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PENSION SIMULATION PROJECT

Investment Return Volatility and the Pennsylvania Public School Employees' Retirement System

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Executive Summary

Public pension funds invest in stocks, bonds, and other assets with the goal of accumulating sufficient funds, in combination with employer and employee contributions, to pay benefits when due. Investments can entail risk, and contributions may be increased (or decreased) to ensure that assets are sufficient to pay benefits.

When a pension fund invests in a portfolio of assets that entails higher risk, expected investment returns generally will be higher and contributions lower than for a portfolio of lower-risk assets. Expected returns, however, are not guaranteed returns, neither in the short or (even) long term.

In this report, we examine the potential implications of investment return volatility for the Pennsylvania Public School Employees' Retirement System (PSERS). We selected PSERS as one of five plans to analyze in detail in our Public Pension Simulation Project. The five plans have a broad range of characteristics. PSERS is a deeply underfunded plan by public pension plan standards, with a market-value funded ratio of 50 percent at the end of the 2016 fiscal year. PSERS uses a relatively conservative amortization method to repay the unfunded liability, and has an uncommon approach to funding under which some employees, under some circumstances, share partially in the plan's investment risk. A recently passed pension reform bill will introduce a defined contribution (DC) component to the traditional defined benefit (DB) plan in PSERS.

We draw several conclusions from our analysis:

- If assumed investment returns are achieved each and every year, PSERS will move toward full funding with contribution amounts as expected.
- If assumed returns are correct on average over the long run, but have a 12 percent standard deviation, then under current funding policy:
    - There is a 26 percent chance that the *funded ratio* of PSERS will fall below 40 percent — what we consider to be crisis territory — sometime between now and year thirty.
    - There is a 6.4 percent probability that *employer contributions* will increase by more than 10 percent of payroll within a consecutive five-year period sometime in the next thirty years. The low risk of sharp increases in employer contribution is partly attributable to PSERS' relatively long ten-year asset smoothing period.
    - The relatively conservative amortization method used by PSERS — twenty-four-year level-percent closed amortization — coupled with full payment of the actuarially determined contribution are crucial to ensuring the funding security of PSERS.
- PSERS' funding policy includes a 4.5-percentage-point cap on the annual growth in the employer contribution rate. In all three investment return scenarios we examined, the cap would rarely be triggered and therefore the cap is likely to have very little impact on the finances of PSERS.
- The impact of the current shared-risk employee contribution rate on the stability of the employer contribution rate is small. In order for the shared-risk mechanism

to have a meaningful impact on the employer contribution risk, PSERS might need to make the employee contribution rate more responsive to the recent history of investment returns and allow the employee contribution rate to vary in a larger range.

- A hybrid plan that includes a defined benefit (DB) component and a defined contribution (DC) component can reduce the employer contribution risk substantially for employees in the hybrid plan. For example, a hybrid plan that provides a DB component one-half as large as the current pure DB plan and supplements it with a DC component can lower employer contribution risk by roughly one-half. This proportional relationship between reduced employee DB benefit and reduced employer cost risk will hold generally, not just in PSERS, as long as certain other aspects of the plan are adjusted similarly. Although the percentage reduction in employer risk is large for affected employees, because hybrid plans usually apply primarily to new hires, as is the case with PSERS, it will be many years before it has a substantial impact on plan and employer finances.
- Finally, the reduction in employer cost uncertainty from a hybrid plan is accompanied by benefit uncertainty for employees. Substantially higher employer contributions would be needed to ensure that a hybrid plan is very likely to provide benefits under most investment scenarios that are at least as large as those guaranteed by the DB plan.

Our findings for PSERS illustrate the wide range of challenges and potential solutions that public pension funds and their governmental sponsors face. In contrast to other funds we have modeled (see www.rockinst.org/government_finance/pension.aspx for other pension reports), PSERS is deeply underfunded and faces greater challenges. The state's recent move to pay full actuarially determined contributions, coupled with PSERS' conservative funding policy, mean that PSERS is on a path to full funding within a little more than two decades, if the state continues to pay full contributions and if investment performance is about as good as the plan assumes. Contributions will be high over those two decades as the state pays down current unfunded liabilities. As with other plans we have modeled, contributions could rise or fall substantially depending upon investment performance. Unlike other plans we have modeled, contribution risks for employers will diminish over the long term as more workers participate in the recently enacted hybrid plans and thereby share a greater portion of the plan's investment risk.

Introduction

Public pension funds invest in stocks, bonds, and other assets with the goal of accumulating sufficient funds, in combination with employer and employee contributions, to pay benefits when due. Investments can entail risk, and contributions may be increased (or decreased) to ensure that assets are sufficient to pay benefits.

When a pension fund invests in a portfolio of assets that entail higher risk, expected investment returns generally will be higher and contributions lower than for a portfolio of lower-risk assets. The disadvantage is that expected returns are not guaranteed returns, neither over short time periods nor even over the long run.

Depending on how volatile investment returns are, a plan's funded ratio — the ratio of pension fund assets to pension fund liabilities — may rise or fall significantly, and required contributions may fall or rise considerably. The extent and timing of these changes will depend in part upon methods used to determine contributions. If adverse movements in investment returns are too large, funded ratios could become so low that they create political crises, which, in some states, may lead to pressure to cut benefits. Adverse movements could cause requested contributions to increase so much that they create fiscal stress for government employers, leading to pressure for substantial increases in taxes or other revenue, cuts in spending, or other undesirable outcomes. Alternatively, investment returns above expectations could lead to very high funded ratios and very low required contributions.

How much risk is too much risk? There is no magic rule, although academic research provides useful insights.[1] Plans, employers, and other stakeholders need to weigh the potential risks and rewards. The key to making these decisions is to understand risks, evaluate risks, and communicate that analysis to those affected.

In this report, we examine the potential implications of investment return volatility for the Pennsylvania Public School Employees' Retirement System (PSERS). We selected PSERS as one of five representative plans to analyze in detail in our Public Pension Simulation Project. The five plans have a broad range of characteristics. PSERS is a deeply underfunded plan by public pension plan standards, with a market-value funded ratio of 50.0 percent at the end of the 2016 fiscal year. PSERS has an uncommon approach to funding under which some employees share partially in the plan's investment risk, in certain circumstances. The other plans, which we examine in separate analyses, include a very well-funded plan, an average plan, a closed plan, and a public safety plan.[2]

Risks can be positive or negative, and we examine both in this report. However, we pay particular attention to the consequences of investment return shortfalls because shortfalls can be extremely problematic for pension plans, beneficiaries, policymakers, and government stakeholders.

To evaluate risks, we focus on risks to the plan measured by the market-value funded ratio, and risks to the employer measured by employer contributions as a percentage of payroll or budget. We examine the probability that the funded ratio or employer contributions may change considerably over time or enter into what we consider to be crisis territory. We analyze PSERS finances under the current funding policy and practice, as well as several alternatives, and we explore different investment return scenarios. We also examine the potential impact of introducing a defined

contribution (DC) component into a traditional defined benefit (DB) plan, which we believe will provide useful insights for the recently enacted DB-DC hybrid plan reform in Pennsylvania.

About the Public School Employees' Retirement System of Pennsylvania[3]

Key Features of PSERS

The Public School Employees' Retirement System of Pennsylvania (PSERS) is a defined benefit retirement plan for public school employees of the Commonwealth of Pennsylvania. The state and individual school districts participate in PSERS. In addition to the pension plan, PSERS also provides voluntary post-employment health care benefits, which we exclude from our analysis — references to PSERS in this report pertain only to the pension plan.

As of June 30, 2016, PSERS had over 257,000 active members and approximately 225,000 retirees and other beneficiaries who receive over $476 million in pension and health care benefits each month. PSERS had $50.0 billion in assets. Its market-value-of-assets funded ratio was 50.0 percent — about the 25th percentile among large public pension plans.[4] Its unfunded liability based on market value of assets was $50.1 billion.

Benefits generally are calculated based on the annual average of the highest three years of compensation. The normal retirement benefit equals 2.5 percent (for members hired before July 1, 2011) or 2 percent (for members hired on or after July 1, 2011) of the final average compensation multiplied by the member's years of employment. The overall PSERS normal cost — the cost of benefit accruals attributed to each new year of service for covered employees — was 15.24 percent of total payroll in 2016.

Act 120 of 2010 Pension Reform

On November 23, 2010, Governor Ed Rendell signed HB 2497 into law, which is now known as Act 120 of 2010. This Act preserves the benefits of existing members (Class T-C and Class T-D) and includes a series of actuarial and funding changes to PSERS and benefit reductions for individuals who become new members of PSERS after July 1, 2011, which are summarized below:

- The act created two new membership classes, T-E and T-F. The annual costs of benefits of T-E and T-F members are less than the costs for pre-Act 120 members.
- Class T-E and Class T-F members share some of the investment risk of PSERS, potentially paying lower contributions when investments do well and paying higher contributions when investments underperform, within certain limitations. (The provisions of the shared-risk employee contribution rate were modified slightly by a pension reform bill recently passed in Pennsylvania.[5])
    - Base employee contribution rates are 7.5 percent of payroll for Class T-E members and 10.3 percent for Class T-F members.
    - Every three years the fund compares prior investment performance to assumed performance. If the investment rate of return (less investment fees)

is 1.0 percent or more above the assumed rate of return based on the prior ten-year period, the member contribution rate for Class T-E and Class T-F will decrease by 0.5 percent. If the investment rate of return (less investment fees) during the prior ten-year period is 1.0 percent or more below the assumed rate of return, the member contribution rate will increase by 0.5 percent. The member contribution cannot fall 2 percentage points below the base rate, and cannot be raised more than 2 percentage points above the base rate. If the retirement system is fully funded and the shared-risk employee contribution rate is greater than the base rate at the time of the comparison, the member contribution rate reverts to the base rate.

- Act 120 mandated that the outstanding balance of the unfunded accrued liability as of June 30, 2010, including changes in the unfunded accrued liability due to the funding reforms of Act 120, be amortized over a twenty-four-year period as a level percent of pay, beginning July 1, 2011.
- To address the employer contribution rate spike caused by the amortization payments for the 2010 unfunded liability, Act 120 imposed lower and upper limits on the rate at which employer contributions may rise from year to year, known as "collars." The employer contribution rate cannot increase by more than 4.5 percentage points of payroll relative to the prior year's final contribution rate.[6] If the actuarially determined contribution rate falls below the upper-limit rate, the final contribution rate is the actuarially determined contribution rate so long as it does not fall below the employer normal contribution rate.

Act 5 of 2017 Pension Reform

In June 2017, Pennsylvania Governor Tom Wolf signed into law Act 2017-5, which will change the retirement benefit structure available to new state employees. New members of PSERS hired on or after July 1, 2019, will be offered three options for retirement benefits: two hybrid benefit options that include a defined contribution (DC) component in addition to a defined benefit component, and a pure defined contribution option. This pension overhaul is intended to shift part of the funding risk, which is almost entirely borne by the state and school districts under the current pure DB plan structure (save for the shared-risk provisions, which have a relatively small impact as examined below), to new employees.

Funding Approach

To fund the plan, the independent actuary determines a recommended employer contribution. This contribution is an actuarially determined amount calculated using the following method and funding policies:

- PSERS uses the Entry Age Normal actuarial cost method, a widely used method.
- The employee contribution rate for Pre-Act 120 members is 7.5 percent. Class T-E and T-F members are subject to the "shared-risk" employee contribution rate. Base contribution rates for T-E and T-F members are 7.5 percent and 10.3 percent, respectively.
- Actuarial gains and losses are amortized over a twenty-four-year period as a level percent of payroll.

- Asset values are smoothed over ten years.

The actuarially determined contribution is a recommended amount and the contribution actually paid could differ from it. During 2006 through 2010, the employer contribution as a percentage of the actuarially determined contribution ranged from 27 percent to 41 percent.

Starting from 2011, actual employer contributions have been capped by the Act 120 employer contribution growth collar. The actual employer contribution as a percentage of the actuarially determined contribution rose from 27 percent in 2011 to 69 percent in 2015. For fiscal year 2016-17, PSERS received 100 percent of actuarially required contributions for the first time in fifteen years. This marks a significant milestone in PSERS' contribution history and establishes a path to full funding.

