Appropriateness of Risk-Taking by Public Pension Plans, Part I

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INTRODUCTION

Public pension funds receive contributions from governments and employees, and invest those funds with the goal of having enough money to pay future benefits when due. Governments and pension funds can't predict the future with certainty, so they adjust contribution requirements to reflect experience – requesting higher contributions if experience hasn't been as good as expected, or reducing requirements if experience has been better than expected.

The biggest uncertainty is how well the pension fund's investments will do. Currently public pension funds have approximately $3.7 trillion in assets, about two-thirds of which are invested in stocks, real estate, hedge funds, and other assets subject to substantial investment risk. Thus, investment returns can be much greater or less in any given year than pension funds expect. This creates risks that employer contributions may have to rise considerably, or may be able to fall considerably. It also creates risks that plan funding will fall to very low levels, particularly if governments do not pay actuarially determined contributions. Conversely, very good investment returns could lead to significant plan overfunding.

Understanding these issues is important because if contributions rise sharply, governments may have to raise taxes significantly, or cut services sharply. Or governments may be unwilling to pay requested contribution increases and may seek to cut pension benefits.

In a previous report we examined how plan funding policies and practices affect the risks of underfunding and of sharp contribution increases.[1] In this report we examine the risk-taking behavior of pension funds and insights from research about both the causes of this risk-taking and the appropriate degree of risk.

THE RISE OF PUBLIC PENSION FUND RISK-TAKING

In investing, there is a trade-off between risk and reward: investing in safe assets involves little or no risk of loss, but the return generally will be small. Investors can seek higher returns but that comes at the price of greater risk: the actual return may be higher or lower than expected, and the investor may even lose money. This is true for individuals, and it is true for pension funds.

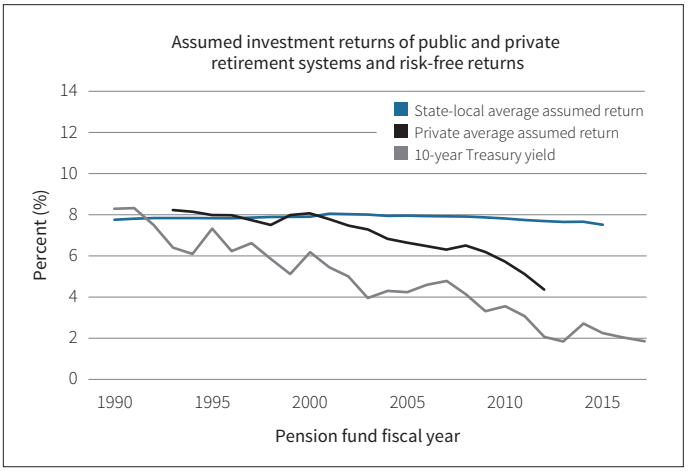
Declining interest rates have forced public pension funds to either lower assumed returns or take more risk

In 1990 the typical public pension fund assumed it would earn about 7.8 percent.[2] At the same time, 10-year U.S. Treasury securities were yielding 8.3 percent, so a pension fund could achieve its assumed return with minimal risk.[3] In the quarter-century since, interest rates on 10-year Treasury have fallen markedly and are now below 3 percent; rates on other securities fell as well. The decline was part of a longer-term trend that accelerated during and after the Great Recession.[4]

This decline has created an extremely difficult investing environment for public pension funds and all retirement savers. Because expected returns and risks are related, the decline in risk-free rates and in expected returns for many assets more generally means that plans needed to either reduce their assumed investment returns, or take greater risk to justify those returns.

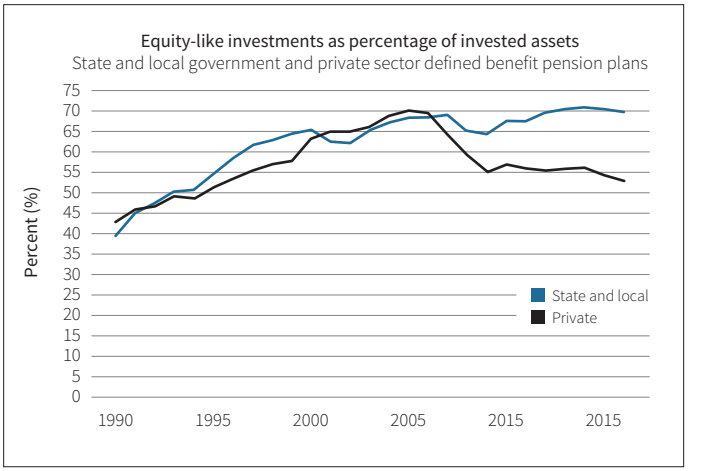
Figure 1 shows what happened: while nominal risk-free returns declined, public pension funds' earnings assumptions have been "sticky," barely falling at all, even though private plans reduced

Figure 1. As yields on risk-free Treasuries fell, private plans lowered assumptions but public pension plans did not



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)

Figure 2. Public plans increased their exposure to equity-like assets while private plans moved in the other direction



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

their assumptions. Between 1990 and 2015, the average public pension plan's assumed investment return fell from 7.8 percent to 7.5 percent while the 10-year Treasury yield fell from 8.3 percent to 2.2 percent.[5]

Although public sector plans in the U.S. barely lowered their assumptions, private sector defined benefit plans in the U.S. lowered their assumptions, as did both public and private plans in Canada and Europe. For example, between 1993 and 2012 (the final year of the study from which the data are drawn), when the 10-year Treasury yield fell by 4.3 percentage points, large private sector U.S. plans lowered their discount rates by 3.8 percentage points, from 8.2 percent to 4.4 percent.[6] By contrast, the average liability discount rate used by large public plans for funding purposes fell from 7.8 percent to 7.7 percent in this period.

