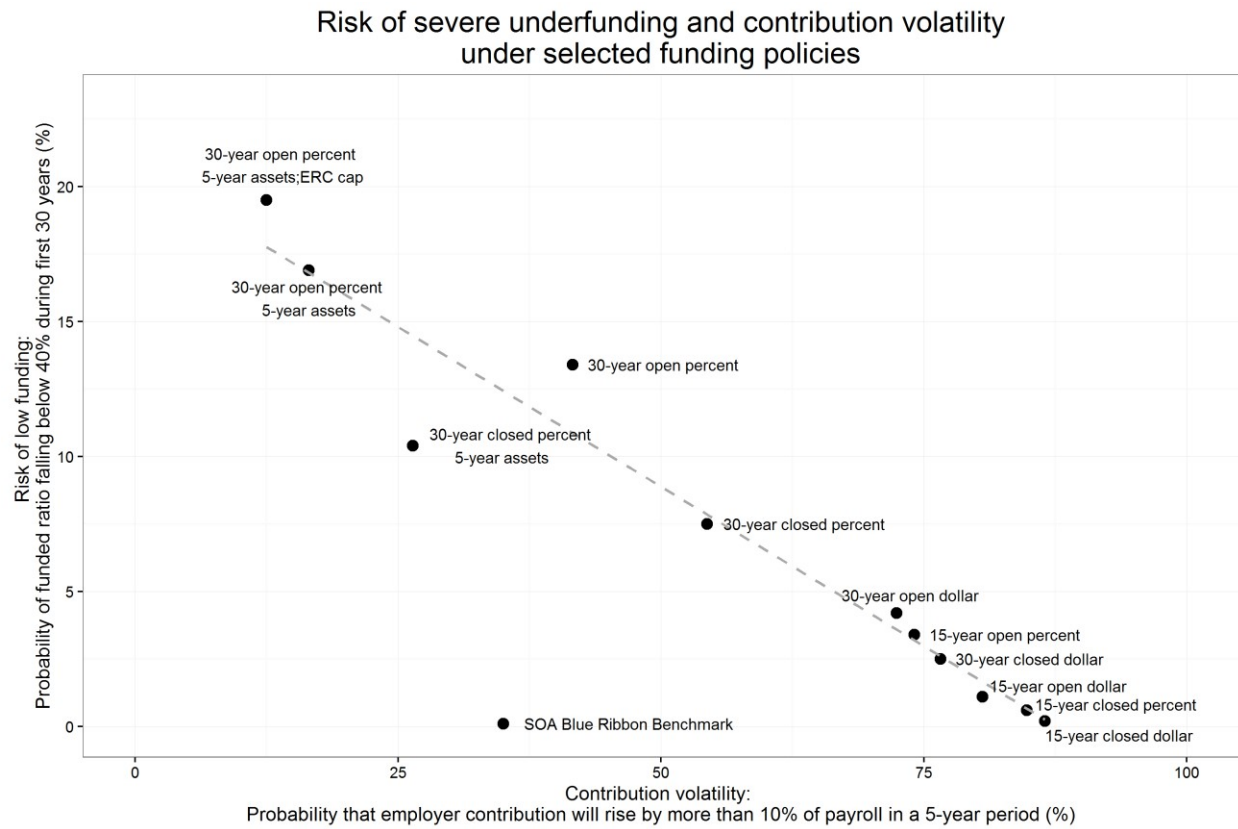


### The trade-off between contribution volatility and the risk of underfunding

As much of the previous discussion suggests, there is a trade-off between contribution volatility and the risk of underfunding. Governments understandably want stable contributions – inherently difficult to achieve when investment returns are volatile. In general, the more that plans and governments rely on amortization and other smoothing techniques to reduce contribution volatility, the greater the risk that funding ratios will fall to low levels – perhaps to levels that are not politically sustainable and that lead to significant benefit cuts or risk of nonpayment.

Figure 10 illustrates this tradeoff. The vertical axis shows the probability that the funded ratio will fall below 40 percent at any point during the first 30 years. The horizontal axis shows a measure of contribution volatility – the probability that employer contributions will rise by more than 10 percent of payroll during any five years in the first 30. The graph makes clear that plans that use funding policies with low contribution volatility, such as 30-year level-percent open with 5-year asset smoothing, have much greater likelihood of encountering a very low funded ratio.

Figure 10 Contribution smoothing policies reduce contribution volatility but increase the risk of severe underfunding



Finally, Table 2 shows the probability of severe underfunding and the contribution volatility measures for a larger group of funding policies, including all of the policies in Figure 10.

Table 2 Funded ratio risk and contribution volatility for selected funding policies

Funding Policy	Probability that funded ratio will fall below 40% during first 30 years	Probability that employer contributions will rise above 30% of payroll during the first 30 years	Probability that employer contributions will rise by more than 10% of payroll in a 5-year period
15-year level dollar - closed	0.2%	65.9%	86.5%
15-year level percent - closed	0.6%	60.5%	84.8%
30-year level dollar - closed	2.5%	33.6%	76.6%
30-year level percent - closed	7.5%	22.2%	54.4%
30-year level percent - closed; 5-year asset smoothing	10.4%	19.3%	26.4%
15-year level dollar - open	1.1%	48.7%	80.6%
15-year level percent - open	3.4%	29.5%	74.1%
30-year level dollar - open	4.2%	24.8%	72.4%
30-year level percent - open	13.4%	3.5%	41.6%
30-year level percent - open; 5-year asset smoothing	16.9%	2.5%	16.5%
30-year level percent - closed; 5-year asset smoothing; 20% ERC cap	19.5%	0.0%	12.5%
SOA Blue Ribbon Panel Benchmark	0.1%	100.0%	35.0%

Note: Funding policy in the SOA Blue Ribbon Panel Benchmark consists of 15-year level-percent open amortization with 5-year asset smoothing. We have used a 5.9% discount rate for liability calculations, based on our analysis of current market conditions. However, the pension fund is assumed to earn a long-run compound return of 7.5%, to maintain comparability with other funding policies in the table.

## Conclusions and policy implications

The most-common funding policies and practices reduce contribution volatility at the same time that they increase the likelihood of severe underfunding. These policies are unlikely to bring underfunded plans to full funding within 30 years, even if investment-return assumptions are met every single year and employers make full actuarially determined contributions. For example, a 75 percent funded plan using a common policy of 30-year open amortization as a constant percentage of payroll, with 5-year asset smoothing, would only reach 85 percent funding after 30 years even if it earned 7.5 percent every year. When investment returns are variable, plans and their sponsors face substantial risk of potential crises: the same plan would face a one in six chance of falling below 40 percent funding within 30 years if its investment return assumption is correct on average but has a 12 percent standard deviation. If sponsors do not pay full actuarial contributions or if reasonable expected returns are less than 7.5 percent, the risk of severe underfunding would be greater.

This raises important questions about the impact that pension contributions will have on state and local government taxes and spending, and questions about the security of pension benefits. When returns are good and contributions are driven downward, will governments resist the urge to increase benefits, or will they raise them as some have done in the past? Will they resist the urge to embark on other spending programs that may have to be cut in later years if returns are bad? When returns are bad and requested contributions are driven up sharply, will elected officials be willing to raise taxes and cut spending to support those contributions, or will many pay less than actuarially determined amounts as often has occurred previously?

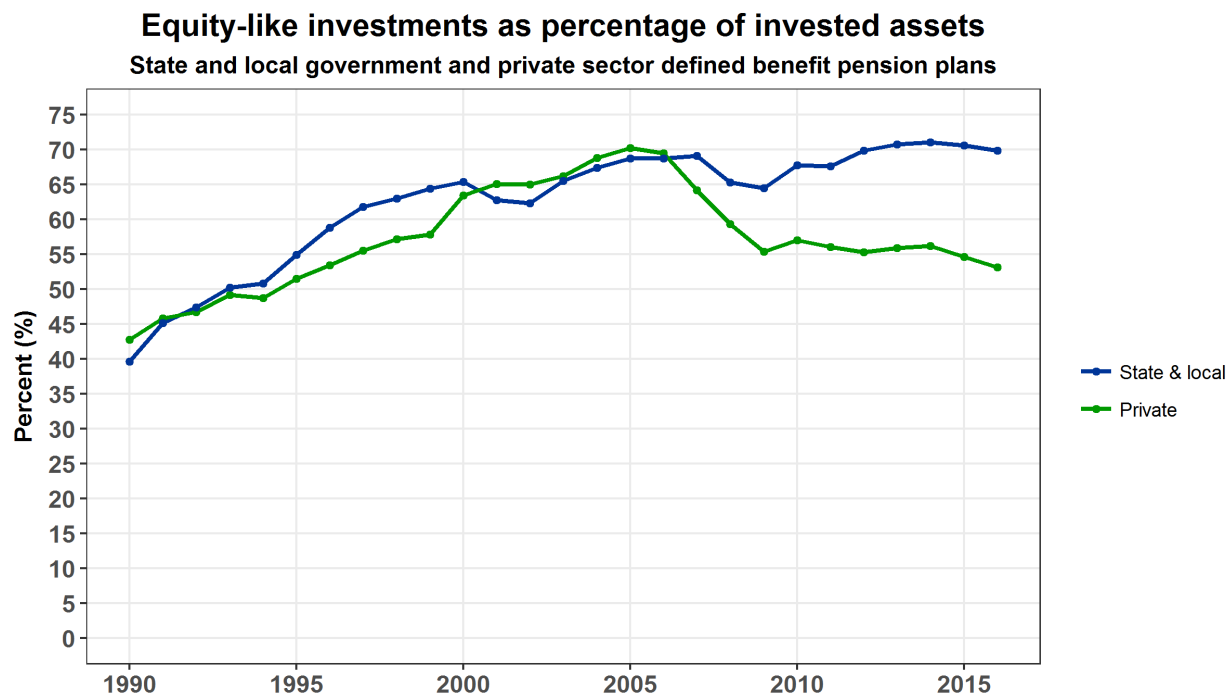
In the current low-interest-rate and low-inflation environment plans are taking the risk of substantial investment income shortfalls to have reasonable chances of achieving their investment return assumptions. This means that investment earnings will be particularly volatile and funding policy takes on greater importance. In the face of earnings volatility, plans can attempt to dampen contribution volatility through the smoothing methods available to them, but only at the expense of making funded ratios more volatile, increasing the risk that pension funds will become severely underfunded and that required contribution increases will be politically untenable.

## Investment risk-taking and the changing environment

### Public pension plan investment risks have increased over time

Public pension plans in the U.S. now invest nearly two-thirds of their assets in equity-like investments, up from one-quarter in the 1970s and about 40 percent in 1990. While public plans once were more conservative investors than private defined benefit plans, they now have a much greater share of their assets invested in equity-like investments than do private plans. (Figure 11.<sup>29</sup>)

Figure 11. Public pension funds have increased their investments in equity-like assets