Investment Return Assumption

PSERS currently uses a 7.25 percent earnings assumption. As of June 30, 2016, approximately 21.8 percent of assets were in equity, 25.3 percent in collective trust funds, 8.4 in fixed income, and the remainder in other asset classes including real estate and private equity. As of June 30, 2016, the one-year, three-year, five-year, and ten-year annualized rates of return were 1.29 percent, 6.24 percent, 6.01 percent, and 4.94 percent, respectively.

How We Modeled the Finances of PSERS

Our Pension Simulation Model

We have developed a simulation model that can be used to evaluate the implications of investment risk to public pension funds. The model calculates the annual cash flows, fiscal position, and covered payroll of a public pension plan for future years. Typically, we run a simulation for fifty years or more but focus our analysis on the earlier years. Each year the model starts with beginning asset values and computes ending assets by subtracting benefits paid, adding employee and employer contributions (including any amortization), and adding investment income, which we calculate in the model.

The model keeps track of these values and other variables of interest, such as the funded ratio and employer contributions as a percentage of payroll. It saves all results so that they can be analyzed after a simulation run in any way desired.

Investment returns in this model are determined flexibly, and can be:

- **Deterministic:** for example, 7.25 percent every year.
- **Stochastic:** for example, 7.25 percent expected return in every year, with a 12 percent standard deviation, drawn from a normal distribution. ("Stochastic" means that returns are random and follow a specific distribution.)

When investment returns for a scenario have a stochastic component we run 2,000 simulations, each with a different set of annual investment returns (drawn from the same assumed probability distribution), so that we can examine the distribution of results. (See the Appendix, "Illustration of Possible Investment Returns in a Stochastic Scenario" for an example.) Each simulation results in different investment earnings, leading to different funded ratios and contribution requirements. By examining the 2,000

different sets of results we can gain insight into the probability of alternative outcomes. (See the box, "Deterministic Versus Stochastic Models" for a more detailed discussion on the advantages of the stochastic approach.) For example, we examine the probability that the funded ratio will fall below 40 percent anytime during the first thirty years — a level that has been associated with crisis in other states.

Modeling the Finances of PSERS

We use our pension simulation model to generate projections of covered payroll, annual benefit payments, and actuarial liabilities of PSERS. We assume that enough new employees are hired each year to keep the size of the covered workforce constant over time.[7] Actuarial liabilities, annual benefits, and payroll vary from year to year, but do not vary across simulations in a single scenario. These projections are based on the demographic data, decrement tables, benefit provisions, and actuarial assumptions provided in the PSERS actuarial valuation report of 2016. The projections do not incorporate the hybrid DB-DC plans established by Act 2017-5, but they do include the Act's modifications to the shared-risk employee contribution rates (see the descriptions under "Funding Approach" above). We analyze the impact of introducing a DC component into a DB plan separately below (see "How Would Transitioning to a DB-DC Hybrid Pension Plan Affect the Funding Risks of PSERS?").

Employer contributions are determined as follows:

- The model calculates the actuarially determined contribution using the current PSERS policy: actuarial losses and gains are amortized over twenty-four years using level-percent repayment. Asset values are smoothed over ten years.
- When the total actuarially determined contribution is greater than the employee contribution, the employer contribution is equal to the difference between them.
- When the total actuarially determined contribution is smaller than the employee contribution, the employer contribution is zero. No negative employer contribution (withdrawal from the fund) is allowed.
- The Act 120 employer contribution growth collar is then applied to the actuarially determined contribution rate to determine the final employer contribution rate.

To summarize, the employer contribution is designed to fill the gap between the employee contribution and an actuarially determined total contribution, except that (a) it cannot be negative, (b) it must be at least as great as the employer normal cost (total normal cost minus employee contribution), and (c) it cannot grow by more than 4.5 percentage points of payroll from one year to the next.

Deterministic Versus Stochastic Models

When pension systems make projections of future earnings on their investments, they generally use a deterministic approach. A deterministic approach assumes a constant rate of return that does not vary over time. Currently, PSERS assumes that investments will earn a rate of return of 7.25 percent in all future years.

An alternative method to project future investment returns is a stochastic approach. A stochastic approach specifies the mean and variance of a distribution of returns based on the profile of investments and historical experience. The method allows returns to vary randomly over time based on the specified distribution. In theory, the random draw of potential returns should provide information about the likely range of actual returns over a thirty-year (or longer) investment horizon. The method also allows analysts to identify and quantify certain types of risk.

This paper uses a stochastic approach to illustrate potential investment and funding risks for PSERS. Compared to a deterministic approach, a stochastic approach has two important features. The first and more notable feature is that earnings will vary considerably. Potential outcomes on the lower end of the distribution could greatly increase the risks of severe underfunding or fiscal stress for the state government and school districts. The stochastic approach used by this paper clearly illustrates those possible outcomes.

The second feature is less obvious, but nonetheless important for policymakers assessing the future condition of a pension system. In the deterministic approach in which returns are constant over time, the annual compound return over a period of time is always equal to the assumed annual return. For example, if a plan assumes a 7.25 percent return, and gets that return every year, its long-run compound annual return will be 7.25 percent.

But when returns vary, as they do under the stochastic approach (and in the real world), the long-run compound return is lower than the expected annual return. We can see this from a simple example: if a plan earns 10 percent in year one and 10 percent in year two, then $100 would grow to $121 at the end of year two. But if the plan earns 20 percent in year one and 0 percent in year two, also averaging 10 percent per year, it will only have $120 at the end of year two (a compound annual return of 9.5 percent). The varying returns produced a lower compound annual return than did the constant returns. In general, the longer the investing horizon and the greater the volatility, the more the compound annual return will fall below the average annual return.

For a plan to achieve a 7.25 percent compound average return it would need a higher expected annual return. According to a widely used approximation formula, an expected annual return of 7.97 percent is required to achieve an expected long-term compound return of 7.25 percent, assuming a 12 percent standard deviation for the investment return distribution. As illustrated by this paper, the median outcome under the stochastic approach and the deterministic outcome will generally be close over time, but that requires an implicit assumption of a higher average rate under the stochastic approach.

In the stochastic investment return scenario "*Assumption Achieved*" in this paper, we set the expected annual return to 7.97 percent so that, with a standard deviation of 12 percent, the expected long-term compound rate of return will be equivalent to the deterministic constant rate of 7.25 percent assumed by PSERS.

Investment Return Scenarios

To examine the potential implications of investment return volatility for PSERS, we construct the following investment return scenarios:

1. *Assumption Achieved:* We model a stochastic version of the plan's assumption, in which the expected long-term compound return is 7.25 percent — that is, the 7.25 percent return assumption is expected to be correct on average but varies from year to year and from simulation to simulation.[8] The standard deviation — a measure of how much returns vary — is 12 percent.[9,10] This is our base-case stochastic scenario against which we compare other stochastic scenarios.
2. *15 Years of Low Returns:* Expected investment returns fluctuate around an average that rises from 5 percent to 6.5 percent during the first fifteen years, then fluctuate around the plan's long-run assumption of 7.25 percent. This scenario recognizes that in the current low-inflation and low-interest-rate environment, it may be plausible for expected returns to be quite low for a long time, and then gradually rise, which makes it extremely difficult to achieve assumed returns in the short run, even if they may be achievable in later years.
3. *High Volatility:* The expected investment return is 7.25 percent, but investment return volatility is higher than in other scenarios, with a standard deviation of 17.2 percent rather than 12 percent, consistent with some current market forecasts.[11]

Table 1 shows these three simulation scenarios. The first two columns label and describe the simulation. Columns three and four show the expected compound return during subperiods of the first thirty years. The fifth column shows the expected compound return over the full thirty years and the sixth column shows the standard deviation.

Table 1. Investment Return Scenarios

	Scenario	Description	Year	Expected compound annual return for the period in question	Expected compound annual return over entire simulation period	Standard Deviation
1	**Assumption Achieved: Base Case**	Constant expected return over 30 years that meets the actuarial assumption	1-30	7.25%	7.25%	12%
2	**15 Years of Low Returns**	Starting with a relatively long period of low expected return (year 1-15)	1-10	5%	about 6.4%	12%
			11-15	6.5%		
			16-30	7.25%		
3	**High Volatilty**	High volatility reflecting current market forecasts based on market assumptions from private consulting firms	1-30	7.25%	7.25%	17.2%

Notes:
1. A deterministic simulation is run in each scenario, in which the annual investment returns are fixed and given by the column "Expected compound annual return for the period in question."
2. When expected returns are not constant over the entire simulation period (scenario 2), the approximate formula for calculating expected compound annual return is not readily available and the expected compound annual return is obtained by simulation approach (close to the mean of 50,000 simulations).
3. The thirty-year simulation period shown in this table is 2017-46. In the actual model runs, the simulations start from year 2016, which is the latest year in which the actuarial valuation report is available. A deterministic return of 7.25 percent is used in year 2016 assuming earnings assumption is achieved.

How Would Investment Return Volatility Affect the Funded Status and Employer Contributions of PSERS?

Although we extend our model for fifty years, we generally focus on the first thirty years, in the belief that this is a meaningful period for policymakers.[12] We organize our discussion of results as follows:

- We begin by discussing results for the three investment return scenarios under the current funding policy of PSERS. We compare results of alternative stochastic scenarios to that of *Scenario 1: "Assumption Achieved: Base Case*."
- Next we examine the effects of the "shared-risk" employee contribution rate and the employer-contribution-rate collar on the finances of PSERS.

Before the discussion of simulation results, we first describe the measures we use to quantify funding risks caused by investment return volatility.

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 in states in which cuts are legally permissible; and
- Extremely high contributions, or large increases in contributions in short periods of time, which pose direct risks to plan sponsors 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 and how the trade-offs operate is a function of a plan's contribution policy. 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.[13]

We use several measures to evaluate these risks. We describe the two most useful measures below.

Probability That the Funded Ratio Will Fall Below 40 Percent During the First Thirty Years

When returns are stochastic, many outcomes are possible, including 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 150 in the Public Plans Database[14] 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 seriously underfunded,

with the likelihood of either substantial tax increases, service cuts, or benefit cuts yet to come.

Probability That Employer Contributions Will Rise by More Than 10 Percent of Payroll in a Five-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 five-year period to measure this possibility. 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.

Results With the Investment Return Assumption Achieved (Scenario 1)

In *Scenario 1: "Assumption Achieved: Base Case,"* the expected long-run compound return is 7.25 percent, and returns vary from year to year with a standard deviation of 12 percent.

Impact on Plan Funding

We first show the likely range of funded ratios resulting from the 2,000 simulations under *Scenario 1*. Figure 1 shows the median funded ratio, the 25th percentile, and the 75th percentile, along with the funded ratio in the deterministic version of *Scenario 1*, in which the investment return is 7.25 percent every year. The initial funded ratio is 50.0 percent. In the deterministic run, because there are never any investment shortfalls or overages, the plan marches closer to full funding every year.

In the stochastic scenario, investment returns in any single year will be better or worse than assumed. In some simulations, returns may be worse than assumed for many years in a row. Although contribution policy is intended to put the plan back on a path toward full funding after investment shortfalls, the combination of asset smoothing, a long amortization period, and a series of bad investment returns can lead to circumstances where plan funding becomes dangerously low. By the same token, the plan can become considerably over-funded after experiencing a series of good investment returns.

Figure 1 shows that if the expected long-term compound return is equal to the assumed return of 7.25 percent during the next thirty years, in 25 percent of the simulations with relatively bad investment returns, those at the 25th percentile line or lower, the funded ratio, starting from about 50 percent in 2017, will become 74 percent *or lower* by 2046, while in another 25 percent of simulations with relatively good investment returns, those at the 75th percentile line or higher, the funded ratio will rise to 160 percent or higher. In the other 50 percent of simulations, the funded ratio in 2046 will fall between these values.[15] Improvements in the funded ratio can be partly attributed to PSERS' relatively conservative amortization policy (twenty-four-year level-percent closed amortization) for unfunded liabilities. Under a hypothetical scenario in which PSERS would use open amortization with a twenty-four-year amortization period, the median funded ratio would only rise to 67 percent after thirty years, and the 25th percentile funded ratio would fall to 45 percent.