Public pension plans have shifted into riskier assets

Public pension funds used to be stodgy investors, although that has been changing for a long time. Even before risk-free yields began falling, public plans had been moving away from portfolios that were sharply constrained by "legal lists" (i.e., lists in statute) of allowable investments. In an effort to increase investment returns and to diversify portfolios, states changed laws to allow broader investments, and pension funds changed their cultures and practices, increasing their equity investments.[7] [8]

This trend accelerated with the steep sustained fall in risk-free returns: In an effort to construct portfolios that might achieve returns similar to the 8 percent assumption of days gone by, public pension plans in the U.S. increased their allocation to risky assets to the point where they now invest over two-thirds of their assets in equity-like investments, up from one-quarter in the 1970s. While public plans once were more conservative investors than private defined benefit plans, they now have a much greater share of their assets in equity-like investments than do private plans. (Figure 2.[9])

This shift has increased risk to pension fund assets and to state and local governments

The movement toward equity assets has increased the riskiness of public pension fund assets. One measure of risk is the "standard deviation" – a measure of how volatile investment returns are likely to be, relative to the expected return.[10] Under common assumptions *actual* investment returns would be *expected* to fall within one standard deviation of the expected investment return about two-thirds of the time.[11] The rest of the time they would be outside this range: at least one standard deviation better than the expected return one-sixth of the time, and at least one standard deviation below the expected return the remaining one-sixth of the time.[12]

To illustrate: If a portfolio has an expected return of 8 percent and a standard deviation of 12 percent, then over the very long run about one-sixth of the time actual returns will be above 20 percent, and about one-sixth of the time the portfolio will have a loss of more than four percent.[13] The other two-thirds of the time returns would fall between a gain of 20 percent and a loss of four percent. The higher the standard deviation the greater the volatility of returns, and the greater the likelihood of very large unexpected gains and losses.

As public plans moved into riskier assets, what happened to the expected volatility of assets – to the expected standard deviation? Andrew Biggs of the American Enterprise Institute has estimated

that the standard deviation of a portfolio designed to have an expected return of 8 percent had been about 4.3 percent in 1995, but approximately tripled by 2013.[14] (One industry-association publication has argued that the investment risk-taking of public pension funds has not increased over the last several decades, but that analysis was based on erroneous measures of risk.[15])

Table 1 shows that a one-standard deviation shortfall resulting from a single year's investment underperformance would now amount to more than one-quarter of a year's worth of state and local government taxes.[16] This is more than three times as large as in 1995, and about 10 times as large as in 1985. We compare to taxes because they are the primary source that would be used to repay shortfalls or, alternatively, that might be reduced in the face of large investment gains. The conclusion that risks have increased dramatically holds if we compare investment risk instead to overall budget size or to gross domestic product.[17] (The amounts in Table 1 have been adjusted for inflation and are in constant 2016 dollars, to make it easier to compare dollar values across years.)

To give a sense of how great the risks have become, a one standard deviation shortfall – which has about the same likelihood as rolling a "1" with a single six-sided die – would be roughly equivalent to what state and local governments in the United States spend on highways, police, fire, and corrections combined in a single year.[18] [19] If the shortfall were amortized (spread out with interest) in a manner similar to what many pension funds do, it would require increased contributions from governments of about $25 billion now, rising at the rate of 3 percent annually for 30 years after which the amount would be paid off.[20] This is equivalent to about a 50 percent cut in parks spending for 30 years, or a 25 percent cut in highway capital spending for 30 years – *resulting from a single year of moderately bad investment returns*.[21]

WHY DO U.S. PUBLIC PENSION FUNDS INVEST SO HEAVILY IN RISKY ASSETS?

The decision-making environment encourages U.S. public plans to invest in risky assets

Researchers, politicians, and others have pointed out that the unique environment in which U.S. public pension plans operate encourages investment risk taking.

U.S. public pension plans face at least two incentives that encourage them to invest in risky assets: (1) doing so keeps reported pension liabilities lower than they otherwise would be, and (2) investing in risky assets keeps actuarially determined contributions requested from governments lower than they otherwise would be, at least in the short term. The second incentive – lower near-term pension payments by governments - probably is more powerful than the first.

Investing in risky assets helps to keep reported liabilities low

Under accounting standards and actuarial practice, U.S. public pension funds calculate liabilities based on the investment

Table 1. Riskiness of public pension portfolios relative to state and local government taxes has increased more than 3-fold since 1995

	Potential magnitude of public pension fund investment risk as % of taxes				
Pension fund fiscal year	Invested assets, (billions of 2016 $) (A)	Volatility (risk) for a portfolio with 8% expected return (Standard Deviation) (B)	One standard-deviation risk, (billions of 2016 $) (C = A x B)	State & local government taxes, (billions of 2016 $) (D)	One standard-deviation risk, as % of taxes (E = C ÷ D)
1975	$335	3.7%	$12.4	$516.6	2.4%
1985	698	2.7%	18.8	685.3	2.7%
1995	1,719	4.3%	73.9	978.3	7.6%
2016	3,554	12.0%	426.5	1,576.8	27.0%
2016 / 1985	5.1	4.4	22.6	2.3	9.8
2016 / 1995	2.1	2.8	5.8	1.6	3.6

Sources and notes:
- Volatility estimates for 1975, 1985, 1995 are from Biggs (2013); 2016 is authors' assumption. There is about a 1 in 6 chance of a shortfall of 1 standard deviation or larger in a single year, under plausible assumptions.
- Invested assets from Federal Reserve Board, Financial Accounts of the United States.
- Taxes from Bureau of Economic Analysis, NIPA Table 3.3.
- Taxes and assets are in fiscal year 2016 dollars, adjusted using GDP price index.
- Risk measure is for a single year. Longer-term investment risks are larger.

The assumed investment return that a plan chooses does not change the benefits that ultimately must be paid.

return they assume they will earn on their assets. The greater the assumed return, the lower the pension liability shown in financial reports and actuarial valuations. By contrast, financial theory teaches that liabilities do not depend upon how assets are invested: the proper discount rate depends on characteristics of the liabilities. Because pension benefits are bond-like liabilities consisting of fairly predictable and highly secure annual payments, they should be valued using bond-like rates, not rates linked to the pension fund portfolio. Private pension plans in the U.S., and public and private pension plans in Canada, the U.K., and the Netherlands value their liabilities using rates that do not depend upon the assets they choose to invest in.[22] The standards and practices for U.S. public pension plans are an outlier.