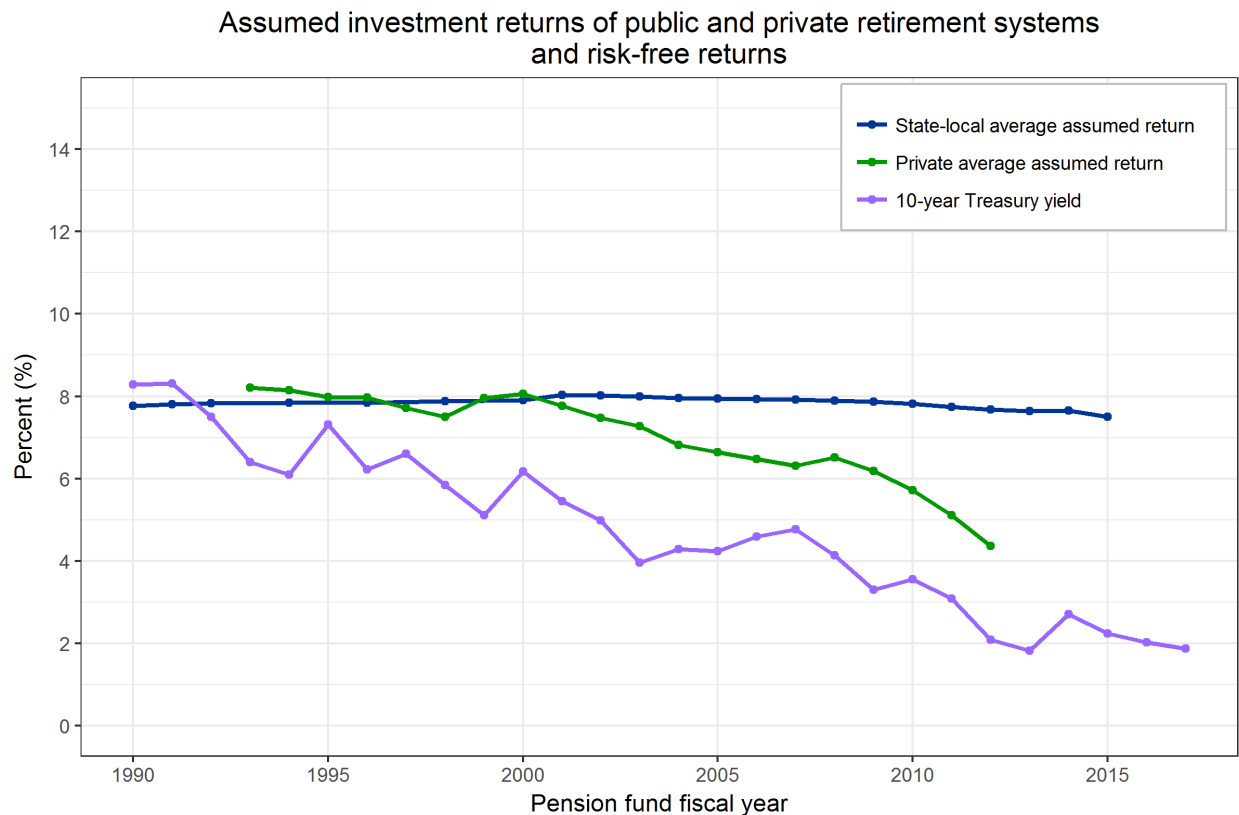


Source: Authors' analysis of Z.1 Financial Accounts of the United States, Federal Reserve Board, Tables L.118.b, L.120.b, and L.122

One likely reason for the increasing allocation of assets by public pension plans to equities is that nominal risk-free returns have declined substantially, but public pension funds' earnings assumptions have been "sticky," barely falling at all. (Figure 12.<sup>30</sup>) In contrast, private sector plans have been reducing earnings assumptions along with the declining risk-free returns. Several economists have argued that assumed returns have not followed risk-free returns downward in part because pension fund boards and sponsors prefer high discount rates, which keep the reported actuarial value of pension liabilities and actuarially determined contributions lower, all else equal. Their research suggests that the move toward riskier assets reflects the unique nature of the regulatory and standards-setting environment for public pension funds, particularly the accounting standards and actuarial practices that value liabilities with discount rates equal to earnings assumptions generally selected by the plans themselves. These standards and practices for public plans in the United States are different than the standards, practices, and rules for private plans and for public plans in other countries.<sup>31</sup>



Figure 12. Public pension fund earnings assumptions barely fell, despite substantial declines in risk-free rates



Sources:

State-local assumed return from Public Plans Database

Private assumed returns provided by Andonov, Bauer, and Cremers

10-Year Treasury yield from Federal Reserve Bank of St. Louis (FRED)

The decline in risk-free rates created difficult choices for public pension funds. In 1990, after a multi-year drop from unprecedented inflation-induced heights, 10-year Treasuries were still above eight percent and public pension plans were assuming they would earn just under eight percent; pension funds could achieve their assumptions while taking very little risk. At the time plan funds were only about 40 percent invested in equity-like assets. From 1990 through the present, risk-free rates fell significantly and 10-year Treasuries are now yielding under two percent. Public pension plans could have chosen to reduce their earnings assumptions as risk-free rates fell. Reducing assumptions would have led to large increases in actuarially determined contributions, causing potential stress for employers. For the most part, public pension funds did not do this, presumably believing that they could achieve their long-term earnings assumptions while taking reasonable risks, and perhaps believing that the fall in risk-free rates was temporary. Between 1990 and 2014, risk-free rates fell by about six percentage points and the share of assets in equity-like investments rose by about 25 percentage points. In any event, in the current environment commonly used discount rates of seven percent to eight percent can only be justified by investing in asset classes that might be expected to earn substantially more, on average, than risk-free assets, but that are likely to have volatile returns.

## Analysis and results for different investment return scenarios

In the analysis that follows, we use the Rockefeller Institute's pension simulation model to examine three sets of investment-return scenarios:

- The “pure” impact of volatility: To isolate the role of investment return volatility, we examine scenarios in which the only thing that changes from scenario to scenario is the volatility of investment returns, while the expected investment return is held constant. (In the real world, higher risk is often accompanied by higher expected returns. We address that trade-off in other scenarios.)
- Policy response to a decline over time in risk-free returns: Here we consider the trade-off that pension funds faced over time as risk-free returns fell, when they faced a choice between investing in riskier assets to maintain an assumed rate of return, or maintaining the same level of portfolio risk by lowering assumed returns and raising contribution requirements. (In practice, they could have chosen between these extremes.) While it is clear in retrospect that plans faced this choice, at the time, as risk-free rates were falling, it may not have been clear that the investing environment was changing fundamentally.
- The true expected rate of return is less than the assumed return: Our examination of publicly available recent capital market assumptions suggests that the assumed investment returns of public pension plans, which are mostly in the range of seven percent to eight percent, are difficult to achieve with their current portfolios even though the share of risky assets has been increased greatly.<sup>32</sup> In this scenario we examine the implications for plan funded status and required employer contributions if the true expected compound return is lower than the assumed return by 1.5 percentage points, in a manner consistent with publicly available capital market assumptions.

In the following sections we describe each set of scenarios in more detail and then present results of our analysis.

### The pure impact of volatility

To analyze the pure impact of volatility, we examine three scenarios, each of which has an expected compound return of 7.5 percent, but with different degrees of volatility: an 8 percent standard deviation (least volatile), a 12 percent standard deviation (consistent with assumptions that several plans have used), and a 16 percent standard deviation (most volatile).<sup>33</sup>

Figure 13 shows the median funded ratio and the 25th percentile and 75th percentile under each scenario. Within a given scenario (any single panel) the range of funded ratios increases over time (the gap between the 75<sup>th</sup> percentile and the 25<sup>th</sup> percentile increases). As we move from left to right across the scenarios, the standard deviation increases and with it the range of likely funded ratios increases (the 75<sup>th</sup>-25<sup>th</sup> percentile gap is greater in the right panel than in the panels to the left). In other words, as investment risk increases funded ratios are likely to become more volatile.

Figure 13. The range of likely funded ratios widens as the volatility of investment returns increases

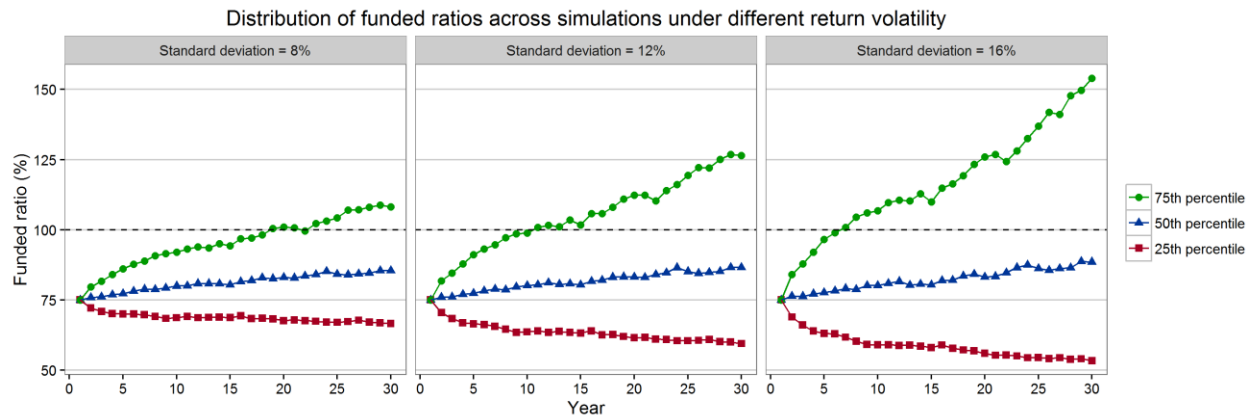


Figure 14 shows the probability that the pension plan will become severely underfunded under each of the scenarios. The impact of volatility is quite clear: The probability that the plan will become less than 40 percent funded sometime in the first 30 years is about 32 percent when the standard deviation is 16 percent, eight times as large as the probability when the standard deviation is only eight percent.

Figure 14. The probability of severe underfunding is much greater when volatility is high than when it is low, if the expected return is held constant

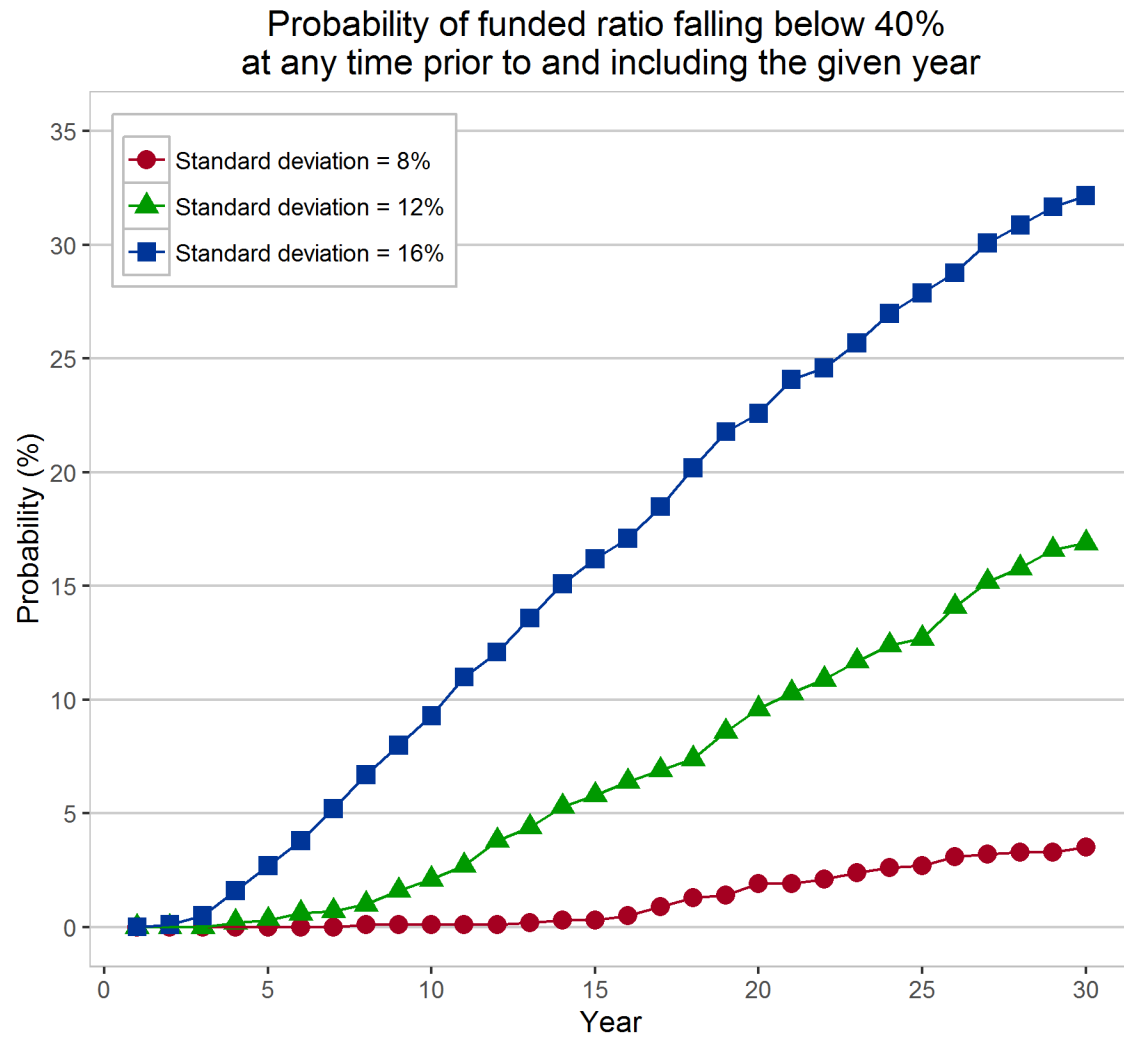
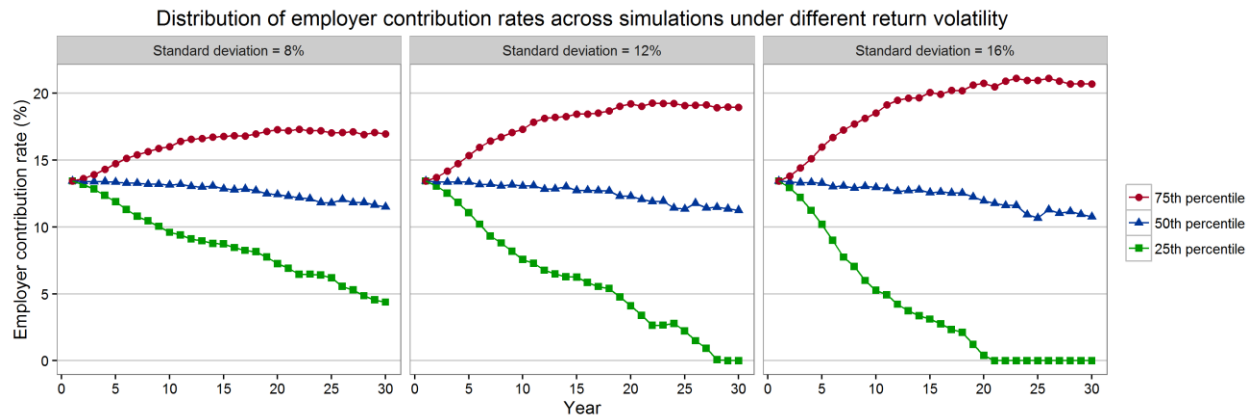