Figure 1. When We Allow Investment Returns to Vary, the Likely Range of the Funded Ratio Is Large Even If the Long-Run Expected Return Assumption Is Correct on Average

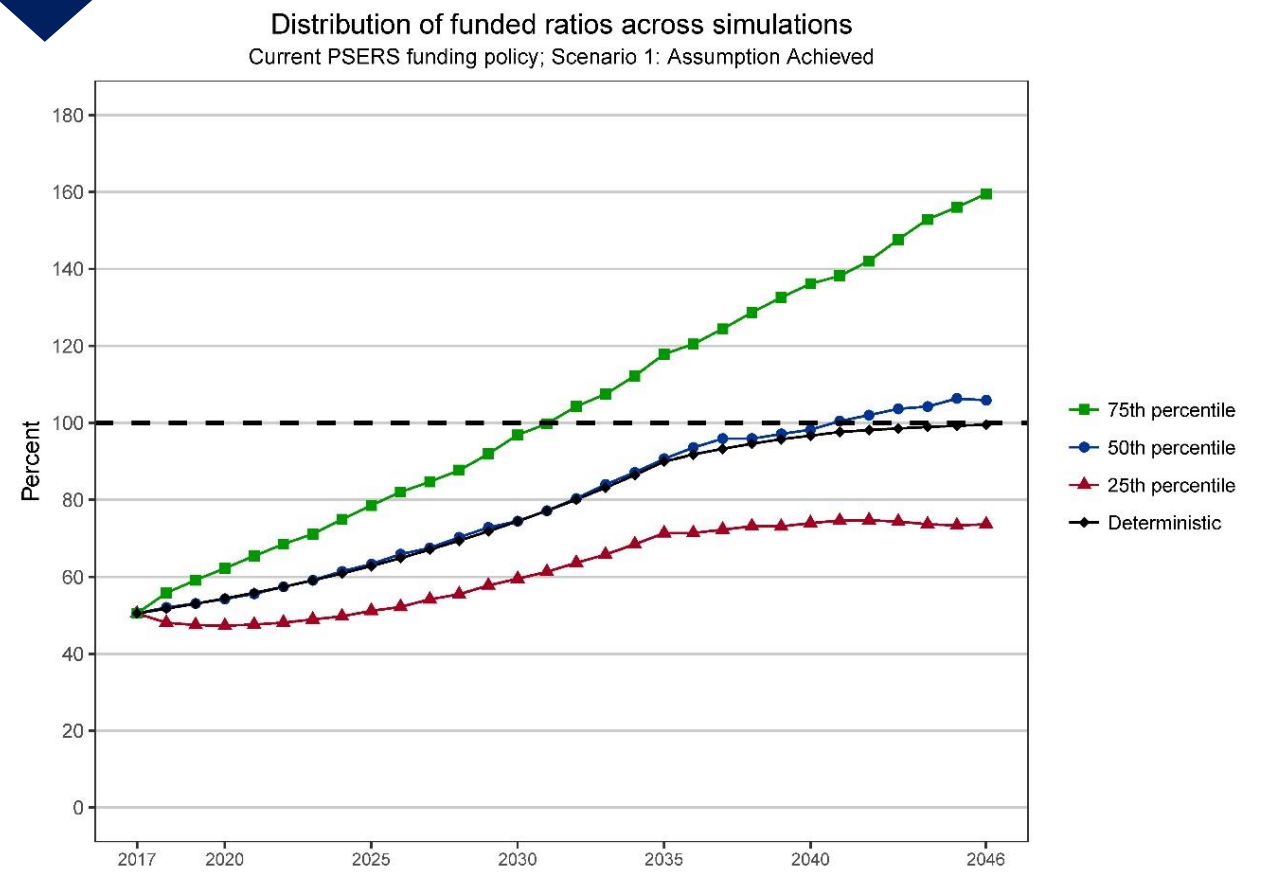
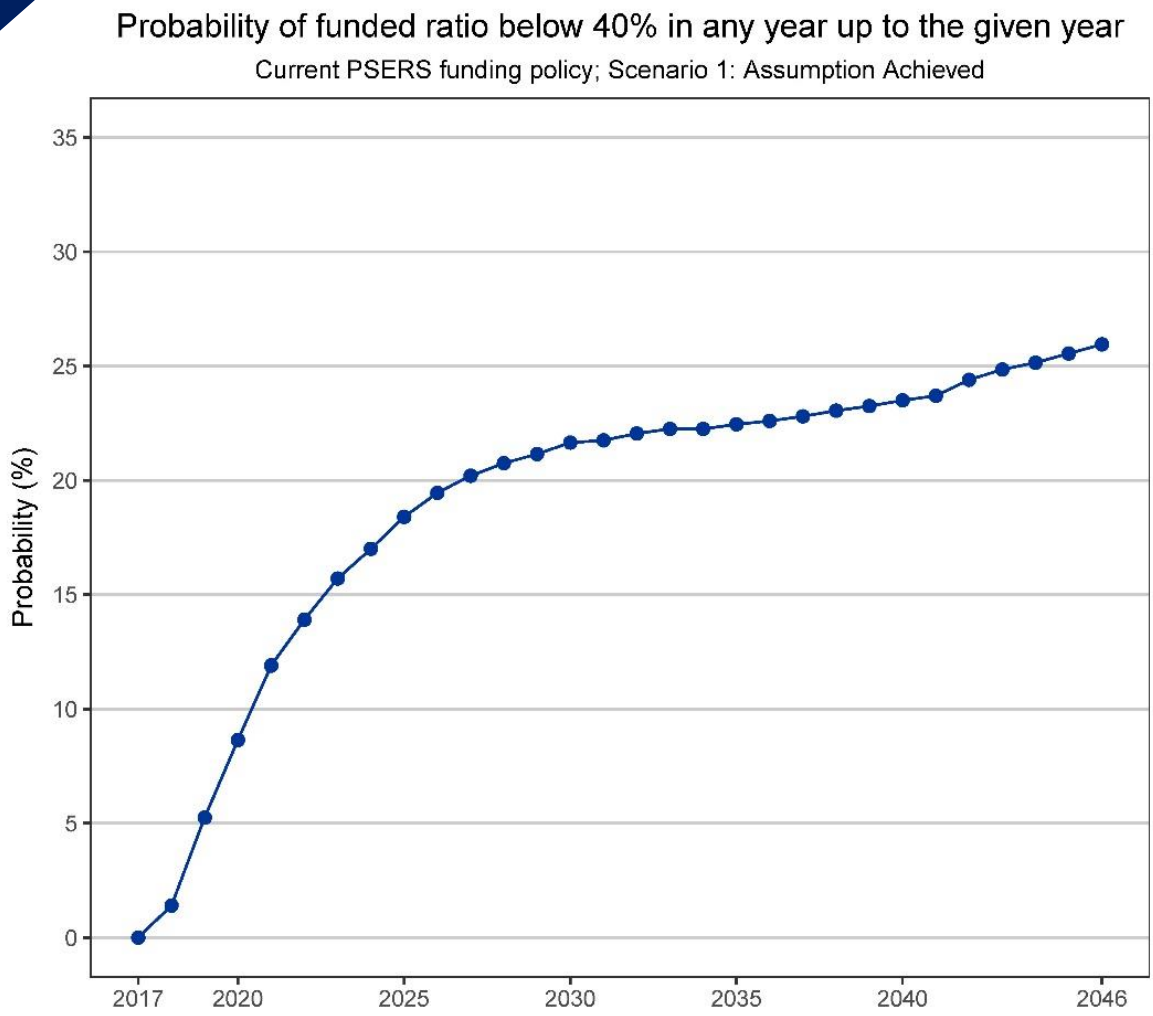


Figure 2 shows the risk of a dangerously low funded ratio under the stochastic scenario. At each year, the graph shows the probability that the funded ratio, based on the market value of assets, will have fallen below 40 percent in any year up to that point. Under *Scenario 1: "Assumption Achieved: Base Case,"* thirty years into the simulation (2046) there is a 26 percent chance that the funded ratio will have fallen below 40 percent at some point in the period. Although a 26 percent chance of becoming severely underfunded under the current funding policy is by no means low, the risk could be even higher if PSERS used a less conservative amortization method. Under the hypothetical scenario in which PSERS would use twenty-four-year open amortization, the probability that the funded ratio will fall below 40 percent at some point in the next thirty years would be 47.5 percent.

Figure 2. There Is a 26 Percent Chance That the Funded Ratio Will Fall Below 40 Percent Sometime in the Next Thirty Years Even If the Expected Return Assumption Is Correct on Average



Impact on Employer Contribution

The amortization payments for the outstanding balance of the 2010 unfunded liability will account for a significant proportion of the total employer contribution to PSERS in the next twenty years. After the 2010 unfunded liability is paid off, the employer contribution rate will drop significantly. Under *Scenario 1 "Assumption Achieved: Base Case,"* where investment returns vary from year to year, there is a 6.4 percent chance that the employer contribution rate will rise by more than 10 percent of payroll within at least one five-year period sometime in the next thirty years. The sharp increases in the employer contribution rate are mostly to occur in the next twenty years when PSERS is paying down the 2010 unfunded liability.

Figure 3 shows the median employer contribution as a percentage of payroll under the stochastic scenario, along with the 25th percentile and 75th percentile, and the employer contribution rates under the deterministic version of *Scenario 1*. The median employer contribution rate, starting at around 32 percent in 2017, gradually increases to about 36 percent in the next twenty years, and then drops drastically after the 2010

unfunded liability is paid off, reaching around 4 percent of payroll in 2046.[16] The 25th percentile for employer contribution rates, which represents simulations with relatively good investment returns, falls to about 25 percent in twenty years, then drops further to about 4 percent in 2046. In a quarter of the simulations that have relatively bad investment returns, those at the 75th percentile line or above, the employer contribution will rise to 44 percent in the next twenty years and will be still around 16 percent after a significant drop.

Figure 3. Employer Contribution Will Drop Substantially After the 2010 Unfunded Liability Is Paid Off in 2034