Because large reported and unfunded liabilities can be controversial and politically awkward, U.S. public plans have an incentive to invest in riskier assets with higher expected returns, allowing them to keep reported liabilities lower than they otherwise would be. (Again, U.S. private plans and plans in many other countries do not have this incentive.) Many researchers have remarked on this incentive.[23]

Investing in risky assets can keep government contributions low in the short term

Even more important, the choice of discount rate affects actuarially determined contributions. The higher the rate, the lower the calculated liability. A lower reported liability means that actuarially determined contributions will be lower - governments can pay less into the fund now, and have more money for education spending, tax cuts, or other near-term priorities.

This is a powerful incentive, and governments and plans have acted on it many times, sometimes quite boldly. For example, in 1990 New York City stated forthrightly that it was raising its investment return assumption from 8.25 percent to 9 percent so that it could reduce its pension contribution, freeing up money in the budget for raises under a proposed new teacher contract. Some analysts and officials questioned whether it was too high, but the city and the union were in favor, and it carried the day.[24]

The assumed investment return that a plan chooses does not change the benefits that ultimately must be paid. If investment return assumptions do not pan out, current contributions will be too low and will have to rise in future years – but that may be a problem for future politicians and future taxpayers.

The investment-return assumption generally is recommended by actuaries and approved by boards, although informal communication and signaling might influence both recommendation and approval. In some cases, as in the New York City example, the government plays an open and public role in choosing the assumption. There are no formal statutory limits on how high or low this assumption may be but it may be constrained by professional judgment and practices.

This again is in contrast with the rules and standards for private pension plans and sponsors in the United States, and private and public plans in Canada, the U.K., and the Netherlands. In these cases, the rates used for funding purposes generally are either based on market interest rates rather than portfolio earning assumptions, or are constrained by law, or are coupled with mechanisms to induce conservatism such as requirements to shoot for more than full funding.

The net result is that public pension funds in the United States generally use higher discount rates for financial reporting and for funding than private plans in the United States, and public and private plans in Canada, the U.K., and the Netherlands.

These incentives put public plan trustees in a difficult situation

Public pension fund boards often have complex relationships with governments, which sponsor funds, pay contributions, and generally must backstop any investment return shortfalls. On one hand, a pension fund board that wants to be sure assets will be available to pay benefits might want a low earnings assumption so that investment risk can be low and contributions will be high. On the other hand, the board may not want to trigger financial and political difficulties for the government by forcing contributions to be high. Another consideration is that if risk-taking is unsuccessful, governments usually have legal responsibility to ensure benefits are paid, and eventually will have to step in and pay higher contributions. Thus, benefit payments may be quite secure in the case of a deeply underfunded plan with strong legal protection of benefits (assuming the government has the capacity to pay up eventually).

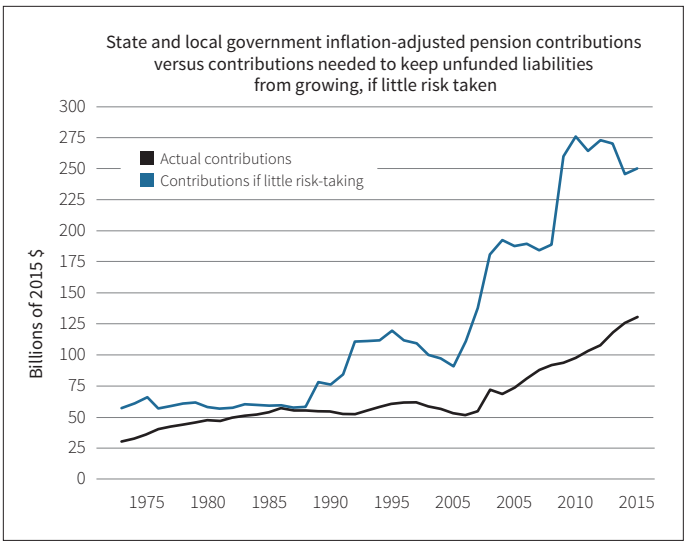
Complicating the situation further, boards generally include a mix of people who represent the perspectives and perhaps interests of different groups, including workers, unions, retirees, the government, and the public at large. The relative power of these groups can vary significantly from fund to fund. Boards generally have fiduciary responsibilities but these responsibilities do not appear to lead boards to change earnings assumptions substantially in response to changing economic conditions,

as Figure 1 demonstrated. In some cases boards have actively resisted lowering earnings assumptions.

These are not just arcane issues – the amounts involved, and therefore the incentives, are huge. Figure 3 shows actual contributions to defined benefit pension plans by state and local governments in inflation-adjusted 2015 dollars (green line). It also shows a rough estimate of the contributions governments would have to make if they were to fund pensions in a highly secure manner, taking very little investment risk (blue line). The blue line assumes governments fund new benefits as they are earned, and cover the interest on unfunded liabilities to keep them from growing, but do not make payments to reduce those unfunded liabilities. The gap between what governments currently pay and what it would take to fund benefits much more securely is large: approximately $120 billion in 2015.[25] In other words, state and local governments would have to approximately double their pension contributions to fund benefits without taking much risk.[26]

Increasing contributions by this much would be quite difficult for elected officials, and for taxpayers and other stakeholders in government who would bear the cost in some combination of higher taxes or lower services. It is roughly equivalent to permanently increasing all state and local sales taxes by a third, or permanently reducing all K-12 education spending by a fifth.[27]

Figure 3. State and local government contributions would have to increase by more than $120 billion annually if public pension plans were to de-risk substantially



Source: Rockefeller Institute analysis of Bureau of Economic Analysis NIPA Table 7.24. 'Little-risk' contributions are based on BEA estimates of ABO liability, which were calculated using low-risk market-based discount rates. In recent years, the rate was 5%. Liabilities and contributions estimated with risk-free rates would be considerably higher. Note that little-risk contributions would be higher still if we included amounts needed to amortize unfunded liabilities.