Figure 15 shows the median employer contribution rate and the 25th percentile and 75th percentile under each scenario. Within a given scenario (any single panel) the range of employer contribution rates increases over time (the gap between the 75<sup>th</sup> percentile and the 25<sup>th</sup> percentile increases). As we move from left to right across the scenarios, the standard deviation increases and with it the range of likely employer contribution rates increases (the 75<sup>th</sup>-25<sup>th</sup> percentile gap is greater in the right panel than in the panels to the left). In other words, as investment risk increases employer contributions are likely to become more volatile.

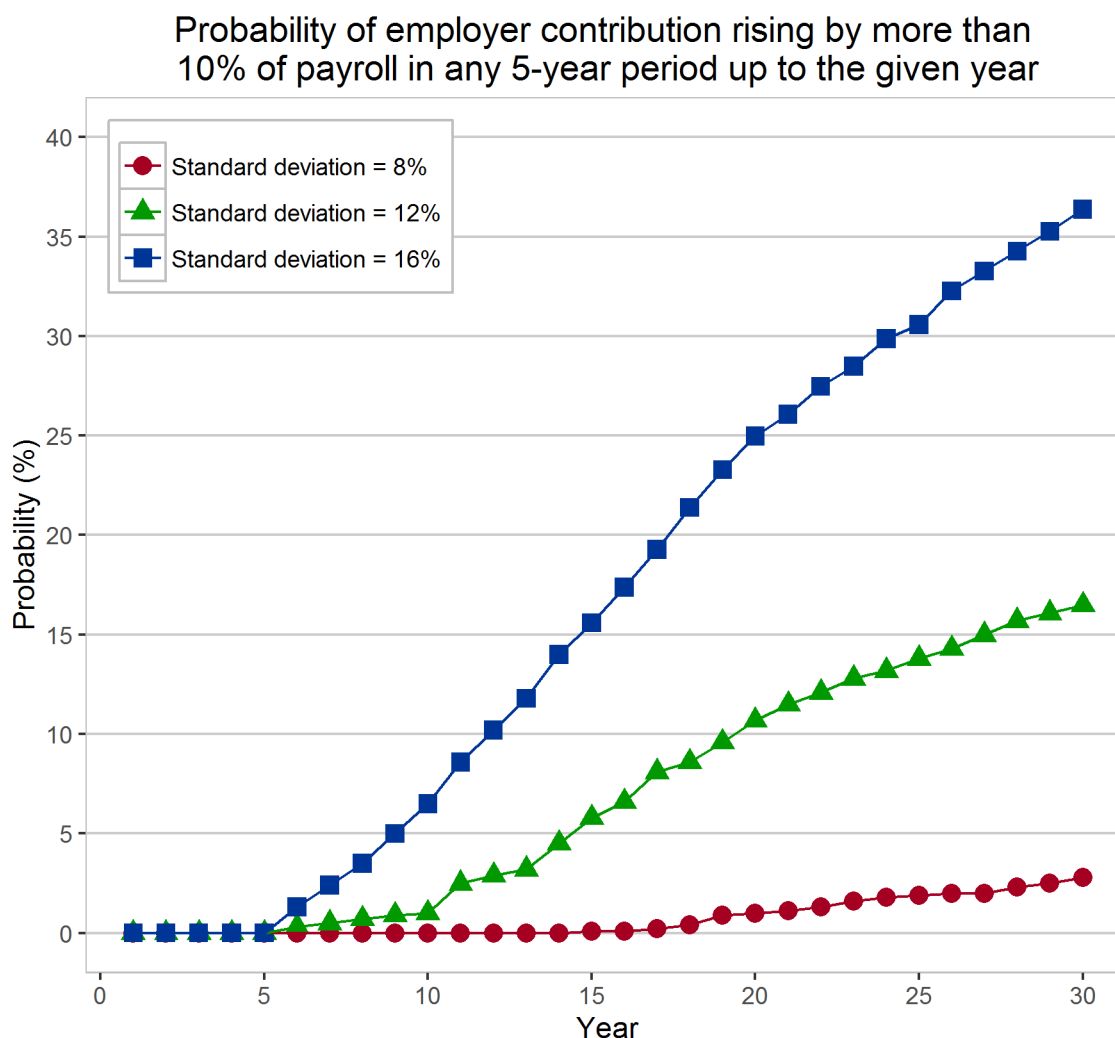
Figure 15. The range of likely employer contribution rates widens as the volatility of investment returns increases



As the range of likely employer contribution rates widens, the chance that employer contribution rates will become extremely high also increases. We do not provide a separate figure showing the probability that the employer contribution will rise above 30 percent of payroll. But the probability is essentially zero by year 30 under the scenario with 8 percent standard deviation, while the probability rises to about 2.5 percent when the standard deviation is 12 percent, and to about 8 percent when the standard deviation is 16 percent.

Figure 16 shows the probability that the employer will face a contribution increase of 10 percent or more of payroll within a five-year period under each of the scenarios. Again, the impact of investment-return volatility is clear: The probability of a significant employer contribution increase sometime in the first 30 years is about 36 percent when the standard deviation is 16 percent, more than 10 times as large as the probability when the standard deviation is only eight percent.

Figure 16. The probability of a substantial increase in employer contributions is much greater when volatility is high than when it is low, if expected return is held constant



As the figures above show, the impact of a “pure” change in volatility on funded ratio and employer contribution risks is substantial. These are not real-world trade-offs because they assume the expected compound return remains a constant 7.5 percent in all three scenarios: in the real world, plans generally can only reduce volatility by accepting a lower expected return. Still, the scenarios illustrate the important impacts that investment-return volatility has on plan and employer finances.

### Scenarios for plan responses to a decline over time in risk-free returns

#### Three scenarios

Next we examine trade-offs that arise when investment-return volatility and expected returns both change, similar in concept to what happened over the last two decades. In this analysis, a substantial decline in risk-free returns presents the plan with the choice between investing in riskier assets to maintain the expected rate of return, or maintaining its asset allocation and

overall risk profile, forcing it to accept a lower expected return and also raise requested employer contributions to make up for lower expected investment income.

We constructed three scenarios: the “good old days,” with a high risk-free rate of 6.7 percent, and two scenarios in which the risk-free rate has fallen by four percentage points to 2.7 percent. (This is about as much as 10-year Treasuries fell between 2000 and the present, and about as much as 30-year Treasuries fell between the mid-1990s and the present.) We constructed these scenarios so that the relationship between the risk premium and volatility is the same across the scenarios:<sup>34</sup>

- The “good old days”: The risk-free rate of return is 6.7 percent and the plan takes on only a little bit of risk: it has an expected compound return of 7.5 percent with a standard deviation of 1.8 percent. It discounts liabilities at 7.5 percent, consistent with its expected earnings.
- Invest in riskier assets, justifying high assumed return: Faced with a risk-free rate that has fallen to 2.7 percent, the plan shifts into riskier assets allowing it to maintain the same 7.5 percent expected compound return, but with more volatility – the standard deviation increases from 1.8 percent to 12 percent. The plan continues to discount liabilities at 7.5 percent, consistent with its assumed earnings. This scenario is similar to how many plans behaved as risk-free rates fell.
- Lower assumed return and maintain asset allocation: In this alternative, the plan also is faced with a risk-free rate that has fallen to 2.7 percent, but instead of shifting into riskier assets, it maintains its asset allocation and lowers its assumed compound return to 3.5 percent, so that its standard deviation is 1.8 percent – the same as in the “good old days.” The plan discounts liabilities at 3.5 percent, consistent with the expected return of its portfolio, and therefore must request substantially higher contributions from employers. This scenario is a sort of counter-reality: what plans might have done if they had been willing to raise employer contributions dramatically.

Table 3 summarizes the key characteristics of the three scenarios.<sup>35</sup>

Table 3. Scenarios for policy response to a decline in the risk-free rate over time

	Risk-free rate	Expected Compound Return	Return volatility (Standard deviation)	Assumed return (Discount rate)
The "good old days" (High risk-free rate)	6.7	7.5	1.8	7.5
Invest in riskier assets, justifying high expected return	2.7	8.2	12.0	7.5
Maintain allocation and lower expected return	2.7	3.5	1.8	3.5

Note:

1. All values are percentage (%).
2. These are simulated scenarios that are intended to reflect main features of investment practices in certain return environments, they are not directly based on historical data.
3. It is assumed that all portfolios have the same Sharpe ratio of 0.46, and the Sharpe ratio does not change across risk-free rate regimes

#### Results – funded ratios

The choice to invest in riskier assets entails much more risk to the funded ratio than either the "good old days" scenario or the "lower discount rate" scenarios. Figure 17 shows the median funded ratios and the 25th percentiles and 75th percentiles, calculated over 1,000 simulations of each of the three scenarios (3,000 simulations in all).<sup>36</sup> The range of likely funded ratios is much greater under the "invest in riskier assets" scenario than under either the "good old days" scenario or the "lower assumed return" scenario. The median funded ratio rises much more rapidly in the "lower assumed return" scenario (rightmost panel). This occurs because the pension fund lowered its earnings assumption and requested much higher contributions from employers, as we will see in the next section. This allowed plan funding to rise quite rapidly relative to the other scenarios.