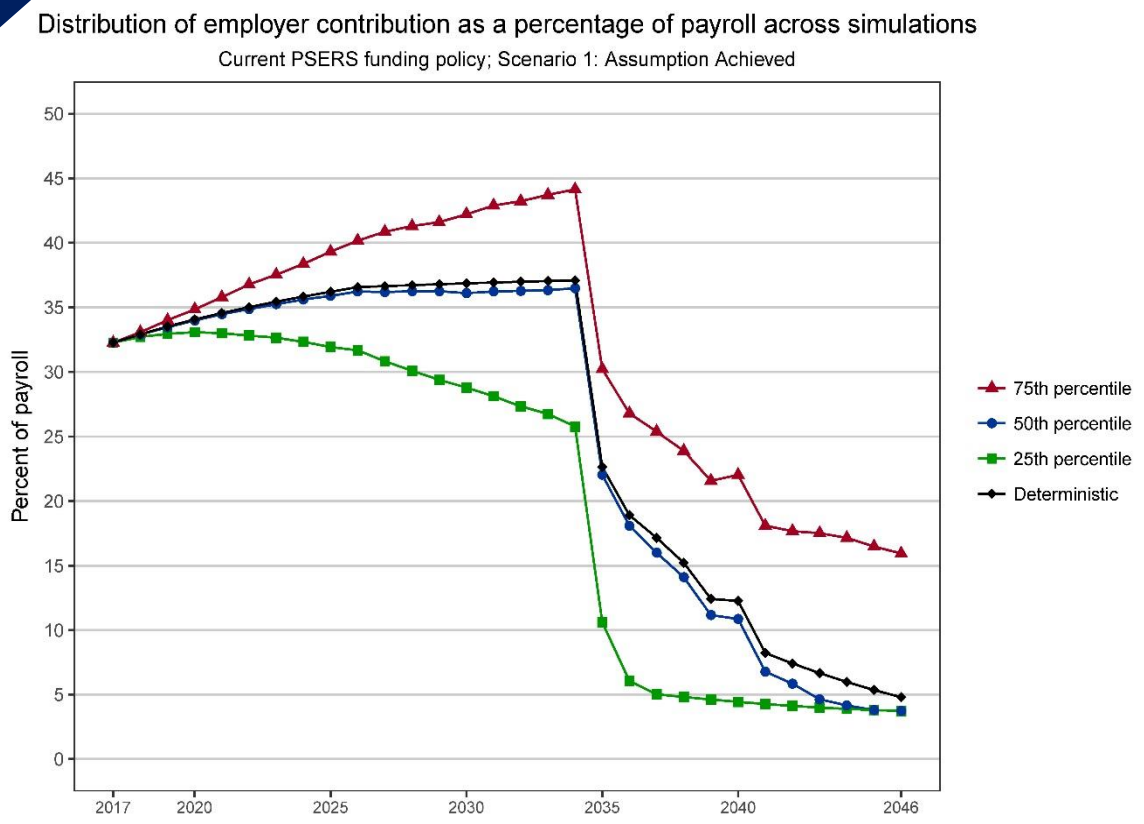
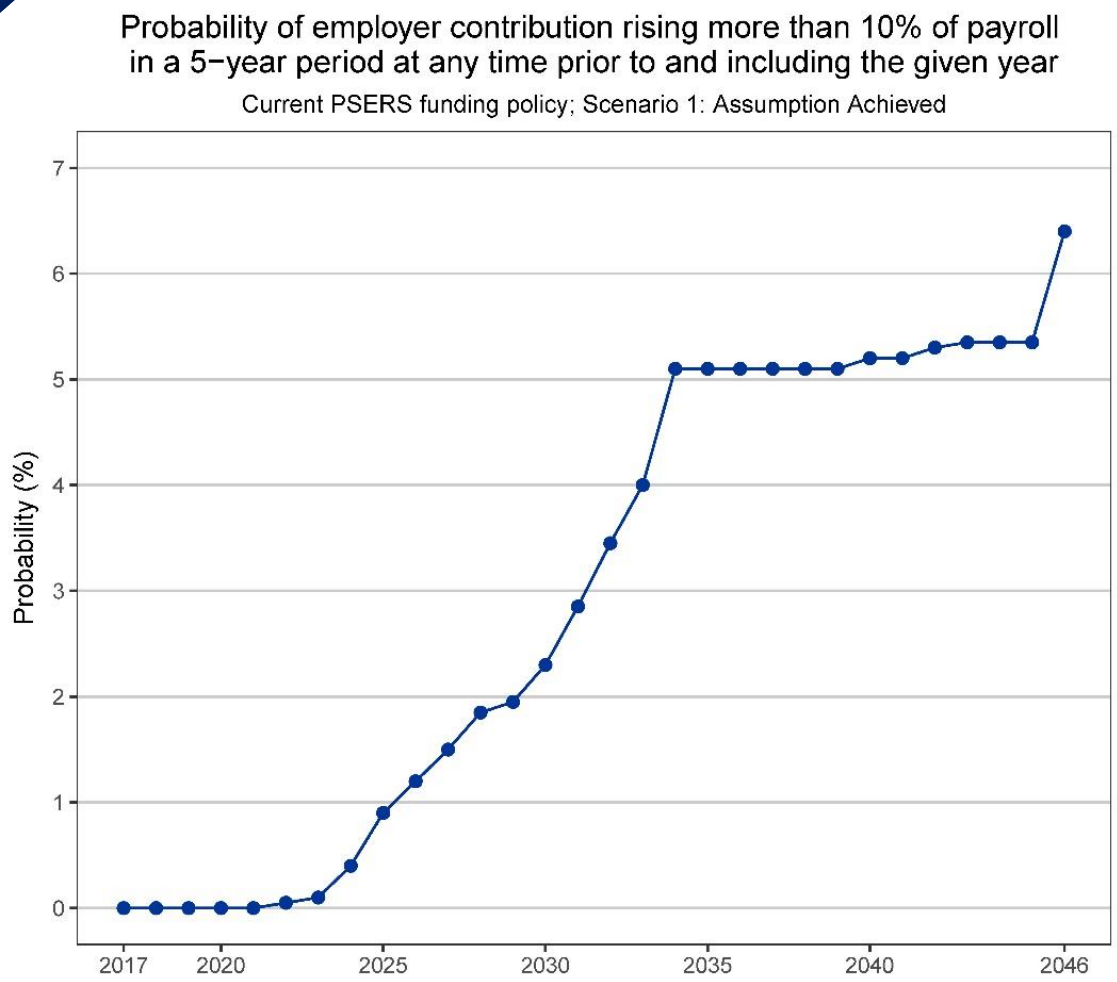


Figure 4 shows the risk of large increases in employer contributions in a short time. Each point shows the probability that the employer contribution rose by more than 10 percent of payroll in any previous consecutive five-year period. For example, the probability at 2030 is about 2 percent. This means that there is about a 2 percent chance that employer contribution rate will have increased by more than 10 percentage points in any previous consecutive five-year period, such as periods from 2020 to 2025, 2021 to 2026, and so on, through 2025 to 2030. By the end of the thirty-year period, there is about a 6.4 percent chance that contributions will have increased by more than 10 points in at least one of those five-year periods. The relatively flat curve after 2034 implies that most of the sharp increases in employer contribution will occur during 2017 to 2034. In the period from 2035 to 2045, as the amortization basis established before 2017 is paid off, the amortization payments will decrease so significantly that the total employer contribution rate is unlikely to rise sharply as a percentage of payroll, even if large investment shortfalls occur. By 2046, the pre-2017 unfunded liability has been fully

paid off for five years and base employer contributions have been low for five years, so the risk that contributions can rise from this new lower base once again climbs.[17]

Figure 4. There Is About a 6.4 Percent Probability That the Employer Contribution Rate Will Rise by More Than 10 Percent of Payroll in a Five-Year Period Sometime in the Next Thirty Years Under the Current PSERS Policy



The ten-year asset smoothing in the current PSERS funding policy plays a very important role in preventing the employer contribution from increasing sharply in a short time period. Under *Scenario 1: "Assumption Achieved: Base Case,"* shortening the asset-smoothing period from ten years to five years would increase the probability of sharp increases in the employer contribution rate from 6.4 percent to 30.2 percent, while it will also slightly reduce the risk of severe underfunding (26 percent to 23.4 percent). While the long asset-smoothing period does not have a substantial impact on the risk of severe underfunding, it may have other impacts. By insulating current policymakers from the consequences of investment shortfalls, it may encourage investment risk-taking that could create a very difficult situation for the fund if investment markets take a sharp drop.

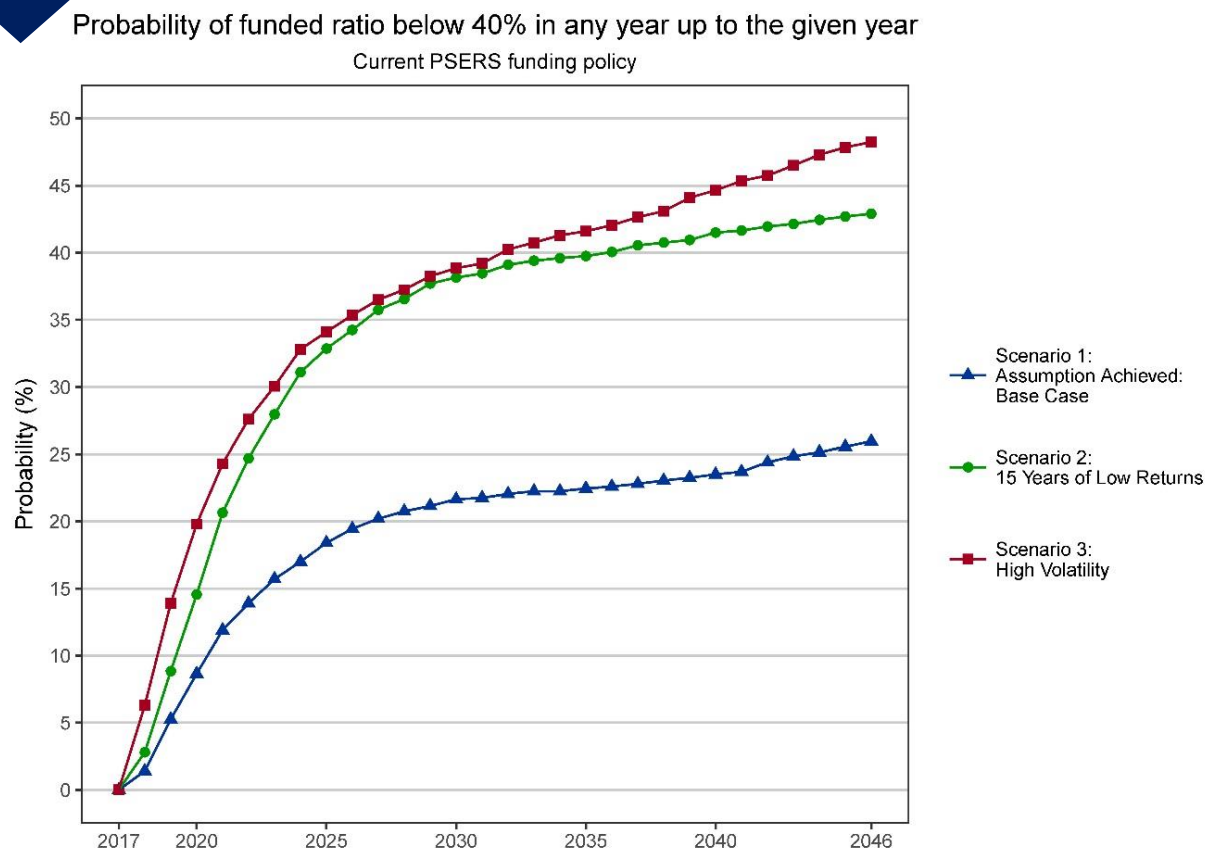
Results for a Period of Low Returns and for Higher Investment Return Volatility (Scenario 2 and Scenario 3)

In this section we compare *Scenario 2: "15 Years of Low Returns"* and *Scenario 3: "High Volatility"* to *Scenario 1: "Assumption Achieved: Base Case,"* in which the expected return is 7.25 percent and the standard deviation is 12 percent. Refer back to Table 1 for details of the investment return scenarios. The simulation results show that fifteen years of low returns and high investment return volatility will substantially increase the risk of severe underfunding and sharp increases in the employer contribution rate over the next thirty years.

Impact on Plan Funding

If the true expected compound return is lower than the assumed return of 7.25 percent in early years, or if investment return volatility is higher than in the base case, the risk of severe underfunding will be much higher for PSERS than in the base-case scenario. Figure 5 shows the probability of the funded ratio falling below 40 percent under the three return scenarios. Under *Scenario 2: "15 Years of Low Returns"* and *Scenario 3: "High Volatility,"* the chances that the funded ratio will fall below what we consider a crisis level — 40 percent — sometime during the next thirty years are about 43 percent and 48 percent, respectively, which are considerably higher than the 26 percent probability under the base-case *Scenario 1*. Thus, in either of these investment-return environments, PSERS could face very substantial risks of a crisis.