Because changes in earnings assumptions have such large impacts on contributions, plans come under pressure not to reduce assumptions, and face criticism when they do. The Illinois Teachers Retirement System (TRS) recently reviewed whether to reduce its investment earnings assumption from 7.5 percent to 7 percent. In response Governor Rauner's administration said that lowering it could have a devastating impact on funding for social services and education.[28] The governor reportedly attempted to stack the pension board by quickly filling vacancies, but the effort was unsuccessful and the board voted to reduce the assumption. Annual contributions are projected to rise by $400-500 million.[29]

Pressures like those encountered by the Illinois TRS can lead pension funds to cast their earnings assumption in cement and look for an investment mix that justifies the assumption. The fixed assumption determines the level of risk the plan considers acceptable. This is backward: Pension funds should decide how much investment risk to take based on the risk tolerance of their stakeholders. That should determine their asset allocation, which in turn should determine their expected investment rate of return.

U.S. public pension plans have responded to incentives by taking more risk

According to recent research, U.S. public plans have responded to these incentives in a big way. Economists Andonov, Bauer, and Cremers examined the behavior of public and private pension funds in the United States, Canada, the United Kingdom, and the Netherlands from 1993 through 2012 using statistical techniques to control for differences across funds and countries.30 Their sample included more than 850 pension funds, including 164 public U.S. funds. They hypothesized that the regulatory environment creates an incentive for U.S. public funds to invest in risky assets that U.S. private funds and the foreign funds do not have, due to their different standards and rules.31 Their analysis shows that "…only U.S. public plans significantly increase their allocation to risky assets when interest rates are falling." The impact was large: the approximately 5 percentage point decline in 10-year Treasury yields over their analysis period was associated with a 15 percentage point increase in U.S. public plans' allocation to risky assets, relative to other plans. They conclude that, "*gradually, U.S. public funds have become the biggest risk-takers among pension funds internationally.*" (Emphasis added.)

To summarize, in the face of falling risk-free interest rates, unlike other pension funds, public pension funds in the United States have increased the riskiness of their assets substantially. The current actuarial, accounting, and political environment creates incentives for this sort of behavior.[32] The risk is more than three times larger, relative to state and local government taxes than it was in 1995. Risks cut in both directions. The

potential consequences of investment shortfalls are quite large, and could result in substantial cuts in services or increases in taxes. Investment gains could result in benefits of similar size.

HOW MUCH RISK IS APPROPRIATE?[33]

Does public pension fund investment risk even matter?

Some researchers have pointed out that under restrictive assumptions, pension fund risk taking could be irrelevant.[34] The idea is that if taxpayers understand fully the risk-taking of the pension funds they are responsible for, they could adjust their own portfolios, increasing investments in risky assets or scaling them back depending on whether the pension funds are taking less or more risk than the taxpayers want. Their tax payments would be volatile because government contributions would rise and fall based on investment returns, but they could keep their standard of living stable by borrowing and saving as needed.[35] While this might be possible for some taxpayers, most won't know much about the investments of pension funds, many won't be able to build portfolios to adjust, and many won't be able to borrow and lend to keep their own consumption smooth.[36]

Thus, as a practical matter, pension fund risk-taking is important – it can lead to higher or lower contributions from government, leading to higher or lower taxes, or cuts or increases in services that affect the well-being of taxpayers and other stakeholders in government.

But public pension plans are long-term investors, so isn't their long-term risk minimal?

The fallacy of time diversification: Assets become more uncertain over long time horizons, not less uncertain

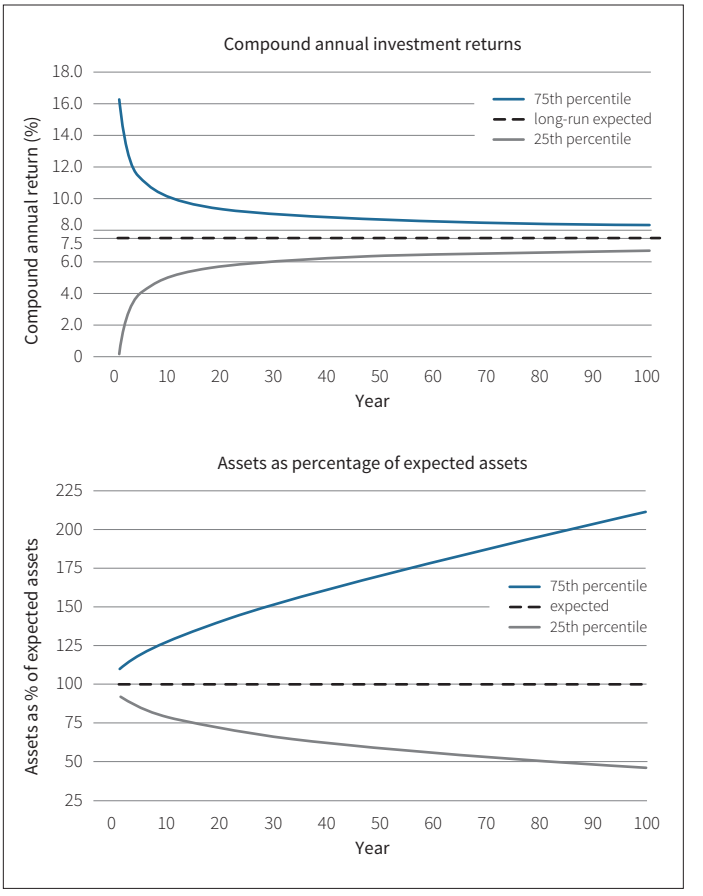
Public pension funds are long term investors in the sense that most of their assets are needed to pay benefits far in the future, with a relatively small amount needed to pay current benefits. Currently, annual benefit payments by most plans are less than 10 percent of their assets; given that contributions come in each year, their net outflow (benefits minus contributions) is even less. Thus, most plans do not currently need to sell assets to make benefit payments and can afford to invest with a longer-term horizon. (As public plans continue to mature, they may become increasingly susceptible to short term risks. They have relatively fixed liabilities that must be paid, and maturing plans may find themselves in a situation where they need to sell assets to meet benefit payments.)[37]

Because public pension funds and governments that pay into them will be around for generations, and because long-run average returns are less volatile than short-run returns, some people have argued that the risks of investing public pension funds diminish over the longer term and are quite small.