Figure 17. The choice to invest in riskier assets entails much more risk to the funded ratio than either the "good old days" scenario or the "lower discount rate" scenario

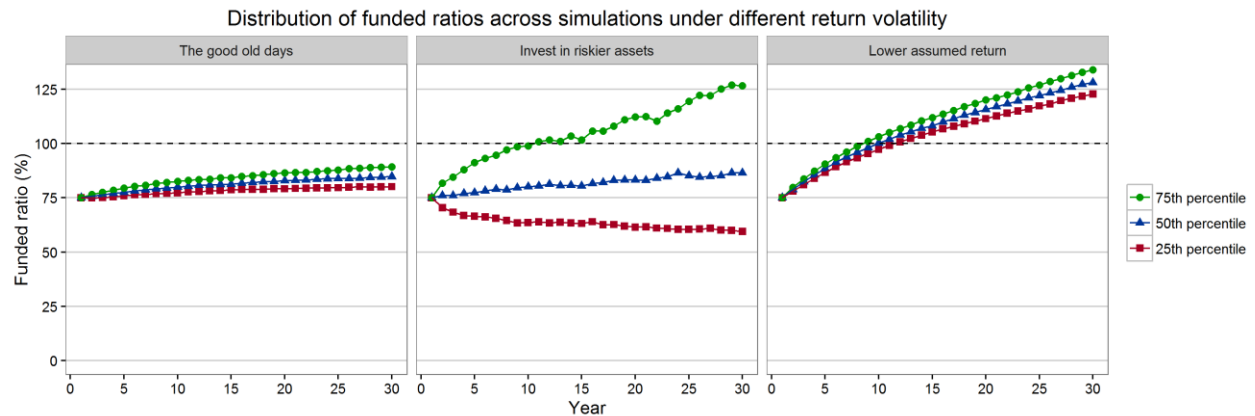
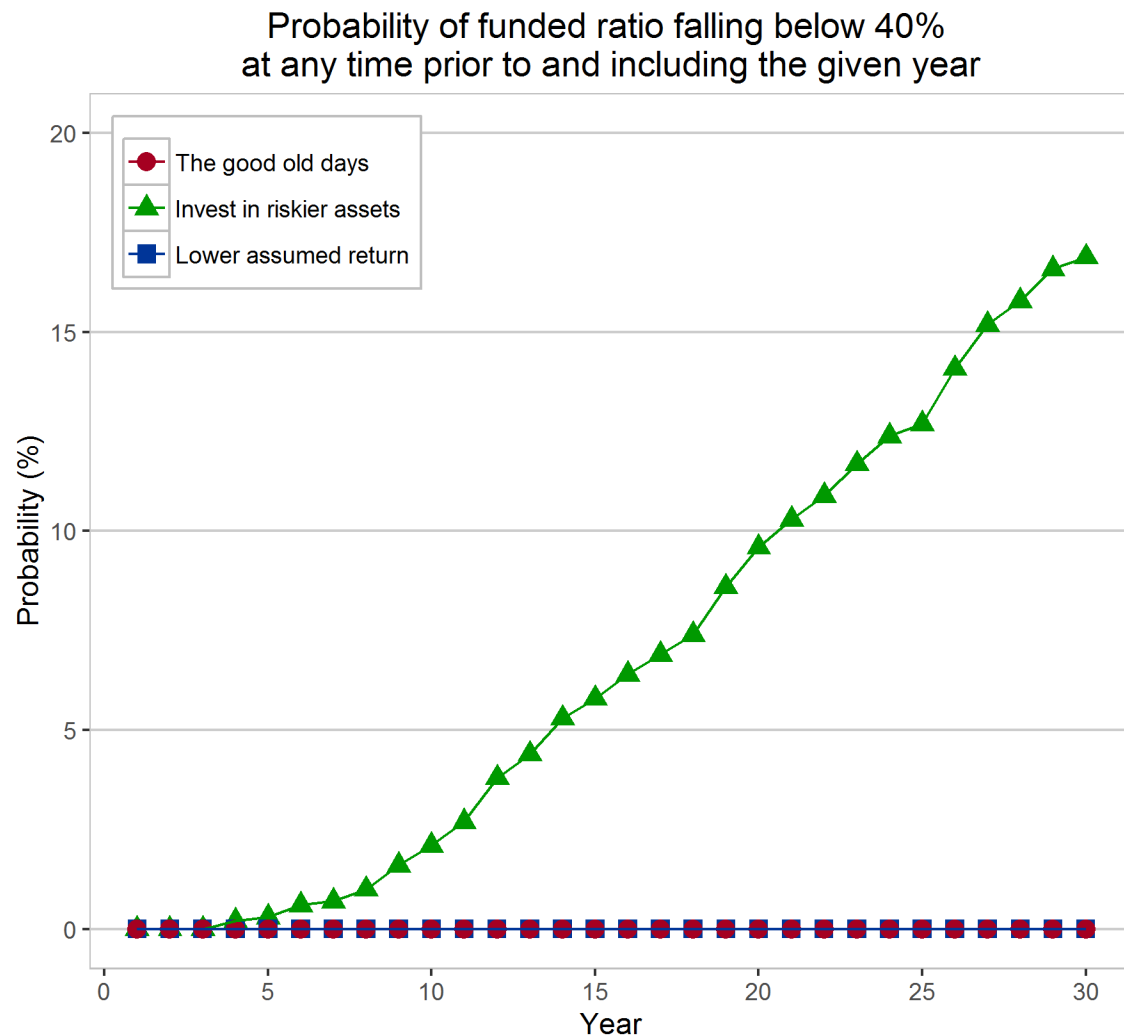


Figure 18 shows the probability of severe underfunding for each scenario. Under the “good old days” and the “lower assumed return” scenarios, there is essentially zero chance of severe underfunding. In both scenarios the standard deviation is only 1.8 percent, so there is very little investment return volatility – the plan almost always comes very close to achieving its assumed return and there is little risk. By contrast, in the “invest in riskier assets” scenario (green line), there is about a one in six (17 percent) chance that the plan will be severely underfunded within 30 years. By taking on risk, the plan kept employer contributions low, at the expense of funding risk.

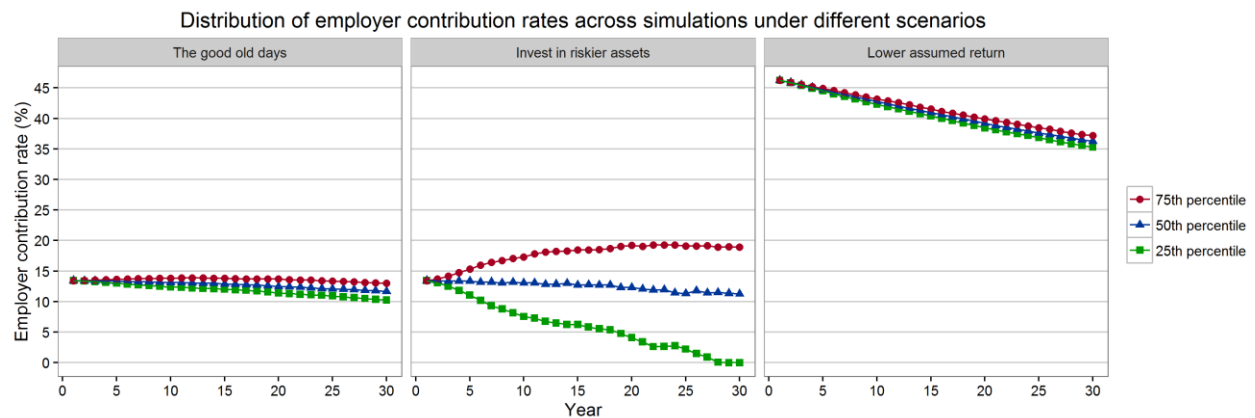
Figure 18. Probability of severe underfunding is much greater in the "Invest in riskier assets" scenario



#### Results – contributions

Figure 19 shows the median employer contribution rates and the 25th percentiles and 75th percentiles under each scenario. Under the “invest in riskier assets” scenario the contributions are much lower than if the plan were to lower the discount rate and increase requested contributions, but they are subject to much greater volatility due to the more-volatile investment portfolio. The median employer contribution under the “lower assumed return” scenario is about triple what the contribution was before risk-free rates dropped (“good old days”) and about triple the contribution that was required when the plan invested in riskier assets. This dramatic increase in contributions that would be required by lowered investment return assumptions may help to explain why plans moved into riskier assets.

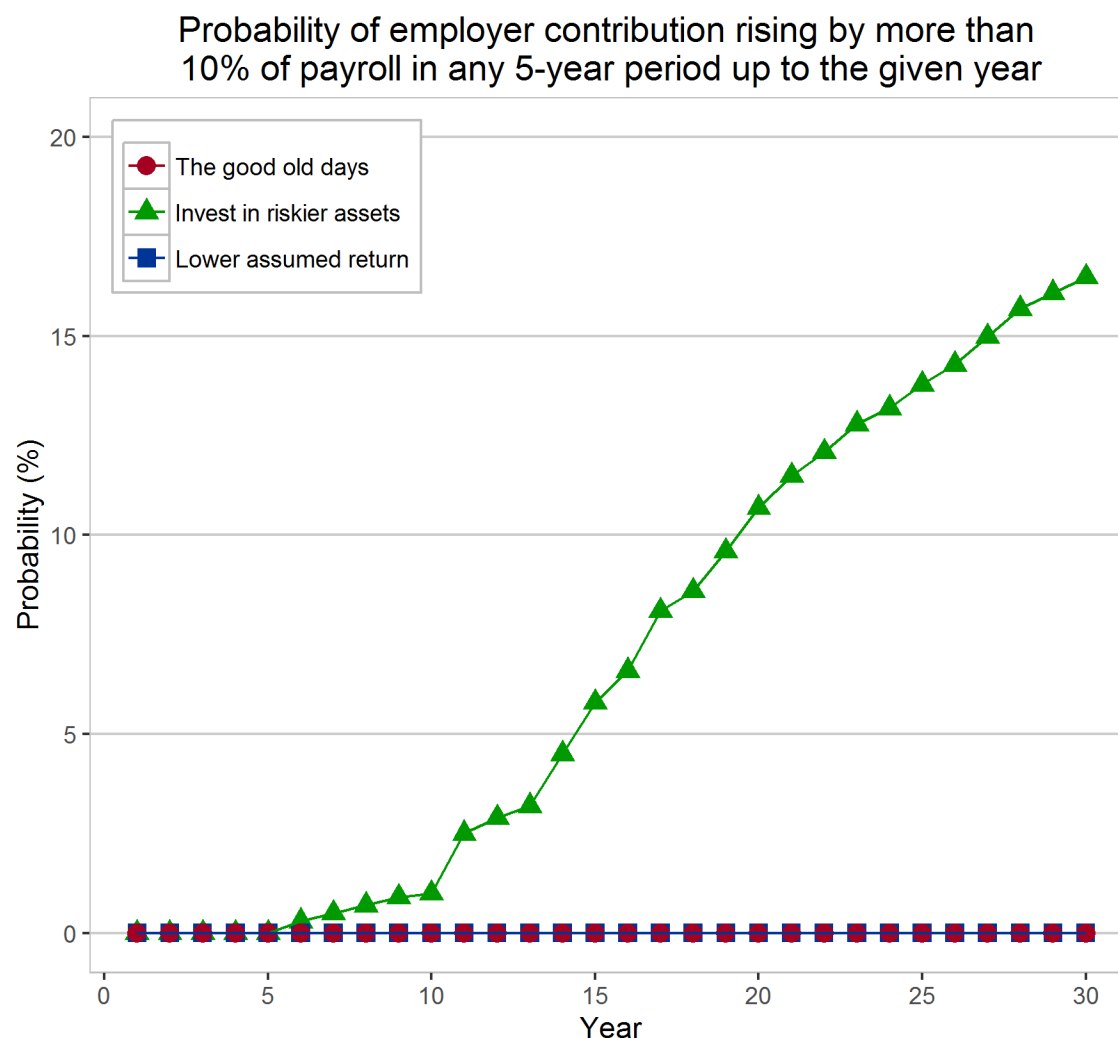
Figure 19. The employer contribution rate is much lower under the "Invest in riskier assets" scenario, but is much more variable



For these scenarios we do not present our measure of the probability that employer contributions will rise above 30 percent of payroll because in this case it does not provide meaningful information.<sup>37</sup>

Figure 20 shows the probability that employer contributions will rise by more than 10 percent of payroll in any five-year period under the three scenarios. The "invest in riskier assets" scenario, with its much greater chance of large investment-return shortfalls, carries a much greater risk that contributions will have to rise substantially in a relatively short period of time than do either of the other scenarios. However, that increase generally will be from a lower level of contributions than would be required under the "lower assumed return" scenario.

Figure 20. The probability of employer contributions rising by more than 10 percent of payroll in a five-year period is greatest in the "Invest in riskier assets" scenario



#### *Summary of impacts of responses to a sustained decline in risk-free interest rates*

Our analysis shows that plans faced a fundamental trade-off in response to a sustained decline in risk-free interest rates, as summarized in Table 4: If they invested in riskier assets, the risk to the pension fund would increase significantly but government contributions would remain low. The riskier-assets scenario resulted in a 16.9 percent probability for our prototypical plan that plan funding would fall below 40 percent sometime during the 30 years – a level that has been associated with crises in several states. If instead the plan lowered assumed investment returns, the risk to the pension fund would remain minimal, but employer contributions would have to triple, and would stay high for all 30 years of the simulation period.<sup>38</sup> This dramatic increase in required contributions may go a long way toward explaining why plans have taken on increased investment risk.