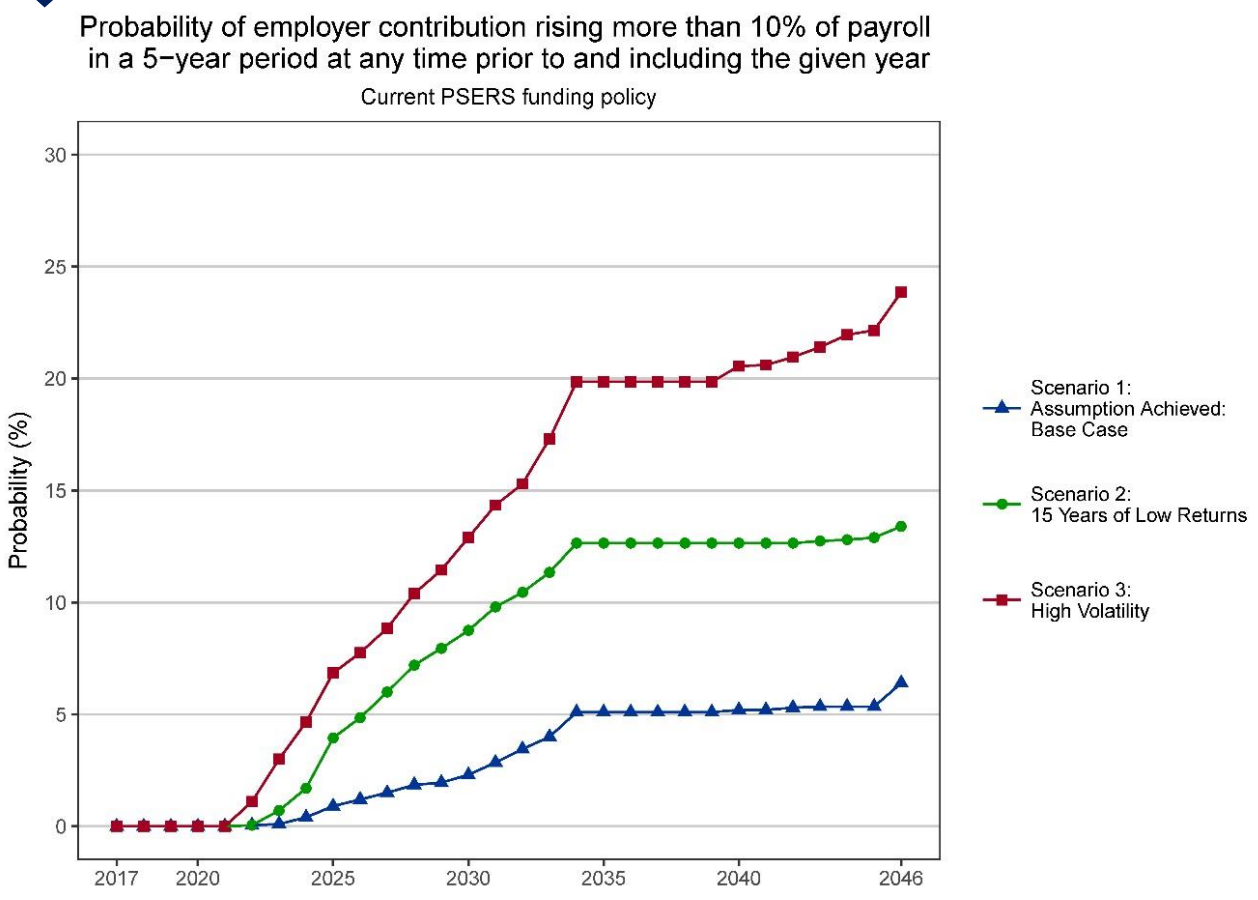
Figure 5. The Risk of Severe Underfunding Is Considerably Higher If There Are Fifteen Years of Low Expected Returns or If Investment Return Volatility Is High



Impact on Employer Contributions

Low expected returns in early years and higher investment return volatility both create much higher risk of sharp increases in employer contributions. Figure 6 shows the probability of the employer contribution rising by more than 10 percent of payroll in a five-year period during thirty years. This probability increases from about 6.4 percent in the *base-case Scenario 1*, to 13.4 percent in *Scenario 2: "15 Years of Low Returns,"* and to 23.9 percent in *Scenario 3: "High Volatility."*

Figure 6. The Risk of Sharp Increases in the Employer Contribution Is Considerably Higher If There Are Fifteen Years of Low Expected Returns or If Investment Return Volatility Is High



Effects of the Shared-Risk Employee Contribution Rate and of Constraints on the Final Employer Contribution Rate

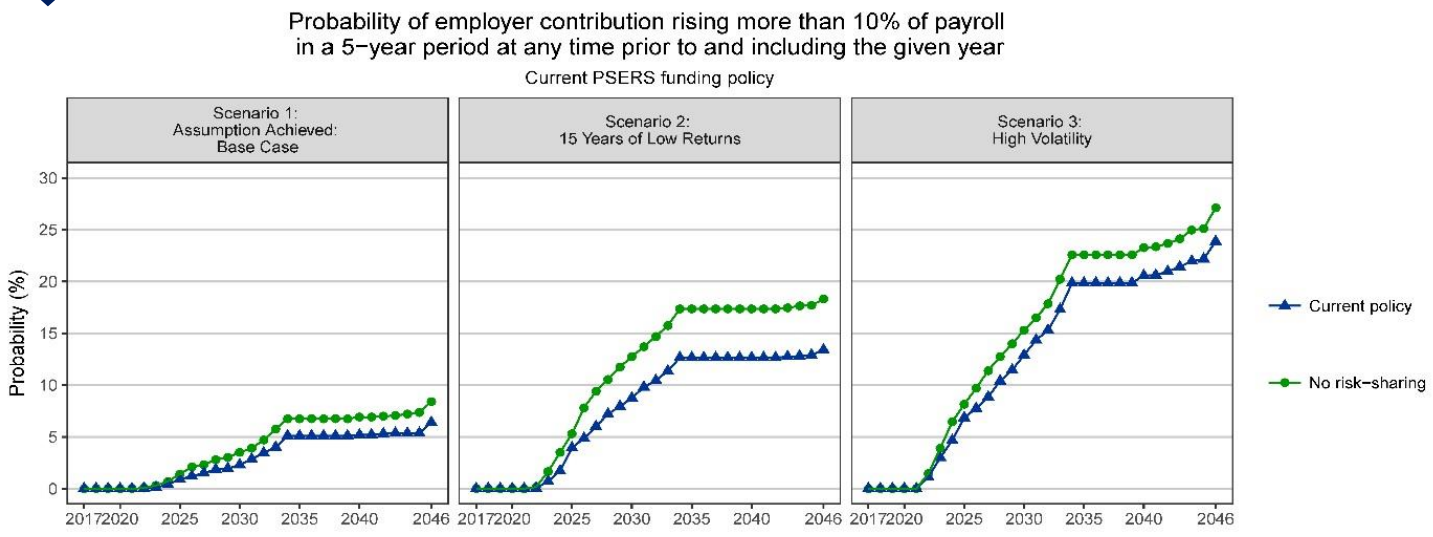
The constraint on the employer contribution rate that limits the annual growth of the final employer contribution rate to 4.5 percentage points of payroll is rarely triggered in all three investment return scenarios we examined in the previous section, and it therefore is likely to have almost no impact on the finances of PSERS in the next thirty years under these scenarios. Under *Scenario 1: "Assumption Achieved: Base Case,"* the employer-contribution-rate constraint is triggered in only six out of the total of 2,000 simulations; even under *Scenario 3* where investment returns are much more volatile,

the number of simulations where the constraint is triggered is only 113. This result is not surprising since the 4.5 percent constraint was designed to phase in the steep increases in employer contribution caused by amortizing the entire 2010 unfunded liability, and investment shortfalls can rarely cause such a big single-year increase in the employer contribution rate under the current funding policy with ten-year asset smoothing.[18]

The shared-risk mechanism allows the employee contribution rate to range from 5.5 to 9.5 percent for Class T-E members and from 8.3 to 12.3 percent for Class T-F members, depending upon a comparison between the ten-year average investment return and the plan's assumption. This sharing has a relatively small effect on the stability of employer contribution rates.

Figure 7 compares the risk of sharp increases in the employer contribution rate under the current PSERS funding policy and under the same policy with the shared-risk employee contribution removed. Without the shared-risk employee contribution, the probability that the employer contribution will rise by more than 10 percent of payroll in five years sometime in the next thirty years is higher by 2 percent, 4.9 percent, and 3.2 percent under *Scenario 1*, *Scenario 2*, and *Scenario 3,* respectively. We also calculated the difference in the present value of employer contributions in the next thirty years in each simulation under the policy with and without the shared-risk mechanism. Under *Scenario 1: "Assumption Achieved: Base Case,"* the shared-risk mechanism would reduce the employer contribution by 2.6 percent in the median case; in the 75th percentile case where the investment returns are relatively bad, the reduction in employer contribution is 5.6 percent.

Figure 7. The Shared-Risk Employee Contribution Rate Reduces the Risk of Sharp Increases in Employer Contribution Only Slightly



The shared-risk employee contribution rate may have a small effect on the employer contribution because it exposes employees to little risk from poor investment returns: 1) the 2 percent floating range for the employee contribution rate is small; 2) the employee contribution rate is adjusted only every three years so that changes in the average investment return may not be reflected in a timely manner; 3) the adjustment is

based on the ten-year average return, which is relatively stable; and 4) the asymmetric adjustment rule makes it more likely that the employee contribution will decrease rather than increase.

Summary of Impacts on the PSERS Funded Ratio and on Employer Contribution

Table 2 summarizes the results of three investment return scenarios — the current PSERS funding policy, an alternative policy with the constraint on employer contribution growth removed, and another alternative in which the shared-risk employee contribution is removed. The next three columns show the results for *Scenario 1: "Assumption Achieved"* under the three different funding policies. The next five columns do the same for *Scenario 2: "15-Years of Low Returns,"* and the final five columns are for *Scenario 3: "High Volatility."*

The table shows that a period of low returns (*Scenario 2*) and a period of high investment return volatility (*Scenario 3*) create significant risks of severe underfunding and sharp increases in employer contributions.

In all three investment return scenarios, the constraint on the growth of the employer contribution is rarely triggered and therefore has almost no impact on the funding and contribution risks of PSERS. This result is largely attributable to the ten-year asset smoothing period in the current PSERS funding policy, the effect of which is strong enough to make the employer contribution relatively stable from year to year and therefore makes the constraint on the employer contribution rate redundant.

The shared-risk employee contribution rate has a moderate impact on the contribution risk of PSERS. Removing the shared-risk mechanism would increase the chance of sharp increases in employer contribution in the next thirty years by 2.0 to 4.9 percentage points, depending on the investment return scenario.

Table 2. Summary of the Impact of Investment Return Volatility Under Different Investment Scenarios and Funding Policies

Probability of crisis-level funding or of significant employer contribution increases under different scenarios and funding policies
All scenarios are stochastic

	Current return assumption of 7.25% is achieved			15 Years of Low Returns			High Volatility		
	Funding Policy			*Funding Policy*			*Funding Policy*		
Risk Measures	**Current PSERS funding policy**	**No contraints on employer contribution rate**	**No shared-risk employee contribution rate**	**Current PSERS funding policy**	**No contraints on employer contribution rate**	**No shared-risk employee contribution rate**	**Current PSERS funding policy**	**No contraints on employer contribution rate**	**No shared-risk employee contribution rate**
***Probability of crisis-level funding sometime in the next 30 years (%)**	26.0	26.0	26.0	42.9	42.9	42.9	48.3	48.3	48.3
****Probability of a significant employer contribution increase sometime in the next 30 years (%)**	6.4	6.4	8.4	13.4	13.4	18.3	23.9	24.1	27.1

Notes on return scenarios:
Scenario 1 (Assumption Achieved: Base Case): Constant expected return over 30 years. Expected compound return is 7.25%, consistent with actuarial assumption of 7.25%.
Scenario 2 (15 Years of Low Returns): Expected returns are 5% in years 1-10, 6.5% in years 11-15, and 7.25% in years 16-30; 30-year compound return is about 6.4%.
Scenario 3 (High Volatility): Constant expected return over 30 years. Expected compound return is 7.25%, standard deviation is 17.2%.

* Probability that funded ratio falls below 40% in at least 1 year out of the next 30 years.
** Probability that employer contribution rises by at least 10 percent of payroll of the State of Pennsylvania in any 5-year period in the next 30 years.

How Would Investment Return Uncertainty Affect the Pennsylvania State Budget?

In this section, we examine the potential fiscal pressure that PSERS may create for the state government of Pennsylvania. We use state employer contributions as a percentage of the Pennsylvania general fund as a measure of fiscal pressure. (We assume that state contributions are 50 percent of total employer contributions, based on the approximate split of state and school district contributions.) To calculate our fiscal pressure measure, we need forecasts of employer pension contributions, which come from our simulation model, and forecasts of the state's general fund revenue, which we describe below.

Projecting Pennsylvania's General Fund Revenue

We constructed a thirty-year projection of Pennsylvania's general fund revenue as follows:

- For fiscal years 2016 to 2021, we used projections from the *Commonwealth of Pennsylvania Economic & Budget Outlook: Fiscal years 2016-17 to 2021-22*.[19]
- For fiscal year 2022 to 2046, we projected revenue using an annual growth rate of 3.5 percent,[20] which is the average growth rate for 2016-21 used in the state's projection, excluding certain one-time revenue gains from fiscal year 2016-17.

The resulting revenue projections are shown in Figure 11 in the Appendix.