This argument focuses on the wrong risk. It is not the average compound return that is important to a pension fund's ability to pay benefits, but the assets accumulated in the fund. Under traditional assumptions that investment returns are independent of each other from year to year, the likely range around compound investment returns shrinks as the investment horizon lengthens, *but the likely range around future asset values actually increases*. The impact of compounding investment returns over a longer period outweighs the narrowing of the range around expected returns, causing asset values to be more uncertain as the investment horizon lengthens.[38]

Figure 4 shows that the uncertainty around asset values increases with time, using assumptions similar to those commonly used by public pension funds: a long-run expected return of 7.5 percent and a standard deviation of 12 percent. The illustration further assumes that investment returns are normally distributed and are not related from one year to the

Figure 4. The likely range around compound annual returns decreases with time, but the range around asset values – which are needed to pay benefits - increases



Source: Authors' simulations.
Assumes: 7.5% expected long-run compund return, 12% standard deviation, normally distributed and independent over time.

next. We simulated one million investment returns from this distribution for each of 100 years. The top panel shows the 75th percentile of the compound annual investment returns from the simulation (blue line) and the 25th percentile (green line), as well as the long run expected return (red line).[39] The bottom panel shows the 75th percentile of accumulated assets as a percentage of assets that would be expected if 7.5 percent were earned every year (blue line) and the 25th percentile (green line), as well as the expected value of this measure, which is always 100 (red line).

To illustrate the calculation, if we only look at the first year, the range around expected returns is quite large – the 25th percentile for expected returns in the first year (the leftmost point on the green line in the top panel), which equals the compound return because we are compounding over one year, is 0.1 percent. We would expect $1 in assets to grow to $1.075 after one year but at the 25th percentile, assets will only be about $1.001 or 93 percent of expected assets (leftmost point on the green line in the bottom panel). By year 100 the likely range for expected compound returns has narrowed considerably so that at the 25th percentile the compound return is 6.67 percent (top panel, green line, rightmost point). However, returns are now compounded over 100 years: expected assets will be about $1,393 but at the 25th percentile assets will be only $639 – just 54 percent of the expected amount (bottom panel, green line, rightmost point).

Thus, even though the uncertainty around compound investment returns diminishes with time, assets become more uncertain as the time horizon extends, because returns are compounded over so many years – assuming, as we do here, that returns are independent from year to year.

Governments almost never go out of business, so can't they tolerate more financial risk?

One common but erroneous corollary to the time diversification argument is that because governments will exist for many generations and have the power to tax, public pension funds can accept more risk than private pension funds. However, as Federal Reserve Board economist David Wilcox noted in comments to the Actuarial Standards Board: "If governments truly … are more tolerant of financial risk than the typical participant in financial markets, then governments should be the preferred providers of all types of financial products involving financial risk, including life insurance, commercial loans, and mortgages, to name but a few. But few analysts really believe that the government is the preferred provider of such products, suggesting that the premise—that governments can afford to be more tolerant of risk—is highly suspect."[40]

Similarly, if states can be more tolerant of risk then they should invest lottery prize funds in risky assets, similar to pension funds. Lotto games have financial characteristics that are similar to pensions in important ways, although the political characteristics are different: prizes often are paid as fixed annuities for 20 years; while payments do not have the legal protections of pension benefits, as a practical matter states could not run successful lotteries if they did not plan to make full prize payments. If states can count on riding out ups and downs in investment markets and being almost certain of earning a risk premium, they would be wise to invest prize funds in risky assets and make additional contributions as needed if investment returns fall short, as they do with pension funds. Yet no state does this as far as we can tell. Instead, most appear to invest in conservative portfolios, often matching the cash flow characteristics of the prize payouts, or else they purchase annuities to pay prizes.[41]

Won't good returns follow bad, and vice versa, lowering the long-term risk?

A second common but erroneous corollary is that risks for pension plan investments are less than we might expect over the long term because bad spells in investment markets will be followed by periods of good returns and vice versa. This is sometimes called "mean reversion" or "time diversification" – the idea that investment returns may revert to the average (or mean) over time, thus providing benefits similar to diversification. If this is true and substantial, then long-run risk would not be as great as Figure 4 suggests, which assumes that returns are independent from year to year.

There has been a great deal of academic research into this topic and the results are mixed. Much of the work is specific to stock market returns, although our concern must be broader: the presumption that pension funds will eventually get their returns typically pertains to portfolios as a whole.

Two early frequently cited papers by Poterba and Summers and by Fama and French, published in 1988, concluded that there was evidence of long-term mean reversion in stock market returns between 1926 and 1985, generally for period lengths of 3-5 years.[42] This view was popularized by the book, *Stocks for the Long Run*, by Jeremy Siegel, which analyzed two centuries of stock returns.[43] However, that work may have been misinterpreted. According to the author, "I never said that that means stocks are safer in the long run.…We know the standard deviation of the average [return] goes down when you have more periods... What I pointed out here is that the standard deviation for stocks goes down twice as much—twice as fast as random walk theory would predict. In other words, they are relatively safer in the long run than random walk theory would predict. Doesn't mean they're safe." [44]

Recent research generally concludes that either there is no evidence for long-term mean reversion, or that the evidence is

mixed and has been limited to specific markets such as United States equities, or that mean reversion is more than offset by other factors. Jorion pointed out shortcomings in past research, particularly its reliance on U.S. equities. He expanded the sample to 15 countries and concluded, "The results are not reassuring. We find no evidence of long-term mean reversion in the expanded sample. Downside risk declines very little as the horizon lengthens."[45] Dimson, Marsh, and Staunton examined stock market data for 20 countries over 113 years and concluded, "much of the popular evidence for mean reversion is attributable to optical illusions that employ perfect hindsight… We find that, without the benefit of foresight, the evidence on mean reversion is weak. Market-timing strategies based on mean reversion may even give lower, not higher, returns."[46]