Table 4. Plans faced a trade-off when risk-free rates fell: Increase risk to the pension fund, or lower return assumptions and increase government contributions

Plan funding and employer contributions under three investment-return scenarios						
	Funded-ratio measures			Employer contribution measures		
	Probability (percent) of falling below 40% at any time within 30 years	Median funded ratio:		Probability of rising by more than 10% of payroll in any 5-year period (within first 30 years)	Median % of payroll:	
		Year 1	Year 30		Year 1	Year 30
Good old days (7.5% expected return, low volatility)	0	75.0	84.8	0	13.4	11.7
Invest in riskier assets (7.5% expected return, high volatility)	16.9	75.0	86.6	16.5	13.4	11.3
Lower assumed return (3.5% expected return, low volatility)	0	75.0	128.1	0	46.2	36.2

#### Scenario in which the true expected rate of return is less than the assumed return

While public pension funds generally have increased investments in risky assets and maintained assumed rates of return as risk-free rates declined, some current market forecasts suggest that it remains very difficult for public pension funds to achieve their assumed returns in the current market environment. To examine the consequences of using earnings assumptions that may be higher than true expected returns (which are unknowable), we constructed a scenario based on our analysis of publicly available capital market assumptions. In this scenario, the standard deviation of returns is 12 percent, the same as in the “invest in riskier assets” scenario, but the expected long-term compound return consistent with this volatility level is only 6 percent, 1.5 percentage points below the assumed investment return.

Figure 21 compares the median funded ratios, and the 25th percentiles and 75th percentiles under a base-case scenario where the true expected compound return equals the 7.5 percent earnings assumption (left panel), and our lower-return scenario in which true expected compound return is only 6 percent but the pension plan assumes it is 7.5 percent (right panel). In this scenario (the right panel) investment returns tend to fall short on average, and the median funded ratio declines over time, falling to about 60 percent by year 30. By contrast, when the earnings assumption is met (left panel), the median funded ratio rises gradually and reaches almost 90 percent after 30 years.

Figure 21. The median funded ratio declines over time when true expected compound return is lower than the earnings assumption

### Distribution of funded ratios across simulations under true expected compound returns

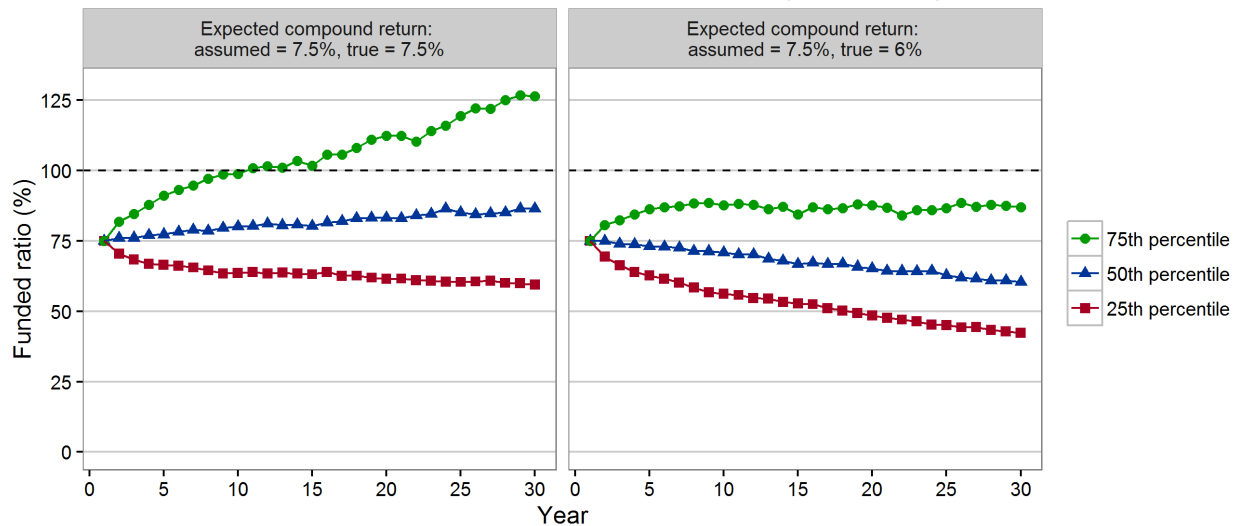
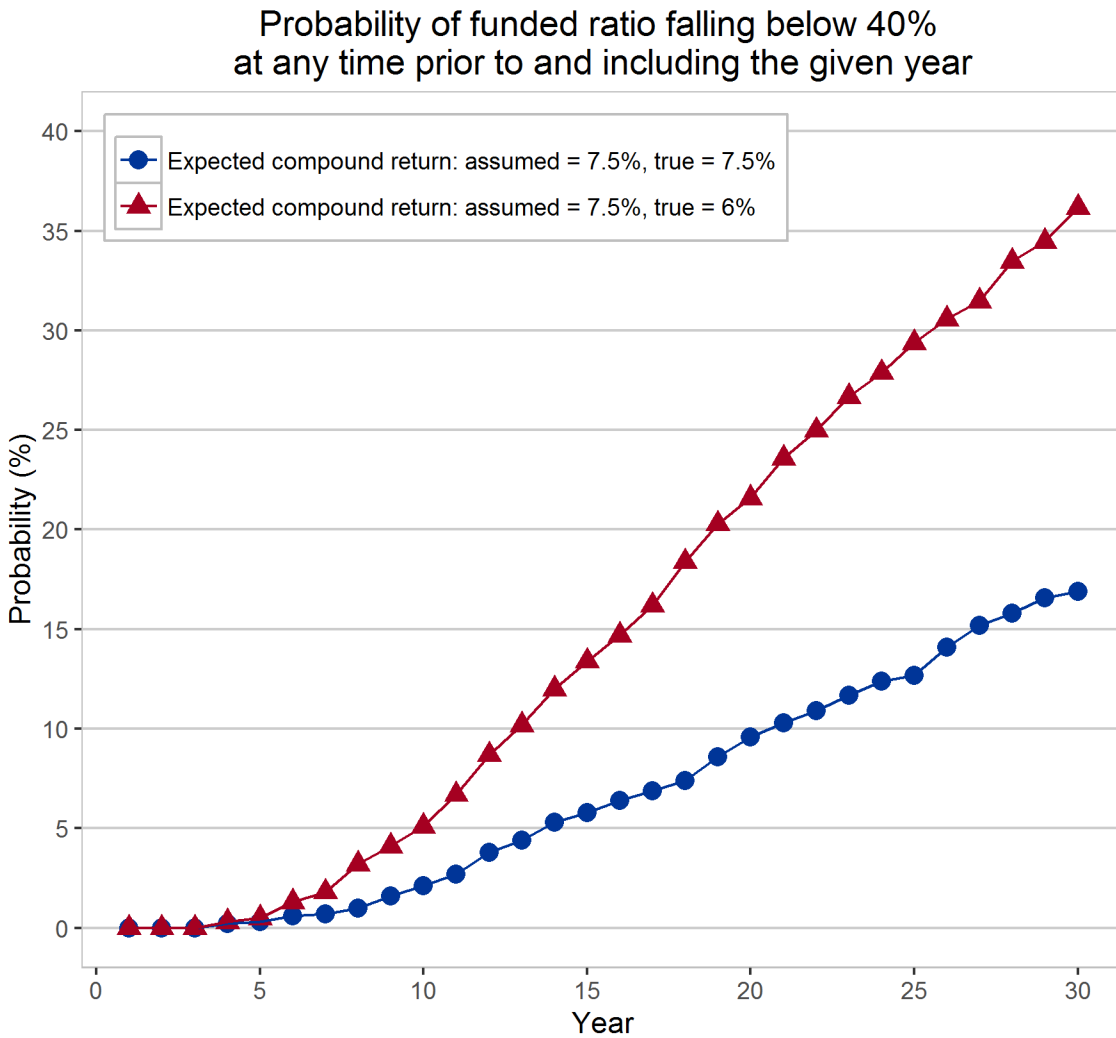


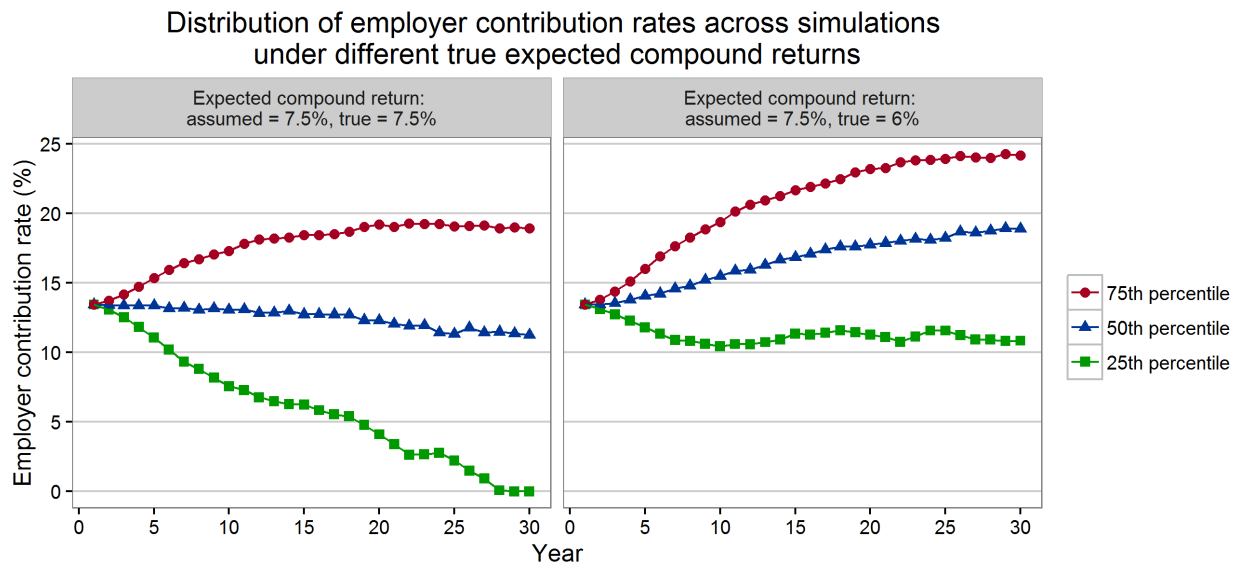
Figure 22 shows that when the earnings assumption is higher than the true return, it greatly increases the risk of the funded ratio falling into crisis territory. The blue line and red line show the probability of the funded ratio falling below 40 percent under the two scenarios. When the true expected compound return falls short of the assumption by 1.5 percent, there is a more than a one in three chance that the funded ratio will fall into what we consider crisis territory at some point in the 30-year period. This risk is more than twice as high as it is if the earnings assumption equals the true expected return.

Figure 22. The probability of extremely low funding more than doubles when the true expected compound return falls short of the earnings assumption



When the true expected compound return is lower than the earnings assumption, actual investment returns are likely to fall short of the assumed return in any given year. When that occurs employer contributions will have to rise to make up the shortfall. Figure 23 shows the median, 25th percentile and 75th percentile employer contribution as a percentage of payroll when the true expected compound return and assumed return are both 7.5 percent (left panel) and when the true expected return is 6 percent but is assumed to be 7.5 percent (right panel). The median employer contribution in the first year is about 14 percent in both scenarios. In the overly optimistic assumption scenario (right panel) it rises continually, reaching about 19 percent by year 30 - approximately 9 percentage points higher than when the 7.5 percent earnings assumption is met.