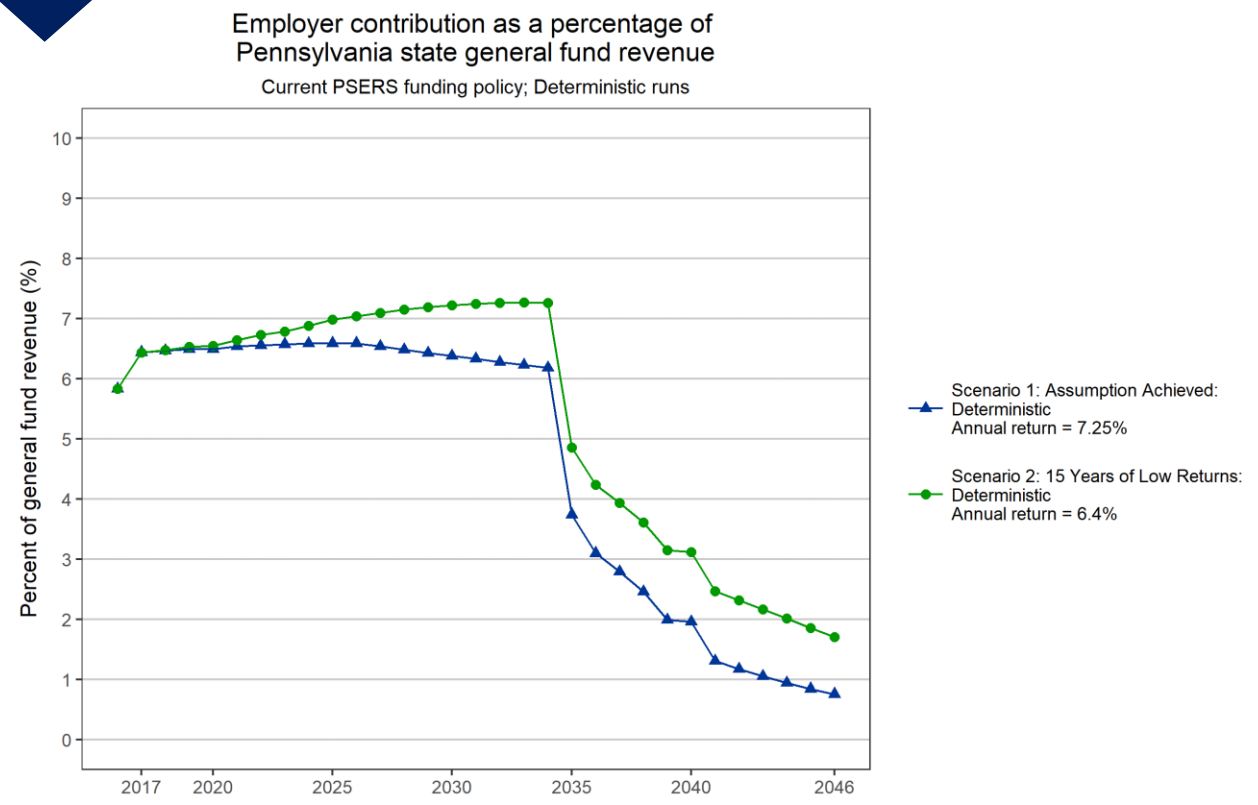
Deterministic Results

We first examine the fiscal pressure that PSERS pension contributions could create under scenarios with deterministic investment returns. Figure 8 shows employer contributions to PSERS paid by the state government, which is 50 percent of the total employer contribution, as a percentage of general fund revenue during the next thirty years under two deterministic simulations with different annual investment returns, labeled Scenarios 1 and 2. As before, *Scenario 1* is the base case, in which PSERS' assumption of a 7.25 percent return is achieved each and every year. *Scenario 2* has fifteen years of low returns before returns rise, as described earlier.

Under the deterministic run of *Scenario 1: "Assumption Achieved"* in which the earnings assumption of 7.25 percent is met each and every year, government contributions as a percentage of general fund revenue will stay relatively stable, around 6 to 6.5 percent in the next twenty years. After the 2010 unfunded liability is paid off in 2035, the government contribution to PSERS will decline considerably from about 6 percent of general fund revenue to less than 1 percent by 2046.

The fiscal pressure from PSERS pension contributions is sensitive to realized investment returns. In the deterministic run of *Scenario 2*, which has returns lower than the assumed rate of 7.25 percent in the first fifteen years, the government contribution to PSERS rises to 7.3 percent of the general fund in 2034, and then declines to 1.7 percent in 2046 as the 2010 unfunded liability is paid off and investment returns rise back to 7.25 percent.

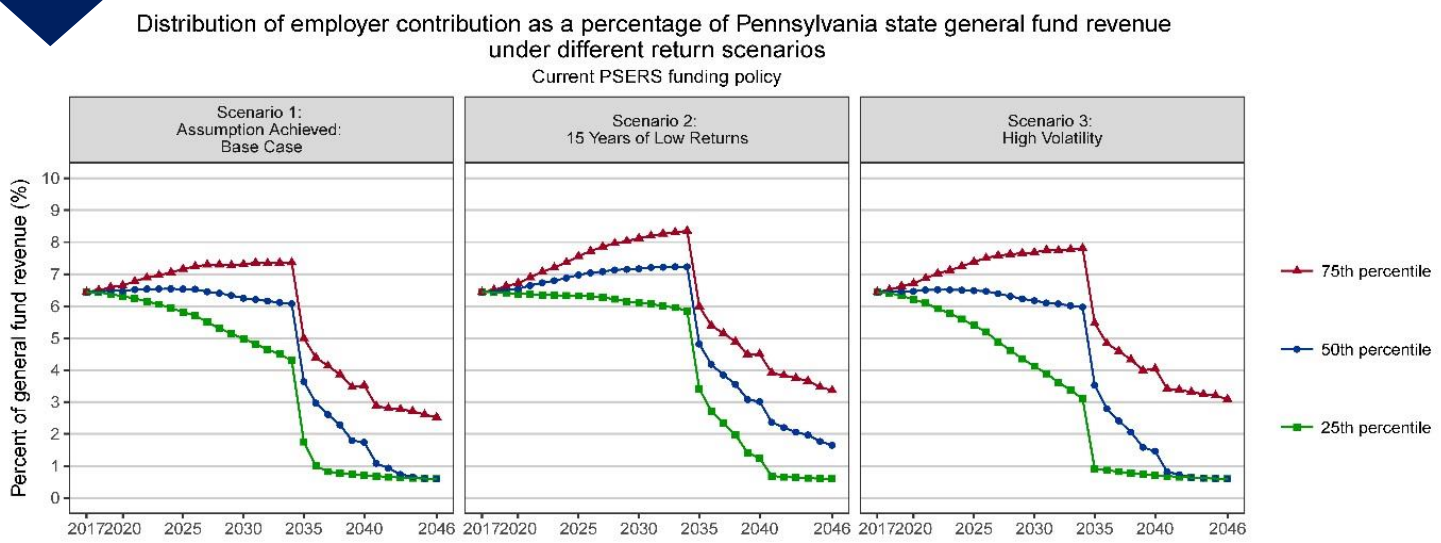
Figure 8. The Fiscal Pressure From PSERS Employer Contributions Will Drop Substantially After 2035; But Will Become Higher Before 2035 If Actual Returns Fall Short of the Earnings Assumption



Stochastic Results

In scenarios with stochastic investment returns, the Pennsylvania state budget faces uncertainty from fiscal pressure related to PSERS employer contributions. Figure 9 shows the distribution of government contributions as a percentage of general fund revenue under the same three investment return scenarios as before. Under the base-case *Scenario 1* with an expected compound return of 7.25 percent and standard deviation of 12 percent (leftmost panel), although the median government employer contribution as a percentage of general fund revenue (blue line) stays around 6 to 6.5 percent through the next twenty years and drops to less than 1 percent after thirty years, in one quarter of the simulations the share of PSERS employer contributions will become 7.4 percent or higher in 2034 and 2.5 percent or higher in 2046 (see the 75th percentile represented by the red line).[21] The 25th percentile line (green line), which represents the share of PSERS employer contributions in simulations with relatively good investment returns, drops to about 4 percent in the next twenty years and drops further to less than 1 percent by 2046. The risks of increases in the fiscal pressure of PSERS employer contributions are higher in scenarios with a period of low returns or greater volatility. The 75th percentile government employer contribution in 2034 is about 8.3 percent of projected general fund revenue under *Scenario 2: "15 Years of Low Returns"* (red line in middle panel), and about 7.8 percent of projected general fund revenue under *Scenario 3: "High Volatility"* (red line in rightmost panel).

Figure 9. There Is Substantial Uncertainty in the Fiscal Pressure of PSERS Employer Contributions Under Scenarios With Stochastic Returns



The results above show that there is still great uncertainty in the fiscal pressure from the PSERS employer contribution before 2035. If returns are relatively bad (represented by the 75th percentile lines), the government employer contribution can rise 7.8 percent to 8.3 percent of projected Pennsylvania general fund revenue, or more, from about 6.4 percent in 2017.

How Would Transitioning to a DB-DC Hybrid Pension Plan Affect the Funding Risks of PSERS?

The potential impact of introducing a hybrid component into PSERS has been examined in studies by the Pennsylvania Independent Fiscal Office and by The Pew Charitable Trusts.[22] Our analysis differs from the previous studies in important ways. First, our goal is to draw general conclusions about the potential impact of introducing a hybrid benefit structure into a traditional DB plan, rather than to estimate fiscal effects for Pennsylvania. Thus, we do not attempt to model the new pension reform bill in all of its detail. Instead, we examine a simplified version that allows us to better isolate the impact of the hybrid plan. But the simplified reform is similar enough to the actual reform in Pennsylvania that we believe it provides useful insights for Pennsylvania. Second, in addition to showing results based on deterministic simulations in which investment returns are constant over time, we use our stochastic simulation model to show how a hybrid plan could affect risks caused by variation in investment returns.

We perform simulations to answer the following questions:

1. To what extent could introducing a hybrid component into a DB plan reduce the risks to employer pension costs?
2. How would the risk-reduction effect roll out over time?
3. How much risk would be shifted to future employees?

How We Model the Hybrid Benefit Pension Reform

We constructed a simplified version of the recent Pennsylvania pension reform, in which the following DB-DC hybrid benefit structure is available to new participants of PSERS in our model:

- The retirement benefit in the DB component of the hybrid plan is half of the benefit in the current pure DB plan. The benefit factor and employee contribution rate in the DB component of the hybrid plans are reduced to 50 percent of those in Class E and Class F of the current pure DB plan: the benefit factor is 1 percent per year of service and the employee contribution rate is about 4 percent. All other DB benefit provisions in the hybrid plan are identical to those in the pure DB plan.
- The total DC contribution rate in the hybrid plan that we model is 5 percent, which is the same as the rate in the hybrid benefit options in the recent pension reform bill. The calculation of the DC plan benefit is based on the assumption that the investment return to the DC account balance is 1.5 percent less than the return to the pure DB plan assets, which reflects higher fees and more-limited investment choices for the DC plan. The employee DC contribution rate is equal to the DB contribution rate in the hybrid plan, which is about 3 percent, and the employer DC contribution rate is about 2 percent.
- We do not incorporate the existing shared-risk employee contribution rate in this analysis. We want to isolate the risk-transfer effect of transitioning to a hybrid plan from a pure DB plan without including other provisions that also reduce contribution risks for the employer.

Risk Reduction for the Employer

We first examine the extent to which introducing our simplified DB-DC hybrid benefit structure would reduce contribution risk for the employer. In Pennsylvania, and in almost any state that adopts a hybrid plan, the new plan will affect only new employees. Regardless of how large or small the impact is for an individual employee, the impact in the early years will be small relative to the size of the plan as a whole and relative to the state budget, but the impact will grow over time as more and more employees are affected. (See the Appendix, "How the Share of the Hybrid Plan in PSERS Would Grow Over Time.") To gain insight into the eventual fully effective impact, we begin by looking at new employees only. Next, we examine what would happen if the hybrid were fully in effect by treating it as if it applied to all current and future employees (see the appendix for modeling details). Finally, we examine how the reform would affect risk as it phases in over time.