Research by Pastor and Stambaugh concluded that there is evidence for mean reversion but other factors such as uncertainty about parameters (we don't know the true mean or standard deviation of expected investment returns) more than outweigh mean reversion and make long-run asset values and compounded returns more uncertain than those in the short run, "Mean reversion contributes strongly to reducing long-horizon variance but is more than offset by various uncertainties faced by the investor…. We find that stocks are actually more volatile over long horizons from an investor's perspective."[47]

The Pastor-Stambaugh conclusion about uncertainty of parameters bears elaboration: Pension plans are subject to two kinds of risk. The first risk is that returns in any given year will be higher or lower than the long-run expected return, even if plans' long-run assumptions are accurate. This risk is the focus of much of this report. But in addition to this year-to-year volatility, plans face a second major risk: neither they, nor anyone, truly knows what to expect for returns over the long run. Investment advisors and others develop estimates based on their analysis of financial markets, but they are just estimates, and they could be quite wrong. Because plans don't truly know what returns might be over the long run, they face much greater investment return uncertainty than can be summarized in our shorthand measure of year-to-year volatility, the standard deviation.

Academic and practitioner research does not rule out mean reversion but it hardly suggests that investors can count on mean reversion in the future, particularly for a diversified portfolio that consists of global stocks, bonds, and other assets.

To the extent there is mean reversion in investment returns, empirical analyses suggest that it is not large. Marlena Lee simulated the impact of mean reversion with a model that used historical sequences of global stock returns, thus incorporating any mean reversion that was in historical data. She concluded that this mean reversion did reduce long-run volatility, but only had a mild impact on overall simulation results.[48]

Thus, research suggests that there is mixed evidence for mean reversion, and that it is not likely to have a major impact on investment volatility. Because it takes decades to accumulate sufficient returns to observe patterns over time, this question is unlikely to be answered more definitively anytime soon.

Risk taking has a cost – that's why insuring against shortfalls is so expensive – a cost that grows with time

Finally, economist Zvi Bodie offered evidence against mean reversion based on analysis of option pricing (the cost of insuring against shortfalls in investment income). He concluded, "If it were true that stocks are less risky in the long run, then the cost of insuring against earning less than the risk-free rate of interest should decline as the length of the investment horizon increases. But the opposite is true."[49] In essence, public plans offer a guarantee against long-run market risk. The cost of these options rises as the duration of the guarantee lengthens, rather than falling as mean reversion would suggest.[50]

Will public pension funds outperform other investors? Historically they have not.

While it is attractive to think that public pension funds might be better investors than their private sector peers, that is not what history and research shows. Several recent studies show that U.S. public pension funds have earned lower returns in public equities (e.g., stocks) than other investors, and that they have also underperformed in private equity and real estate.[51] Recent research concluded that U.S. public pension funds underperform other pension funds by 34 to 58 basis points annually and that this is related to their allocation to risky assets, with the underperformance greater for the more mature public pension funds.[52] Although public pension funds have not outperformed other investors, some evidence suggests that they have taken more risk than is needed for their expected rates of return.[53] ■

The second part of this article will appear in the next issue of In The Public Interest *which will be published in early 2018.*

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ENDNOTES

1 Donald J. Boyd and Yimeng Yin, "Public Pension Funding Practices: How These Practices Can Lead to Significant Underfunding or Significant Contribution Increases When Plans Invest in Risky Assets" (The Nelson A. Rockefeller Institute of Government, June 2016), *http://www.rockinst.org/pdf/government_finance/2016-06-02-Pension_Funding_Practices.pdf*.

2 Paul Zorn, "Surveys of State and Local Government Employee Retirement Systems," Government Finance Review 9, no. 4 (August 1993), *https://www.questia.com/magazine/w1G1-14379961/surveys-of-state-and-local-government-employee-retirement*.

3 Federal Reserve Bank of St. Louis, "FRED - Federal Reserve Economic Data," *FRED Economic Data*, n.d., *https://fred.stlouisfed.org/*. Variable DGS10, average for the one-year period ending on June 30.

4 The declines reflect among other things, declines in inflation and inflation expectations, and changes in real economic growth and expectations for growth. For discussion of the declines in interest rates, see Charles Bean et al., *Low for Long? Causes and Consequences of Persistently Low Interest Rates*, Geneva Reports on the World Economy 17 (London: CEPR Press, 2015); Council of Economic Advisors, "Long-Term Interest Rates: A Survey" (Council of Economic Advisors, July 2015), *https://www.whitehouse.gov/sites/default/files/docs/interest_rate_report_final_v2.pdf.*; and Ben S. Bernanke, "Why Are Interest Rates so Low?," *Brookings Institution*, March 30, 2015, *https://www.brookings.edu/blog/ben-bernanke/2015/03/30/why-are-interest-rates-so-low/*.

5 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) 2001-2015 values are the unweighted mean of assumed returns, computed by the authors from Public Plans Data. 2001-2015. 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/*); and (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*. Data on assumed investment returns for 2016 are not yet available on a comprehensive basis.

6 The private U.S. plan rates are liability discount rates as reported in Aleksandar Andonov, Rob Bauer, and Martijn Cremers, "Pension Fund Asset Allocation and Liability Discount Rates," Available at SSRN 2070054, March 2016, *http://papers.ssrn.com/sol3/Papers.cfm?abstract_id=2070054*. These can differ from earnings assumptions but generally move similarly. We are unaware of a source for private pension fund earnings assumptions.

7 See, among other sources, The Pew Charitable Trusts and the Laura and John Arnold Foundation, "State Public Pension Investments Shift Over Past 30 Years" (The Pew Charitable Trusts and the Laura and John Arnold Foundation, June 2014), *http://www.pewtrusts.org/~/media/Assets/2014/06/PensionInvestments06032014.pdf*.

8 United States Government Accountability Office, "State and Local Government Pension Plans: Governance Practices and Long-Term Investment Strategies Have Evolved Gradually as Plans Take on Increased Investment Risk" (United States Government Accountability Office, August 2010), *http://www.gao.gov/assets/310/308867.pdf*.