Figure 23. The median employer contribution rises over time when the true expected compound return falls short of the earnings assumption

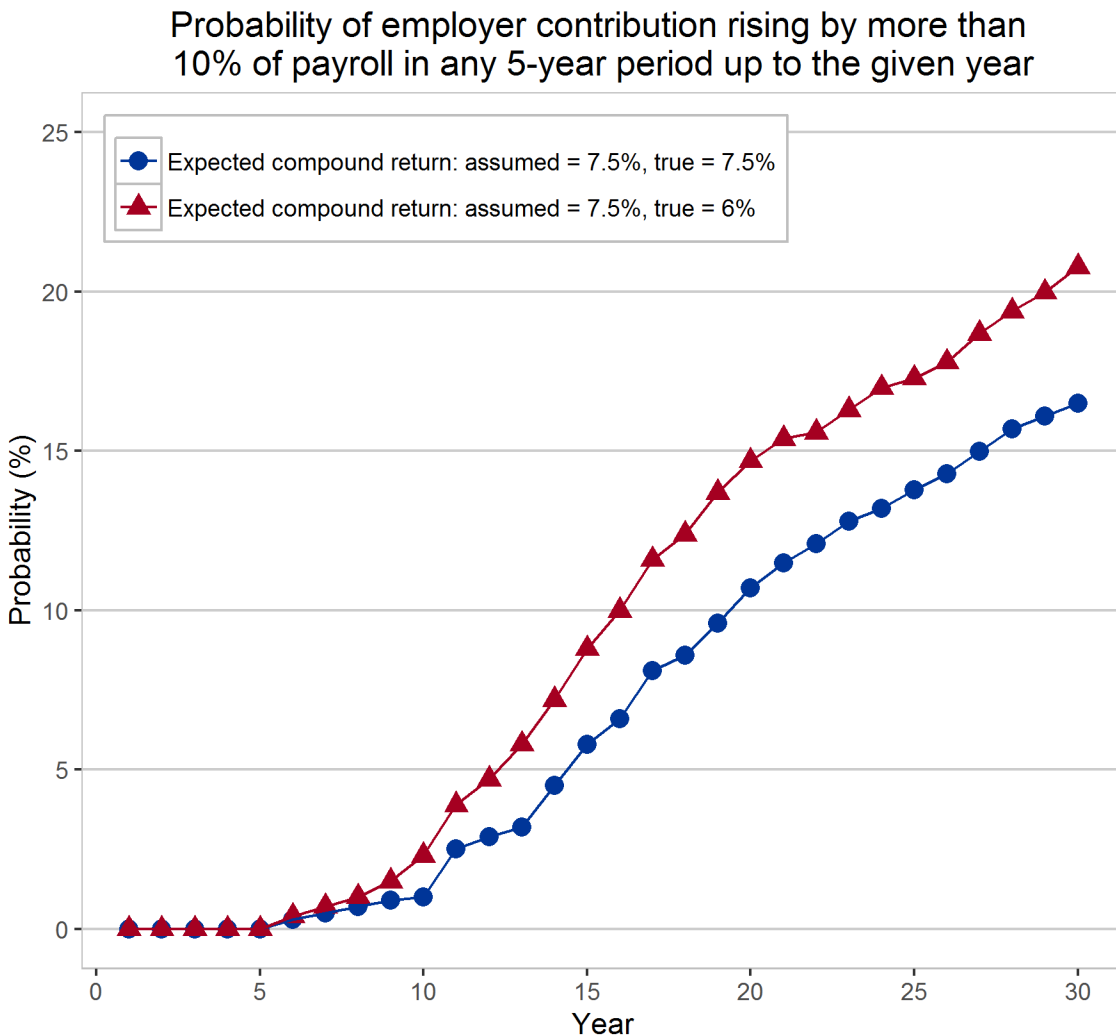


We do not present a separate figure showing the probability that the employer contribution will rise above 30 percent of payroll at some point during 30 years. However, this probability is about 7.5 percent when the assumed return is too optimistic, compared to only 2.5 percent when the expected compound return and assumed return are both 7.5 percent.

Finally, although the two scenarios have the same investment-return volatility, the overly optimistic scenario has a greater risk that employer contributions will rise by more than 10 percent of payroll in a 5-year period, as Figure 24 shows.



Figure 24. Sharp employer contribution increases are likely if assumed returns are higher than “true” expected returns



### Conclusions about investment risk-taking

The decline in risk-free interest rates since the 1980s and 1990s has created a very difficult investing environment for public pension plans. Before the decline, the typical plan could have achieved its investment-return assumptions while taking very little risk. As rates declined, public plans faced a choice: either reduce investment-return assumptions and request much higher contributions from governments, or maintain assumptions, avoid increasing contributions from governments, and take on much greater risk.

For the most part, public pension funds have maintained their investment-return assumptions, perhaps in the belief that interest rate declines were temporary and that in the longer run high investment returns could again be obtained at low levels of risk. But maintaining their assumptions implicitly required them to invest in riskier assets.

We modeled the implications of a sustained reduction in risk-free interest rates by examining a prototypical pension plan under three scenarios:

- *The good old days*: The pension plan can expect to earn a 7.5 percent return with very little investment-return volatility, or risk. This is similar to what plans might have been able to achieve two or three decades ago. As the name implies, pension plans no longer have this beneficial choice available.
- *Invest in riskier assets*: In response to declining risk-free rates, the pension plan maintains a 7.5 percent earnings assumption but invests in riskier assets. Even though it can expect a long-run compound return of 7.5 percent, some years will be much higher and some will be much lower. Our measure of investment-return volatility, the standard deviation, is 12 percent in this scenario. This is similar to what many public pension plans did as risk-free rates fell.
- *Lower assumed return*: In this scenario, instead of investing in riskier assets in response to declining risk-free rates, the pension plan lowers its earnings assumption to 3.5 percent and remains invested in relatively low-risk assets, with a standard deviation of 1.8 percent. This forces the plan to raise contributions from governments. For the most part, public pension plans have not done this (although they have raised contributions in response to investment shortfalls). Lowering risk and raising contributions remains an option.

Pension plans were not limited to one response or the other – they could have chosen to be in-between.

We modeled the finances of our prototypical pension fund over 30 years, assuming that employers pay full actuarially determined contributions. Our analysis shows that plans faced a fundamental trade-off: If they invested in riskier assets, the risk to the pension fund would increase significantly but government contributions would remain low. The riskier-assets scenario resulted in a 16.9 percent probability for our prototypical plan that plan funding would fall below 40 percent sometime during the 30 years – a level that has been associated with crises in several states. If instead the plan lowered assumed investment returns, the risk to the pension fund would remain minimal, but employer contributions would have to triple, and would stay high for all 30 years of the simulation period. This dramatic increase in required contributions may go a long way toward explaining why plans have taken on increased investment risk.

We also examined what would happen if plan earnings assumptions, which are in the range of 7 to 8 percent for most plans, are too optimistic, as some professional market forecasts suggest. We simulated a scenario in which the true expected compound return is 1.5 percentage points lower than the assumed return of 7.5 percent. In that scenario the plan has a more than a one in three chance of experiencing severe underfunding at some point over the next 30 years, which is more than twice as high as when the investment earnings assumption is met. Employer contributions as a percentage of payroll would be expected to rise substantially over time, whereas if the return assumption is met they would fall over time; by the end of 30 years, the median employer contributions in this scenario are almost 50 percent higher than when investment return assumptions are met.

## Conclusions

Stochastic simulation is an important tool for understanding the potential consequences of investment return risk and volatility for public pension plans, for the governments that contribute to these plans, and for stakeholders in these governments who ultimately bear the risks. We have used a stochastic simulation model to examine the interplay between investment return risk and funding policies, and to examine the potential implications of the changing investment environment.

Our analysis of funding policy shows that there are important trade-offs between risks to the finances of public pension plans, and risks to their sponsoring governments. The most-common funding policies and practices reduce contribution volatility at the same time that they increase the likelihood of severe underfunding. These policies are unlikely to bring underfunded plans to full funding within 30 years, even if investment-return assumptions are met every single year and employers make full actuarially determined contributions.

Our analysis of the changing investment return environment shows that the choice by most public pension plans to increase investment portfolio risk in the face of falling risk-free returns, helping them to maintain investment return assumptions, has kept governmental contributions much lower than they otherwise would have been, but also has created greater risk to pension plan funding.

Many funds now are in a very difficult position. Reducing investment risk would help to shore up plan finances, but at the expense of much higher contributions from governments. Many plans have made small reductions in investment-return risk in recent years, but it remains much higher than in earlier periods.

## Appendix

### Illustrative simulations

We examine three arbitrarily chosen individual simulations to illustrate how the model works and the information it produces. In these illustrative simulations we examine a single funding policy: 30-year level-percent open with 5-year asset smoothing, a common approach as discussed earlier. The three individual simulations are:

- A “deterministic” run in which the pension fund earns exactly 7.5 percent on its investments every year
- A run with generally high investment returns in the early years and lower investment returns in later years (sim #56). This run results in a compound annual return of 7.5 percent over the first 30 years.
- A run with generally low investment returns in the early years and higher investment returns in later years, also resulting in a compound annual return of 7.5 percent over the first 30 years (sim #228).

**Error! Reference source not found.** shows the annual return and cumulative compound return for each of the two simulations. As is apparent, even though these two individual simulations achieve the assumed 7.5 percent compound return by the end of 30 years, annual returns are extremely volatile even when investment return assumptions are attained. Furthermore, these two selected simulations understate the volatility that plans face: most of the 1,000 simulations do NOT result in a compound average return of 7.5 percent over 30 years – the 30-year average falls below 6 percent about one quarter of the time, above 9 percent about one quarter of the time, and between 6 percent and 9 percent half of the time. Thus, contributions and funded ratios will be more variable most of the time than in the illustrative simulations we examine below. We summarize the full range of variability later.

### The SOA Blue Ribbon Panel’s Standardized Contribution Benchmark

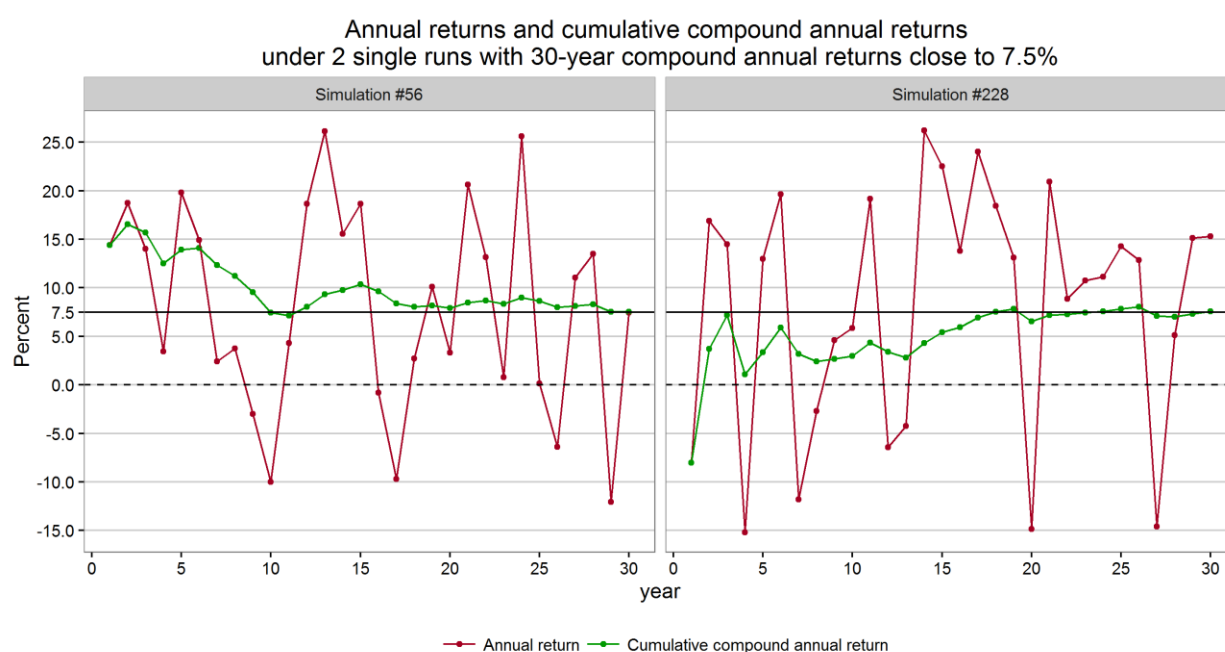
In 2014 a panel commissioned by the Society of Actuaries proposed that public pension plans disclose (but not necessarily fund) a standardized contribution, to help users assess the adequacy and reasonableness of the plan’s actual or recommended contributions.<sup>39</sup> The Standardized Contribution Benchmark (SCB) would have the following key features:

- The discount rate would continue to be based upon an earnings assumption as is current actuarial practice. However, it would be “forward looking” and based upon current market conditions, rather than being based primarily on historical returns. The example contribution provided by the Blue Ribbon Panel in its 2014 report estimated a discount rate of 6.4 percent. In current market conditions, the equivalent rate would be about a half percent lower.
- Unfunded liabilities would be amortized using a 15-year open level-percent method.
- Five-year asset smoothing would be used.

Inflation and salary assumptions would be adjusted to be consistent with the discount rate assumptions.

These features generally would result in a higher benchmark contribution than contributions resulting from other methods for two reasons. First, the discount rate generally would be lower in the current market environment, resulting in (a) higher normal costs, and (b) higher actuarial liabilities and therefore higher unfunded liabilities to amortize. (These movements could be offset partially by lower inflation and salary assumptions.) Second, the 15-year amortization period is shorter than periods in common use (as Table 1 shows, 79 percent of plans use periods of 20 years or more) and thus would result in a higher contribution.