Because the DB benefit in our simulated hybrid plan is only one half that of the current pure DB plan, its actuarial liability and associated assets will be only half as large (at the same funded ratio). As a result, when investment returns fall short, the DB component of the hybrid plan will generate smaller unfunded liabilities and amortization costs than the pure DB plan, and swings in employer costs will be only half as large as those for the pure DB plan, in dollar terms and as a percentage of the state budget.

We examine the risk-reduction effect of the hybrid plan using both deterministic and stochastic simulation approaches:

- For the deterministic approach, we examine the impact of a 1 percentage point sustained shortfall in investment returns on employer pension costs.
- For the stochastic approach, in which investment returns vary from year to year and from simulation to simulation, we examine how much employer pension costs vary under the hybrid plan in comparison to the current pure DB plan.

We define employer pension costs to include the total employer contribution during the simulation period plus any unfunded liabilities remaining in the last simulation year, as these must eventually be paid by the employer. Nominal values of future costs, rather than present values, are used in the calculation of total employer pension costs.[23]

Results of Deterministic Simulations

To examine how much the hybrid plan would reduce risk for employers, we proceed as follows:

- First we calculate how much employer costs would rise under the current plan if there is a sustained 1-percentage-point investment return shortfall, lowering the return from 7.25 percent annually to 6.25 percent.[24]
- Next we calculate how much employer costs would rise under the hybrid plan if there is the same sustained 1-percentage-point investment return shortfall. This increase will be smaller than the above increase for the reasons given earlier (lesser amounts of liabilities and assets).
- Finally, we compare the two. The difference is the reduction in the employer risk:

(Cost of DB at 6.25% — Cost of DB at 7.25%)

minus

(Cost of hybrid at 6.25% — Cost of hybrid at 7.25%)

- We measure this in dollars and as a percentage of the employer-cost-increase under the current plan.

The total employer pension cost includes the total employer contribution over the simulation period of 2017 to 2048 plus the unfunded liability remaining in the last simulation year.

Table 3 shows the impact over thirty years of the hybrid program compared to the current pure DB program, focusing only on newly hired employees. Under the pure DB program, if investment returns fall short of assumed returns by 1 percentage point in every year, employer costs over thirty years will be $7.3 billion higher than if the return assumption is achieved. By contrast, if the hybrid program is in effect for new employees and actual investment returns fall short of assumed returns on a sustained basis, employer costs will be $3.6 billion higher than if assumed returns are achieved. Thus the employer cost will be reduced by 50 percent[25] and the new employees will bear the rest of the risk. While the reduction in risk is relatively small in dollar terms because so few employees are affected, it is a large percentage reduction in risk for the employer.

The 50 percent reduction in employer risk reflects the fact that, for future employees, the DB component of the hybrid plan is half the size of the pure DB plan. We have

verified with our simulation model that the risk transfer for the plan members affected by the hybrid plan reform is proportional to the reduction in their DB benefit compared to the original pure DB plan.[26] This relationship between the risk reduction from a hybrid plan reform and the benefit reduction in the DB component of the hybrid can be generalized beyond PSERS.

Table 3. Impact of Hybrid Program on New Employees

Risk transfer based on pension costs for new hires after 2017 only

	Employer pension cost ($billion) 2017-2048	
	Pure DB	**DB/DC hybrid**
Employer cost if assumed investment return of 7.25% is achieved	$13.7	$14.7
Employer cost if returns fall short by 1% each year	21.0	18.4
Difference	7.3	3.6
% difference vs. higher return	52.9%	24.7%
Risk transfer		$3.6
Risk transfer as % of Pure DB diff.		50.0%

Notes:
1. Employer pension cost: nominal value (no discounting) of the total employer contribution to PSERS during the simulation period of 2017-2048, plus any unfunded liability remaining at the end of 2048.
2. Total DC contribution rate = 5% (employer rate + employee rate).
3. Shared-risk employee contribution rates are not modeled in these simulations.

Table 4 shows the impact of the hybrid program as if it were in full effect now and applied to all current and future employees. Under the pure DB program, if investment returns fall short of assumed returns by 1 percentage point in every year, total employer costs over thirty years for current and new employees would be $59.8 billion higher than if the return assumption is achieved. By contrast, if the hybrid program were in effect for all current and new employees and actual investment returns fall short of assumed returns on a sustained basis, employer costs would be $30 billion higher than if assumed returns are achieved. The employer cost will be reduced by $29.8 billion, or nearly 50 percent.

Table 4. Impact of Hybrid Program If It Were Fully Effective Now

Risk transfer assuming all current and future members

	Employer pension cost ($billion) 2017-2048	
	Pure DB	**DB/DC hybrid**
Employer cost if assumed investment return of 7.25% is achieved	$140.4	$77.9
Employer cost if returns fall short by 1% each year	200.3	107.9
Difference	59.8	30.0
% difference vs. higher return	42.6%	38.5%
Risk transfer		$29.8
Risk transfer as % of pure DB diff.		49.9%

Notes:
1. Employer pension cost: nominal value (no discounting) of the total employer contribution to PSERS during the simulation period of 2017-2048, plus any unfunded liability remaining at the end of 2048.
2. Total DC contribution rate = 5% (employer rate + employee rate).
3. Shared-risk employee contribution rates are not modeled in these simulations.

Pennsylvania and other states generally do not have the ability to move current employees into hybrid plans. Programs generally apply to new employees only. Thus, the risk reduction shown above will not be achieved right away. Table 5 shows the impact of phasing in a hybrid plan for new employees. The hybrid plan applies only to new hires, but the table shows employer costs for all employees to provide insight into the magnitude of savings relative to total costs. The table shows the risk-transfer measures broken down into three time periods: 2017-28, 2029-38, and 2039-48.

Table 5. Impact of Phasing in a Hybrid Plan for New Employees

Risk transfer based on pension costs for all current and future members ($billion)

	2017 - 2048		Impact over time					
			2017 - 2028		2029 - 2038		2039 - 2048	
	Pure DB	DB/DC hybrid	Pure DB	DB/DC hybrid	Pure DB	DB/DC hybrid	Pure DB	DB/DC hybrid
Employer cost if assumed investment return of 7.25% is achieved	$ 140.4	$ 141.4	$ 105.5	$ 105.6	$ 66.8	$ 67.1	$ 19.6	$ 20.1
Employer cost if returns fall short by 1% each year	200.3	197.6	112.3	112.4	$ 91.6	$ 91.3	$ 69.5	$ 66.6
Difference	59.8	56.2	6.8	6.8	24.9	24.2	49.9	46.5
% difference vs. higher return	42.6%	39.8%	6.5%	6.4%	37.3%	36.1%	255.1%	230.6%
Risk transfer		$ 3.6		$ 0.0		$ 0.7		$ 3.5
Risk transfer as % of Pure DB diff.		6.1%		0.7%		2.8%		6.9%

Notes:
1. Employer pension cost: nominal value (no discounting) of the total employer contribution to PSERS during the simulation period of 2017-2048, plus any unfunded liability remaining at the end of 2048.
2. Because the employer pension costs in the sub-periods include the remaining unfunded liabilities in the last years of the sub-periods, the costs in the the sub-periods do not add up to the costs for the entire period, which only include the remaining unfunded liabilities at the end of 2048.
2. Total DC contribution rate = 5% (employer rate + employee rate).
3. Shared-risk employee contribution rates are not modeled in these simulations.

For the entire simulation period, if annual investment returns fall 1 percentage point short of the assumed 7.25 percent investment return in all years, the total employer pension cost for all current members and new hires (leftmost panel) is $59.8 billion (42.6 percent) higher under the pure DB plan than if assumptions are achieved. Under the DB-DC hybrid plan the total employer pension cost is $56.2 billion (39.8 percent) higher. The difference between these cost increases shows that the employer risk reduction under the hybrid plan is $3.6 billion, or 6.1 percent of costs that would be paid under the pure DB plan. (This is the same as the risk reduction shown in Table 3, where we focused solely on new employees.) The majority of the risk transfer occurs in the last ten-year period (last panel), when the number of hybrid plan members as a share of total employees is largest. The risk transfer in the first two periods is minimal.

The risk transfer will be small relative to the total pension costs in the next thirty years because it takes a long time for the hybrid plan to expand and the liability of the hybrid plan will only account for a relatively small share of the total liability of PSERS in the next thirty years.

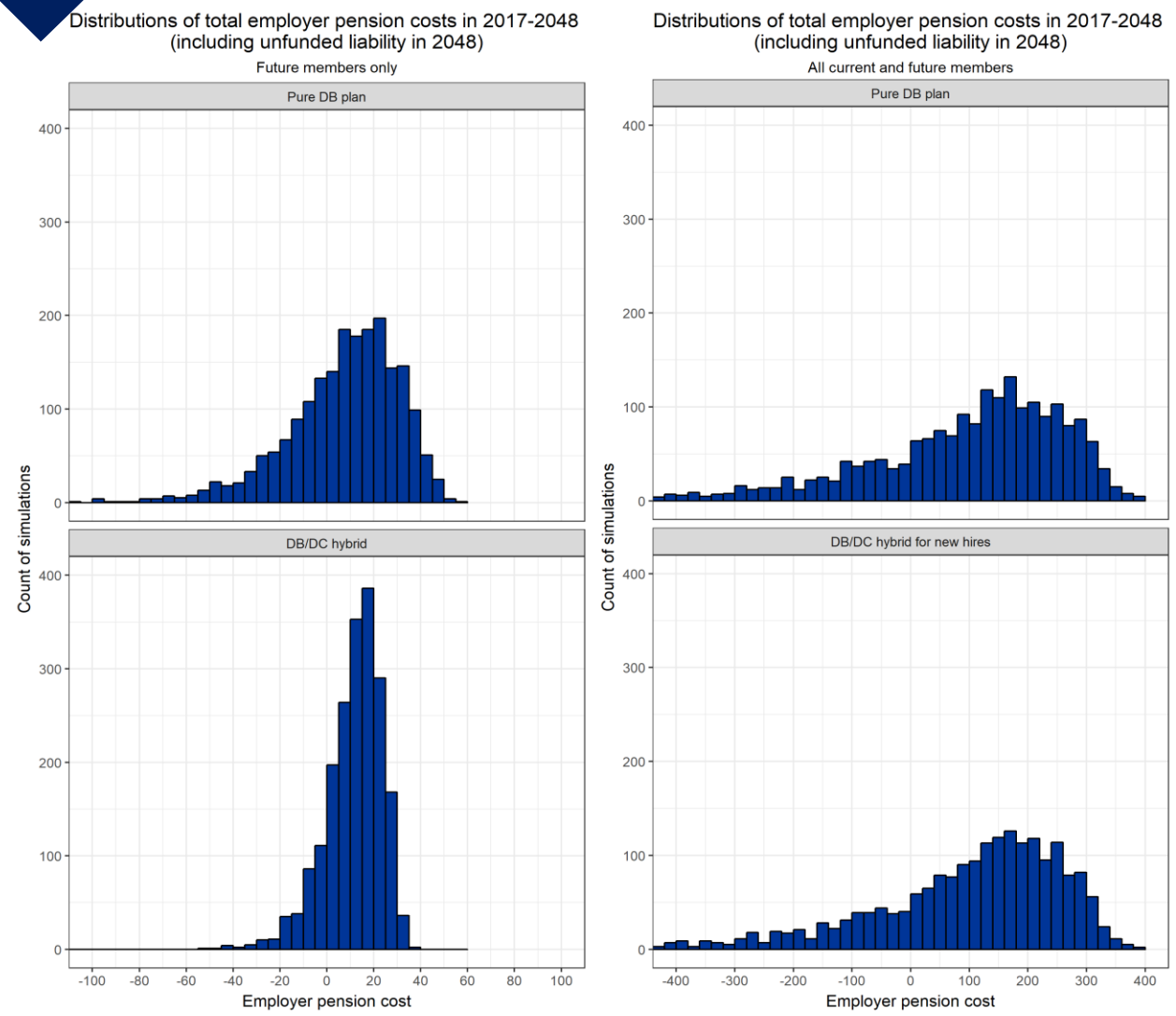
Results of Stochastic Simulations

For each randomly generated return series for the simulation period of 2017-48, the corresponding employer pension costs can be calculated. We run 2,000 stochastic simulations and compute the employer pension cost for each. The dispersion of the resulting distribution of employer pension costs reflects the uncertainty in pension costs when returns are stochastic.