9 The source is the Financial Accounts of the United States from the Federal Reserve Board. 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 treat as equity-like investments the following: (1) cash and short-term assets such as time deposits, money market funds, checkable deposits, and repurchase agreements, (2) debt securities, and (3) mortgage loans, although some securities in the latter two categories clearly can be risky.

10 There are other important ways of measuring and evaluating risk, but the standard deviation is widely used, widely understood, and generally very useful. For a discussion of an approach to thinking about risk that attempts to limit large losses, see Ranji Nagaswami, "The Road Ahead: Rethinking the Investment Policy Roadmap," *Rotman International Journal of Pension Management 5*, no. 1 (2012): 42, *http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2061693*.

11 This assumes that investment returns are normally distributed. While much research examines ways in which investment returns deviate from normality, normality often is a good first approximation.

12 This is what we would expect to happen over a sufficiently long time period, if our 8 percent and 12 percent assumptions are correct. Actual outcomes could be very different, over shorter time periods.

13 And this may be optimistic. A recent analysis by Callan Associates, reported on in the Wall Street Journal, suggested that a portfolio with an expected compound return of 7.5 percent would have a standard deviation of about 17.2 percent. See Jay Kloepfer and Julia Moriarty, "Risky Business" (Callan Institute, September 2016).

14 Andrew G. Biggs, "The Multiplying Risks of Public Employee Pensions to State and Local Government Budgets," Economic Perspectives (American Enterprise Institute, December 2013), *http://www.aei.org/files/2013/12/18/-the-multiplying-risks-of-public-employee-pensions-to-state-and-local-government-budgets_142010313690.pdf*.

15 For the argument, see National Conference on Public Employee Retirement Systems, "Are State and Local Pension Funds Taking More Risk Now Than Before?," Research Series (National Conference on Public Employee Retirement Systems, March 2016), *http://www.ncpers.org/files/NCPERS%20Research%20Series_2016_Risk%20Calculations.pdf*.; for a convincing dissection of the argument see Andrew G. Biggs, "Public Employee Pensions Aren't Taking More Investment Risk? You're Kidding Me," *Forbes*, March 11, 2016, *http://www.forbes.com/sites/andrewbiggs/2016/03/11/public-employee-pension-arent-taking-more-investment-risk-youre-kidding-me/#6fc8f3df11c3*.

16 This analysis is similar to and an elaboration on a discussion in Andrew G. Biggs, "The Public Pension Quadrilemma: The Intersection of Investment Risk and Contribution Risk," *The Journal of Retirement*, Summer 2014.

17 Taxes are not the only revenue source available for state and local governments to pay pension contributions. Some contributions may be supported in part by fees, or even in part by revenue from the federal government. However, based on our experience with state and local government finances we do not believe these other sources play a significant role and we don't believe including them would alter the trend over time. In addition, state and local governments could devise other revenue sources, so another useful measure of capacity to pay is gross domestic product. When GDP is the denominator, the trends over time are virtually identical to those shown in the table.

18 The 1 in 6 statement assumes normally distributed investment returns.

19 Authors' analysis of U.S. Census Bureau, 2013 Annual Surveys of State and Local Government Finances.

20 Based on 30-year amortization as a level percentage of pay. We ignore asset smoothing for purposes of the example. Assumes a shortfall of $426.5 billion, an 8 percent interest rate, and a 3.5 percent annual growth rate in payments.

21 Based on authors' analysis of data from U.S. Bureau of the Census, Annual Surveys of State and Local Government Finances, 2013 (*http://www.census.gov/govs/local/*). Assumes shortfall would be amortized over 30 years as a level percentage of payroll, with annual payroll growth of 3 percent.

22 United States Government Accountability Office, "Pension Plan Valuation: Views on Using Multiple Measures to Offer a More Complete Financial Picture," Report to the Chairman, Committee on Health, Education, Labor, and Pensions, United States Senate (United States Government Accountability Office, September 2014).

23 See for example 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. George Pennacchi and Mahdi Rastad, "Portfolio Allocation for Public Pension Funds," *Journal of Pension Economics and Finance* 10, no. 2 (2011): 221–45, doi:10.1017/S1474747211000102.

24 Josh Barbanel, "Pension Shift For Teachers Is Questioned," *The New York Times*, October 11, 1990, sec. N.Y. / Region, *http://www.nytimes.com/1990/10/11/nyregion/pension-shift-for-teachers-is-questioned.html*. Also see Felix G. Rohatyn, "Felix G. Rohatyn, Chairperson, Municipal Assistance Corporation for the City of New York to Members of the New York State Financial Control Board and the Speaker of the City Council," October 17, 1990.

25 Constructed from NIPA Table 7.24. More detailed citation to come.

26 In several ways these numbers understate what it would take to reduce risk: they are based on estimates, assume no payments to reduce unfunded liabilities, and they were calculated by the U.S. Bureau of Economic Analysis using a discount rate based upon high-quality corporate bond rate that is considerably higher than risk free rates.

27 Based on authors' analysis of data from U.S. Bureau of the Census, Annual Surveys of State and Local Government Finances, 2013 (*http://www.census.gov/govs/local/*).

28 Yvette Shields, "Illinois Teachers Fund Weighs Its Investment Assumption," *The Bond Buyer*, August 24, 2016, *http://www.bondbuyer.com/news/regionalnews/illinois-teachers-fund-weighs-its-investment-assumption-1111872-1.html*.

29 Kim Geiger, "Rauner Loses $400 Million Vote on Teacher Pension Fund Issue," *Chicago Tribune*, August 26, 2016, *http://www.chicagotribune.com/news/local/politics/ct-bruce-rauner-teacher-pensions-vote-met-0827-20160826-story.html*.

30 Andonov, Bauer, and Cremers, "Pension Fund Asset Allocation and Liability Discount Rates."

31 They defined risky assets as public equities, alternative assets, and risky fixed income such as high yield bonds.

32 For example, see Andonov, Bauer, and Cremers, "Pension Fund Asset Allocation and Liability Discount Rates.". 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.