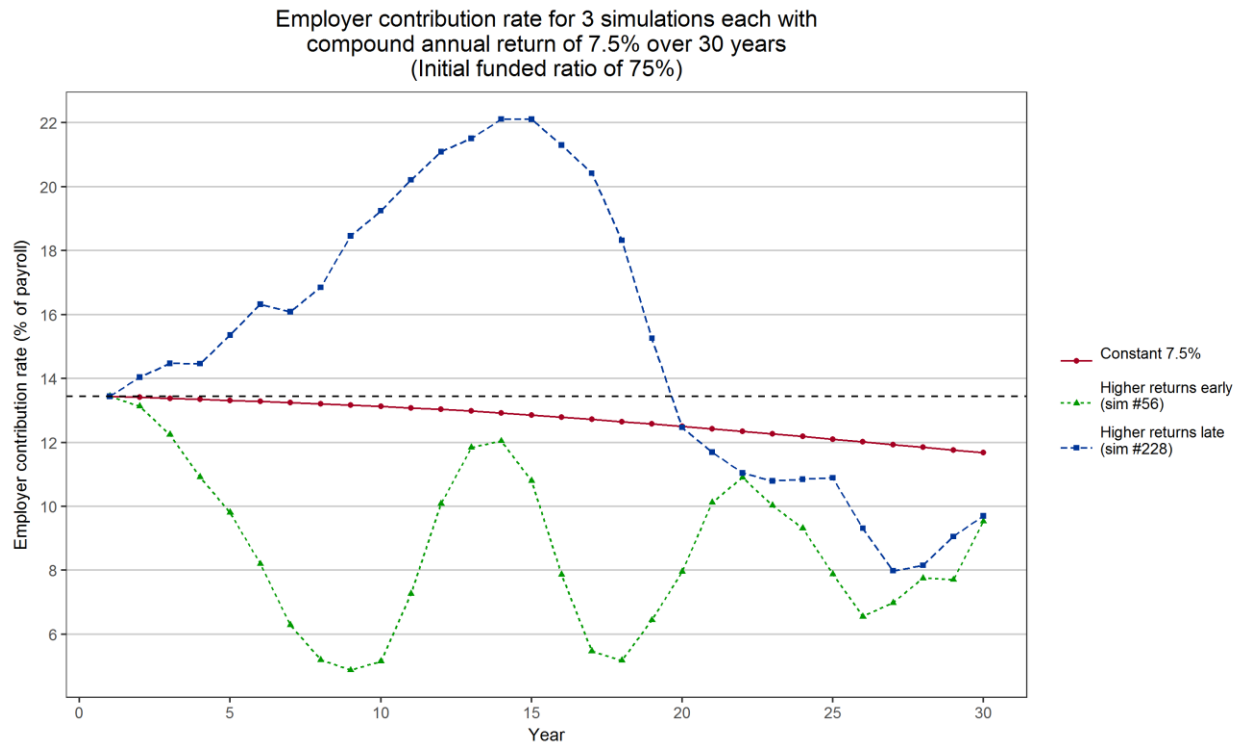
*Figure 25 Simulated returns are extremely volatile from year to year, even if assumed return is achieved at 30 years*



**Error! Reference source not found.** shows employer contribution rates for the three simulations. The rates are quite stable for the run in which returns are precisely 7.5 percent every year – the typical actuarial assumption – but they are highly variable for the other two simulation runs. Simulation #228 with low early returns and high later returns results in substantial but varying contribution rates, increasing by about 8 percentage points of payroll in the first 15 years (a 57 percent increase), then falling almost continuously as higher investment returns are achieved. Simulation #56, with high early returns and low later returns, generates lower contributions than the deterministic simulation throughout the first 30 years, but contributions fluctuate considerably, rising or falling by as much as 6 percentage points of payroll in periods of three to four years.

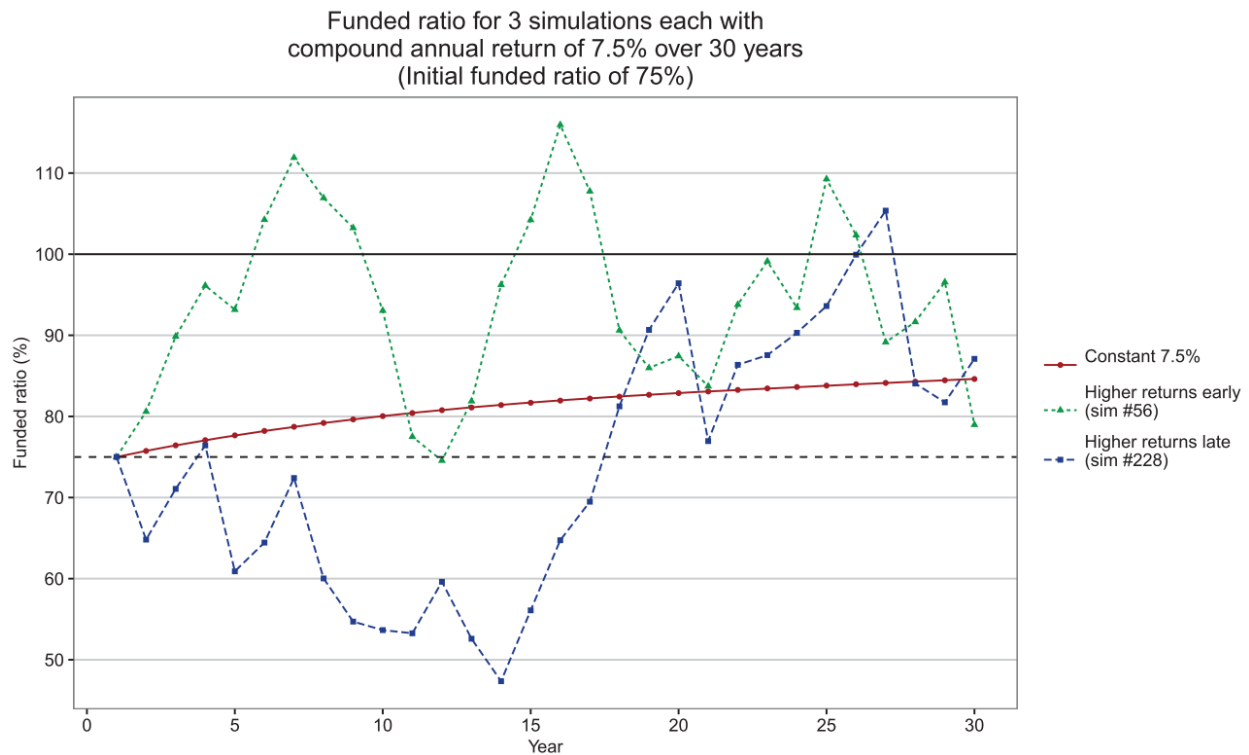
Thus, even if a plan achieves its assumed returns over a 30-year period, contributions – and legislators who must adjust government budgets to accommodate contributions – will be on a bumpy ride.

Figure 26 Employer contribution rates vary dramatically even for simulations that have the same compound average return



**Error! Reference source not found.** shows the variability in funded status. After 30 years the plan remains less than 90 percent funded in all 3 simulations, even though the plan achieved its investment return assumption and the employer made all actuarially determined contributions. In the higher-returns-early simulation (#56), funded status rises above 100 percent at several points during the first 30 years. In the higher-returns-late simulation (#228) the funded ratio falls below 50 percent at 14 years but then rises nearly continually for about 10 years before falling. It may seem comforting to see that when the funded ratio dipped below 50 percent in year 14, future simulated investment returns combined with employer contribution increases were so great that they pulled funding up to nearly 100 percent over the next six years. But politicians who find themselves in such a situation would have no comfort: they would be faced with many years of high contributions and no reason to believe that future returns will be high simply because past returns were low. It happens by design in our simulation because the two simulations we selected were known to achieve assumed returns by the end of 30 years.

Figure 27 Funded status varies dramatically for simulations that have the same compound average return



Other simulations can produce very different results, including funded status above 100 percent for extended periods, and funded status well below 40 percent, particularly in simulations that do not achieve a 7.5 percent compound annual return in the first 30 years.

It is not just the timing of investment returns and of employer contributions that varies across the three runs. The different simulations result in very different values for the cumulative present value of employer contributions, as shown in **Error! Reference source not found..** (We calculate the present value of contributions and payroll using a 7.5% discount rate. Alternative discount rates would result in different present-value calculations.) In the higher-returns-early scenario (sim #56), the present value of employer contributions over the first 30 years is 9.1 percent of the present value of payroll. By contrast, the present value is 15.9 percent of payroll in the higher-returns-later scenario (sim #228). The present value for the constant 7.5 percent scenario falls between the two extremes. Each of these variable-return simulations differs from the constant-returns simulation by at least 20 percent, and the higher-returns-later simulation is 75 percent more expensive than the higher-returns-early scenario. Thus, the order in which investment returns arrive is important, even when the compound annual return is the same – high returns early can have a large beneficial impact on overall contributions, while higher returns later can have a large detrimental impact.

*Table 5 Funded ratios, employer contributions, and the cumulative present value of employer contributions vary even when compound returns are the same*

### Three simulations with compound annual return of 7.5%

	Constant 7.5%	Higher returns early (sim #56)	Higher returns later (sim #228)
Average compound annual return:			
Years 1-15	7.5%	10.3%	5.4%
Years 16-30	7.5%	4.8%	9.7%
Years 1-30	7.5%	7.5%	7.5%
Funded ratio, year 30	84.6%	79.0%	86.8%
Present value of employer contributions, years 1-30, as % of present value of payroll (discounted at 7.5%)	13.0	9.1	15.9
% by which present value of employer contributions is above (below) constant 7.5% scenario	0.0%	(30.0%)	21.8%

What causes the order of returns to matter? Negative cash flow, before considering investment returns (i.e., benefit payouts that exceed total contributions), plays a role. When a plan has negative cash flow, relative to a plan that does not, investible assets will be higher in early years than later. In this case, good returns early will generate more investment income than good returns later, because they will be applied to greater investible assets. Required contributions therefore will be lower. The interplay between the order of returns, contributions, and plan funded ratio can become quite complex when contributions are smoothed; as a result it is difficult to understand and predict precisely how contributions and funded status will vary. Most plans currently have negative cash flow before investment income and so these issues are quite relevant.



## Endnotes

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<sup>1</sup> An arithmetic mean of 8.22 percent and standard deviation of 12 percent generate a long-run compound return of about 7.5 percent.

<sup>2</sup> Alan Milligan, “Annual Review of Funding Levels and Risks, 2012,” *Report for Finance and Administration Committee, March 18, 2013* (Sacramento: California Public Employees’ Retirement System, March 2013).

<sup>3</sup> Andrew G. Biggs, “The Public Pension Quadrilemma: The Intersection of Investment Risk and Contribution Risk,” *The Journal of Retirement*, Summer 2014.

<sup>4</sup> Julia K. Bonafede, Steven J. Foresti, and Russell J. Walker, *2015 Report on State Retirement Systems: Funding Levels and Asset Allocation* (Santa Monica: Wilshire Consulting, February 25, 2015), [https://www.wilshire.com/media/38890/wilshire\\_2015\\_state\\_funding\\_report.pdf](https://www.wilshire.com/media/38890/wilshire_2015_state_funding_report.pdf).

<sup>5</sup> U.S. Census Bureau, 2014 Annual Survey of Public Pensions: State-Administered Defined Benefit Data.

<sup>6</sup> These estimates of unfunded liabilities, prepared by the U.S. Bureau of Economic Analysis and the Federal Reserve Board, are greater than those of actuaries. Donald J. Boyd and Yimeng Yin, “By The Numbers: State and Local Government Unfunded Pension Liabilities Rise by \$268 Billion in the Third Quarter of 2015” (Rockefeller Institute of Government, January 30, 2016), [http://www.rockinst.org/pdf/government\\_finance/2016-01-20\\_By\\_the\\_Numbers\\_Brief\\_No4.pdf](http://www.rockinst.org/pdf/government_finance/2016-01-20_By_the_Numbers_Brief_No4.pdf).