33 For concise review of important academic research on the appropriateness of equity investing by public pension funds, see Alicia H. Munnell, *State and Local Pensions: What Now?*, 1st ed. (Brookings Institution Press, 2012), 65–67. and Jeffrey R. Brown, Robert L. Clark, and Joshua D. Rauh, "The Economics of State and Local Pensions," *Journal of Pension Economics and Finance* 10, no. 2 (2011): 165–66, doi:10.1017/S1474747211000138. Brown et al. 2011, pp.165-166

34 Lawrence N. Bader and Jeremy Gold, "The Case Against Stock in Public Pension Funds," Working Paper (Pension Research Council, 2004), *http://www.pensionresearchcouncil.org/publications/document.php?file=31&download=1*. Deborah J Lucas and Stephen P. Zeldes, "How Should Public Pension Plans Invest?," *American Economic Review* 99, no. 2 (April 2009): 527–32, doi:10.1257/aer.99.2.527. Pennacchi and Rastad, "Portfolio Allocation for Public Pension Funds."

35 For a more formal description of this, see Lucas and Zeldes, "How Should Public Pension Plans Invest?"

36 In addition, some taxpayers – especially renters – may be able to move to avoid the consequences of risks that turn out poorly. Homeowners may find that large pension fund investment shortfalls lower the value of their homes, as potential purchasers anticipate higher taxes in the future to repay investment shortfalls.

37 For most plans, annual benefit payments exceed annual contributions, and have negative cash flow before considering investment returns, which makes negative investment returns very painful. And it could, in come circumstances lead to liquidity difficulties.

38 For a more-formal discussion, see Zvi Bodie, "On the Risk of Stocks in the Long Run," *Financial Analysts Journal*, no. May-June 1995 (1995): 18–22, *http://papers.ssrn.com/sol3/papers.cfm?abstract_id=5771*.

39 For simplicity, in the top panel we show the expected long-run return as the red line. This is NOT the same as the expected compound return in each year. In the first year, the expected compound return would be the same as the expected arithmetic return, which is about 8.2 percent when the standard deviation is 12 percent. Over time the expected compound return falls due to what is sometimes known as volatility drag, and the eventual long-run expected compound return is 7.5 percent. The red line is this long-run expected compound return.

40 David Wilcox, "Comment to the Actuarial Standards Board on Proposed ASOP 27: Selection of Economic Assumptions for Measuring Pension Obligations," August 19, 2008, *http://host actuarialstandardsboard.org/wp-content/uploads/2014/06/comment_31.pdf*. Dr. Wilcox noted in his comments that his views were his own and do not necessarily reflect views of the Federal Reserve Board.

41 Tom Tulloch, Email conversation between Kathleen Tempel, Rockefeller Institute of Government, and Tom Tulloch, North American Association of State & Provincial Lotteries, August 2015. We are aware of a proposal in New York that would have allowed investment in stocks: "NY State Lottery Considers An Investment Gamble: Gothamist," February 10, 2009, *http://gothamist.com/2009/02/10/ny_state_lottery_considers_an_inves.php*.

42 James M. Poterba and Lawrence H. Summers, "Mean Reversion in Stock Prices: Evidence and Implications," *Journal of Financial Economics* 22, no. 1 (1988): 27–59; Eugene F. Fama and Kenneth R. French, "Permanent and Temporary Components of Stock Prices," *Journal of Political Economy* 96, no. 2 (1988): 246–73.

43 Jeremy J. Siegel, *Stocks for the Long Run* (New York, NY: McGraw Hill, 2008).

44 Paula Hogan, "The Great Debate: Interview with Jeremy Siegel and Zvi Bodie, The National Association of Personal Financial Advisors NAPFA 2004 National Conference, Toronto, Canada" (The National Association of Personal Financial Advisors, April 23, 2004).

45 Philippe Jorion, "The Long-Term Risks of Global Stock Markets," Working Paper (Graduate School of Management, University of California at Irvine, 2003).

46 "Credit Suisse Global Investment Returns Yearbook 2013," n.d., *http://www.investmenteurope.net/digital_assets/6305/2013_yearbook_final_web.pdf*.

47 Lubos Pástor and Robert F. Stambaugh, "Are Stocks Really Less Volatile in the Long Run?," *The Journal of Finance* 67, no. 2 (2012): 431–478, *http://onlinelibrary.wiley.com/doi/10.1111/j.1540-6261.2012.01722.x/full*.

48 Marlena I. Lee, "Stress Testing Monte Carlo Assumptions," *Pension Research Council WP* 25 (2013), *http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2337179*.

49 Zvi Bodie, "On the Risk of Stocks in the Long Run."

50 See Andrew G. Biggs, "An Options Pricing Method for Calculating the Market Price of Public Sector Pension Liabilities," *Public Budgeting & Finance* 31, no. 3 (2011): 94–118.

51 Amit Goyal and Sunil Wahal, "The Selection and Termination of Investment Management Firms by Plan Sponsors," *The Journal of Finance* 63, no. 4 (2008): 1805–1847, *http://onlinelibrary.wiley.com/doi/10.1111/j.1540-6261.2008.01375.x/full*. Yael V. Hochberg and Joshua D. Rauh, "Local Overweighting and Underperformance: Evidence from Limited Partner Private Equity Investments," *Review of Financial Studies* 26, no. 2 (2013): 403–451, *http://rfs.oxfordjournals.org/content/26/2/403.short*.

52 Andonov, Bauer, and Cremers, "Pension Fund Asset Allocation and Liability Discount Rates."

53 Odd J. Stalebrink, Kenneth A. Kriz, and Weiyu Guo, "Prudent Public Sector Investing and Modern Portfolio Theory: An Examination of Public Sector Defined Benefit Pension Plans," *Public Budgeting & Finance* 30, no. 4 (Winter 2010): 28–46, doi:10.1111/j.1540-5850.2010.00967.x. This paper compared actual asset allocations of large public pension funds to allocations that the authors estimated could achieve the same targeted returns at minimum risk – i.e., efficient allocations. The public plan portfolios generally required much greater risk than the efficient portfolios, which generally allocated 50-60 percent of assets to real estate and hedge funds,