<sup>7</sup> American Academy of Actuaries, “Objectives and Principles for Funding Public Sector Pension Plans,” Issue Brief (American Academy of Actuaries, February 2014), [http://www.nasra.org/files/Topical%20Reports/Funding%20Policies/Public-Plans\\_IB-Funding-Policy\\_02-18-2014.pdf](http://www.nasra.org/files/Topical%20Reports/Funding%20Policies/Public-Plans_IB-Funding-Policy_02-18-2014.pdf).

<sup>8</sup> Henning Bohn, “Should Public Retirement Plans Be Fully Funded?,” *Journal of Pension Economics and Finance* 10, no. 02 (2011): 195–219, doi:10.1017/S1474747211000096.

<sup>9</sup> Society of Actuaries, “Report of the Blue Ribbon Panel on Public Pension Plan Funding” (Society of Actuaries, February 2014).

<sup>10</sup> Jeffrey R. Brown and David W. Wilcox, “Discounting State and Local Pension Liabilities,” *American Economic Review* 99, no. 2 (April 2009): 538–42, doi:10.1257/aer.99.2.538.

<sup>11</sup> Society of Actuaries, “Report of the Blue Ribbon Panel on Public Pension Plan Funding,” February 2014.

<sup>12</sup> Alicia H. Munnell and Jean-Pierre Aubry, “The Funding of State and Local Pensions: 2014-2018” (Center for State and Local Government Excellence, June 2015), [http://slge.org/wp-content/uploads/2015/06/15-07-SLGE-Funding-of-State-and-Local-Pensions-2014-2018\\_web-final.pdf](http://slge.org/wp-content/uploads/2015/06/15-07-SLGE-Funding-of-State-and-Local-Pensions-2014-2018_web-final.pdf).

<sup>13</sup> R. Novy-Marx and J. Rauh, “Public Pension Promises: How Big Are They and What Are They Worth?,” *The Journal of Finance* 66, no. 4 (2011): 1211–49.

<sup>14</sup> Consider a plan that provides a benefit of 2 percent per year of service times the average salary in the final five years of work, plus a 2 percent annual cost of living adjustment (COLA). For an employee who works from age 20 to 65 with 4 percent annual raises and lives until age 85, the annual cost of benefits (the “normal cost”) spread over salary earned during working years is 8.2 percent of payroll if the discount rate is 8 percent. However, as the discount rate falls the annual cost rises. At a 6 percent rate the normal cost would be 15.9 percent of payroll and at a 4 percent discount rate the cost would be 30 percent of payroll – nearly 4 times as great as at 8 percent. (Higher discount rates might be associated with higher price inflation and faster salary growth, affecting benefits and payroll. The example holds these constant.)

<sup>15</sup> Line 6, “Imputed employer contributions”, of National Income and Products Account Table 7.24. Transactions of State and Local Government Defined Benefit Pension Plans (<http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&903=395>). In addition, estimates of unfunded liability would be higher, potentially leading to greater amortization costs as well. (Note that BEA calculates the cost of funding the accumulated benefit obligation rather than the projected benefit obligation, so these numbers are not exactly comparable to actuaries’ estimates but are a useful approximation.)

<sup>16</sup> In mid-February 2016 the yield on a 30-year Treasury bill was approximately 2.6 percent. <http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield>. Both the U. S. Bureau of Economic Analysis and Moody’s Investors Service value liabilities using a high-quality corporate bond rate that was in the 4 to 4.5 percent range as of late 2015. Moody’s uses the Citibank Pension Liability Index

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(<https://www.soa.org/professional-interests/pension/resources/pen-resources-pension.aspx> and <https://www.yieldbook.com/m/indices/citi-pension-liability.shtml>), an index of high credit-quality taxable bonds duration-weighted to be consistent with the liability duration of a typical private sector pension plan. This rate was 4.3% at January 31, 2016 (<https://www.soa.org/Files/Xls/2015-09-pen-citigroup.xls> and [https://www.yieldbook.com/x/ixFactSheet/CPLI\\_YC167.csv](https://www.yieldbook.com/x/ixFactSheet/CPLI_YC167.csv)). Moody's Investors Service, "Adjustments to US State and Local Government Reported Pension Data," April 17, 2013. BEA used a rounded rate of 5.0% for analysis it did in relation to 2010 and 2011, when the CPLI was about a percentage point higher than in late 2015, so it appears broadly consistent with the Moody's approach. David G. Lenze and others, "State and Local Government Defined Benefit Pension Plans: Estimates of Liabilities and Employer Normal Costs by State, 2000-2011" (Bureau of Economic Analysis, 2013), <http://192.149.12.20/papers/pdf/State-and-Local-Government-Defined-Benefit-Pension-Plans.pdf>.

<sup>17</sup> Governmental Accounting Standards Board, "Statement No. 25 of the Governmental Accounting Standards Board: Financial Reporting for Defined Benefit Pension Plans and Note Disclosures for Defined Contribution Plans" (Governmental Accounting Standards Board, November 1994).

<sup>18</sup> Governmental Accounting Standards Board, "Statement No. 27 of the Governmental Accounting Standards Board: Accounting for Pensions by State and Local Governmental Employers" (Governmental Accounting Standards Board, November 1994).

<sup>19</sup> Governmental Accounting Standards Board, "Statement No. 67 of the Governmental Accounting Standards Board: Financial Reporting for Pension Plans, an Amendment of GASB Statement No. 25" (Governmental Accounting Standards Board, June 2012).

<sup>20</sup> Governmental Accounting Standards Board, "Statement No. 25 of the Governmental Accounting Standards Board: Financial Reporting for Defined Benefit Pension Plans and Note Disclosures for Defined Contribution Plans."

<sup>21</sup> "LAGERS Forty-Fourth Comprehensive Annual Financial Report Fiscal Year Ended June 30, 2012" (Missouri Local Government Employees Retirement System, October 1, 2012), <http://www.molagers.org/assets/cafr-2012.pdf>.

<sup>22</sup> Alicia H. Munnell et al., "State and Local Pension Costs: Precrisis, Post-Crisis, and Post-Reform" (Center for Retirement Research at Boston College, February 2013), [http://crr.bc.edu/wp-content/uploads/2013/02/slp\\_30.pdf](http://crr.bc.edu/wp-content/uploads/2013/02/slp_30.pdf).

<sup>23</sup> Because these are remaining amortization periods, they likely understate the intended amortization period of the typical plan. For example, a plan that uses 30-year closed amortization that has already completed three years of amortization of an unfunded liability might report remaining amortization of 27 years.

<sup>24</sup> Governmental Accounting Standards Board, "Statement No. 25 of the Governmental Accounting Standards Board: Financial Reporting for Defined Benefit Pension Plans and Note Disclosures for Defined Contribution Plans."

<sup>25</sup> Natalya Shnitser, "Funding Discipline for U.S. Public Pension Plans: An Empirical Analysis of Institutional Design," *Iowa Law Review* 100 (2015): 663–714.

<sup>26</sup> Each combination of a pension plan and a year is an observation in this context.

<sup>27</sup> The median SOA Benchmark contribution eventually falls to zero. This is because our model does not allow contributions to be negative, and so during periods of particularly good returns employers and employees contribute "too much" to the plan and eventually this can lead to extended periods in which employers do not have to make contributions.

<sup>28</sup> Andrew G. Biggs, "The Public Pension Quadrilemma: The Intersection of Investment Risk and Contribution Risk," *The Journal of Retirement*, Summer 2014.

<sup>29</sup> The source is the Financial Accounts of the United States from the Federal Reserve Board, March 10, 2016 release. We define equity-like investments to include corporate equities, directly owned real property, and an allocated share of mutual funds and certain other assets (Financial Accounts code FL223093043); we allocated the latter using the share that corporate equities are of mutual fund assets for the economy as a whole. We do not include cash and short-term assets such as time deposits, money market funds, checkable deposits, or repurchase agreements, and we do not include debt securities or mortgage loans. Calculations by other analysts sometimes result in higher equity shares than we report here, and can vary depending on the definitions used and on data sources and methods.

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<sup>30</sup> In the figure, the Treasury yield is the 10-year constant maturity yield, averaged over the typical public pension plan fiscal year (ending in June) from the daily rate available as variable DGS10 from the Federal Reserve Economic Data (FRED) website of the Federal Reserve Bank of St. Louis (<https://research.stlouisfed.org/fred2/>). The assumed investment returns are from several sources: (1) 2001-2014 values are the unweighted mean of assumed returns, computed by the authors from Public Plans Data website, 2001-2014. Center for Retirement Research at Boston College, Center for State and Local Government Excellence, and National Association of State Retirement Administrators (<http://crr.bc.edu/data/public-plans-database/>); (2) 1990-1992, 1994, 1996, 1998, and 2000 are from Surveys of State and Local Government Employee Retirement Systems, generally authored by Paul Zorn and generally available through <https://www.questia.com/magazine/1G1-14379961/surveys-of-state-and-local-government-employee-retirement>; (3) 1989 is from Olivia S. Mitchell and Robert S. Smith, "Pension Funding in the Public Sector," *The Review of Economics and Statistics* 76, no. 2 (May 1994): p. 278 (<http://www.uh.edu/~bsorensen/Mitchell%26SmithPensions.pdf>).

<sup>31</sup> For example, see Aleksandar Andonov, Rob Bauer, and Martijn Cremers, *Pension Fund Asset Allocation and Liability Discount Rates: Camouflage and Reckless Risk Taking by U.S. Public Plans?*, May 2012. The longer term move toward riskier assets also reflected responses to laws allowing "prudent person" approaches to investing and laws explicitly allowing investments in a broader range of assets.

<sup>32</sup> See assumptions in: *Asset/Liability Study: Los Angeles Fire and Police Pension System* (RVK, Inc., October 2015) and *Michigan State Employee's Retirement System: Asset/Liability Study* (Portland, OR: RVK, Inc., September 2012). Also see assumptions of Callan Associates reported in Timothy W. Martin, "Pension Funds Pile on Risk Just to Get a Reasonable Return," *Wall Street Journal*, May 31, 2016, sec. Markets, <http://www.wsj.com/articles/pension-funds-pile-on-the-risk-just-to-get-a-reasonable-return-1464713013>. Callan Associates has noted that it sympathizes with public pension funds given the challenges that professionals face in achieving assumed returns in the current interest rate environment.

<sup>33</sup> The 16 percent scenario is quite consistent with assumptions of Callan Associates reported in Martin, "Pension Funds Pile on Risk Just to Get a Reasonable Return."

<sup>34</sup> The portfolio mean return and standard deviation at 6.7 percent risk-free rate are derived in such a way that each portfolio has a Sharpe ratio of 0.46. This is broadly consistent with what a typical plan today appears to assume: it is consistent with an arithmetic mean return of 8.22 percent and standard deviation of 12 percent (generating a long-run compound return of about 7.5 percent), and a risk free rate of 2.7 percent. The Sharpe ratio of 0.46 is higher than what is used or implied in many recent studies, reflecting the optimistic views of public pension plans about the return they can achieve with their current portfolio. For example, Novy-Marx and Rauh use a Sharpe ratio of 0.4 for the stock market in "The Liabilities and Risks of State-Sponsored Pension Plans," *The Journal of Economic Perspectives* 23, no. 4 (2009): 191–210. We will examine in the next section a scenario in which the expected long-run compound return is only 6 percent and the implied Sharpe ratio is 0.335, which is consistent with current capital market assumptions discussed earlier and lower than what is implied by public pension fund assumptions.

<sup>35</sup> When investment returns are variable, the long-run compound return (which we show in the table) will be lower than the expected annual arithmetic return. In the model, we draw expected arithmetic returns. We determine the appropriate expected arithmetic mean by a widely used approximation formula under which the long-run compound return equals the annual expected return minus one half of the annual variance.

<sup>36</sup> To ensure comparability for purposes of the figure, liabilities and the funded ratio in each scenario are discounted using a 7.5 percent discount rate for each graph line.

<sup>37</sup> Under the "lower assumed return" scenario, the employer contribution rates need to be approximately 46 percent of payroll in the first year, and therefore the probability that the employer contribution rate will rise above 30 percent of payroll at some point during the 30-year period is 100 percent. Under the scenario "invest in riskier assets," in which the contributions are generally much lower, the probability is only 2.5 percent even though investment returns are much more volatile. The pension fund under the "good old days" scenario has no exposure to this type of risk at all.

<sup>38</sup> The plan would be likely to become overfunded under this scenario.

<sup>39</sup> Ibid.