Under the stochastic approach, we define risk transfer as the reduction of uncertainty in employer pension costs when the hybrid plan is introduced to PSERS. Because the DB component is relatively smaller under a hybrid plan, the assets for which the employer bears investment risk are smaller, and the amount by which employer costs will vary in response to investment return variation also is smaller.

Figure 10 compares the distributions of employer pension costs under the pure DB plan and the hybrid plan. In these simulations, investment returns are drawn from a normal distribution with a long-term expected compound return of 7.25 percent and standard deviation of 12 percent. The left panel shows the distribution of employer pension costs for new hires when they all participate in the current DB plan (top graph), compared with employer costs when members are in the hybrid plan (bottom graph). Employer costs are substantially less dispersed under the hybrid plan than under the pure DB plan. The right panel shows the distribution of total employer pension costs for all current and future members, when new hires participate in the current pure DB plan (top graph) and alternatively when all new hires participate in the hybrid plan (bottom graph). The two distributions are quite similar, which is consistent with the result of the deterministic simulation in which the risk transfer is quite small relative to the total pension costs for current and future members.

Figure 10. Impact of Hybrid Program on the Distributions of Employer Pension Costs



Notes:

1. Employer pension cost: nominal value (no discounting) of the total employer contribution to PSERS during the simulation period of 2017-2048, plus the remaining unfunded liability at the end of 2048.
2. There are negative values of total contribution because in simulations with very good realized investment returns in the 30-year period the plan can have a surplus in assets that is even larger than the total employer pension cost during the period. One reason for the existence of very large surplus is that our simulation model intentionally does not allow for withdrawal from the assets when when there is a surplus (no amortization for the surplus).
3. Total DC contribution rate = 5% (employer rate + employee rate).
4. Shared-risk employee contribution rates are not modeled in these simulations.

To quantify the reduction of uncertainty in pension costs under the stochastic simulation approach, we defined the stochastic risk transfer measure as follows:

(75th percentile cost of pure DB - 25th percentile cost of pure DB)

minus

(75th percentile cost of hybrid - 25th percentile cost of hybrid)

Table 6 shows the computed risk-transfer measure based on all current and future members (lower panel) and based on future members only (upper panel). As expected,

the risk transfer is relatively small (6.4 percent) based on the total cost of all current and future members, and the risk transfer for future members is 50 percent.

Table 6. The Impact of the Hybrid Program on Uncertainty in Employer Pension Costs

Risk-transfer-based pension costs for new employees only

	75th percentile($b)	Median ($b)	25th percentile($b)	Diff. between 75th pctile and 25th pctile ($b)
Pure DB	24.1	10.8	-5.8	29.9
DB-DC Hybrid	19.9	13.3	5.0	14.9
Risk transfer, $B				14.9
Risk transfer as % of Pure DB diff.				**50.0%**

Risk-transfer-based pension costs for all current and future members

	75th percentile($b)	Median ($b)	25th percentile($b)	Diff. between 75th pctile and 25th pctile ($b)
Pure DB	217.1	128.8	-0.8	217.9
DB-DC Hybrid	214.2	131.3	10.3	204.0
Risk transfer, $B				14.0
Risk transfer as % of Pure DB diff.				**6.4%**

Notes:
1. Employer pension cost: nominal value (no discounting) of the total employer contribution to PSERS during the simulation period of 2017-2048, plus the remaining unfunded liability at the end of 2048.
2. There are negative values of total contribution because in simulations with very good realized investment returns in the 30-year period the plan can have a surplus in assets that is even larger than the total employer pension cost during the period. One reason for the existence of very large surplus is that our simulation model intentionally does not allow for withdrawal from the assets when there is a surplus (no amortization for the surplus).
3. Total DC contribution rate = 5% (employer rate + employee rate).
4. Shared-risk employee contribution rates are not modeled in these simulations.

How Much Risk Would Employees Bear?

The reduced risk in employer pension costs is transferred to employees in the form of uncertainty in retirement benefits: unexpectedly good investment returns in their defined contribution accounts would lead to higher assets at retirement and greater income in retirement, and unexpectedly bad returns would lead to lower income in retirement. In this section we estimate the benefit risk borne by the hybrid plan participants.

We first compare retirement benefits received by a typical plan member, who entered the workforce at age thirty and retires at age sixty-five, under the pure DB plan and the DB-DC hybrid plan. We use stochastic simulations to obtain distributions of retirement benefits for this member under different scenarios. Table 7 presents the 25th percentile, median, and 75th percentile hybrid plan benefit as a percentage of the pure DB benefit under different expected returns and total DC contribution rates. With the total DC contribution rate of 5 percent, which is the rate adopted in the recent

Pennsylvania pension reform bill, and expected return of 7.25 percent, the median hybrid plan benefit is about 86 percent of the pure DB benefit,[27] and the 25th percentile benefit suggests that there is a one-in-four chance that the hybrid plan benefit would be less than or equal to 77 percent of the pure DB plan benefit. If the expected return is 1 percentage point lower than the assumed return of 7.25 percent, the median and 25th percentile hybrid plan benefits are only 80 percent and 73 percent of the pure DB plan benefit, respectively.

We also calculate hybrid plan benefits with a 7.2 percent total DC contribution rate (row 3 and 4 in Table 7), which is a “benchmark" rate we computed that can ensure a typical employee, who enters the workforce at age thirty and retires at age sixty-five, will receive approximately the same amount of retirement benefits under the current pure DB plan and the DB-DC hybrid plan when the assumed return of 7.25 percent is achieved every year. When the return assumption of 7.25 percent is met, the median hybrid plan benefit is approximately equal to the pure DB benefit, and there is a one-in-four chance that the hybrid benefit would be less than or equal to 89 percent of the pure DB plan benefit. The hybrid plan benefits become lower when the expected return is 6.25 percent.

Table 7. Uncertainty in DB-DC Hybrid Retirement Benefits

Total DC contribution rate	Expected Return	Hybrid plan benefit as % of pure DB plan benefit		
		25th percentile hybrid benefit	Median hybrid benefit	75th percentile hybrid benefit
5%	**7.25%**	77%	86%	98%
	6.25%	73%	80%	90%
7.2%	**7.25%**	89%	102%	119%
	6.25%	83%	93%	107%

Notes:
1. The 7.2% DC contribution rate is a “benchmark" rate we computed that can ensure a typical employee, who enters the workforce at age 30 and retires at age 65, will receive approximately the same amount of retirement benefits under the current pure DB plan and the DB-DC hybrid plan when the assumed return of 7.25% is achieved every year.
2. The calculation of the DC plan benefit is based on the assumption that the investment return to the DC account balance is 1.5 percent less than the return to the pure DB plan assets, which reflects higher fees and more-limited investment choices for the DC plan.

The results of the stochastic analysis shown in Table 7 suggest that even when the expected return assumption is met, the hybrid plan benefit can be significantly lower than the pure DB benefit, if the realized investment returns are bad.

If the hybrid plan were required to guarantee the same benefit level as the pure DB plan even when realized investment returns are low, what DC contribution rate would be needed? We use our stochastic simulation model to determine the minimum DC contribution rates required to ensure the hybrid plan benefits are no less than the DB plan benefit with a 75 percent chance and a 90 percent chance. The required DC contribution rates are shown in Table 8. With the 7.25 percent return assumption met, a

9.25 percent DC contribution rate is needed to secure a hybrid plan benefit that is no less than the pure DB plan benefit with a three-in-four chance, and a 12 percent DC contribution rate is needed to secure this benefit level with a 90 percent chance. If the expected return is lowered to 6.25 percent, the required DC contribution rates would have to rise by another 2 percentage points (11 percent DC contribution rate for a 75 percent chance and 14 percent DC contribution rate for a 90 percent chance). The results show that the DC contribution rate of 5 percent in the recent pension reform bill needs to be at least doubled to guarantee the same benefit level of the pure DB plan under scenarios with relatively bad investment returns.

Table 8. Total DC Contribution Rates Required to Guarantee the Same Benefit Level as the Pure DB Plan When Realized Investment Returns Are Low

	Total DC plan contribution rate required to ensure the hybrid plan benefit is no less than the pure DB plan benefit with a	
	probability of 75%	probability of 90%
Expected return = 7.25%	9.25%	12%
Expected return = 6.25%	11%	14%

Note:
The calculation of the DC plan benefit is based on the assumption that the investment return to the DC account balance is 1.5 percent less than the return to the pure DB plan assets, which reflects higher fees and more-limited investment choices for the DC plan.

Summary of Impacts of Transitioning to a DB-DC Hybrid Pension Plan

The results of both deterministic and stochastic simulations show that the hybrid plan reform would have a significant risk-transfer effect on future members who are affected. However, the risk transfer will be small relative to the total pension costs in the next thirty years, because it takes a long time for the hybrid plan to expand and the liability of the hybrid plan will only account for a relatively small share of the total liability of PSERS in the next thirty years. The size of the risk transfer is proportional to the benefit reduction in the DB component of the hybrid plan compared to the pure DB plan, a conclusion that would hold for other states and plans.

The reduced risk in employer pension costs is transferred to employees in the form of uncertainty in retirement benefits. Even when the expected return assumption is met, the hybrid plan benefit can be significantly lower than the pure DB benefit if the realized investment returns are bad. If hybrid plan pension reform aims to guarantee the same benefit level of the pure DB plan under scenarios with relatively bad investment returns, the DC contribution rate of 5 percent in the recent pension reform bill would need to be increased significantly.

Conclusions

We draw several conclusions from our analysis:

- If assumed investment returns are achieved each and every year, PSERS will move toward full funding with contribution amounts as expected.
- If assumed returns are correct on average over the long run, but have a 12 percent standard deviation, then under current funding policy:
  - There is a 26 percent chance that the *funded ratio* of PSERS will fall below 40 percent — what we consider to be crisis territory — sometime between now and year thirty.
  - There is a 6.4 percent probability that *employer contributions* will increase by more than 10 percent of payroll within a consecutive five-year period sometime in the next thirty years. The low risk of sharp increases in employer contribution is partly attributable to the relatively long (ten years) asset-smoothing period.
  - The relatively conservative amortization method used by PSERS — twenty-four-year level-percent closed amortization — coupled with full payment of the actuarially determined contribution is key to ensuring the funding security of PSERS.
- In all three investment return scenarios we have examined, the 4.5-percentage-point constraint on the annual growth of the employer contribution rate will rarely be triggered in the next thirty years and, therefore, has very little impact on the finances of PSERS in these scenarios.
- The impact of the current shared-risk employee contribution rate on the stability of the employer contribution rate is relatively small. In order for the shared-risk mechanism to have a meaningful impact on the employer contribution risk, PSERS might need to make the employee contribution rate more responsive to the recent history of investment returns and allow the employee contribution rate to vary in a larger range.
- A hybrid plan that includes a DB component and a DC component can reduce the employer contribution risk substantially for new hires. For example, a hybrid plan that provides a DB benefit one half as large as the current pure DB benefit and supplements it with a DC benefit can lower employer contribution risk by roughly one half. This proportional relationship between reduced employee DB benefit and reduced employer cost risk will hold generally, not just in PSERS, as long as certain other aspects of the plan are adjusted similarly. Although the reduction in employer risk is large in percentage terms, it will be many years before it has a substantial impact on plan and employer finances, assuming it applies only to new hires. Finally, the reduction in employer cost uncertainty is accompanied by benefit uncertainty for employees. Mitigating that uncertainty would require substantially higher employer contributions.

Appendix

Illustration of Possible Investment Returns in a Stochastic Scenario

Table 9 illustrates possible investment returns for a scenario with a 7.25 percent expected return and a 12 percent standard deviation.[28] Returns vary randomly from year to year and from simulation to simulation, even though the expected return is the same. Some simulations produce much better outcomes for a pension plan than others. For example, simulation #3 clearly has much lower returns in the first two years than simulation #1; as a result, in our model assets and the funded ratio would be lower at the end of year two in simulation #3 than in #1.

Table 9. Investment Returns in the Model Can Vary Greatly From Year to Year and From Simulation to Simulation

Illustration of investment returns used to calculate pension fund finances

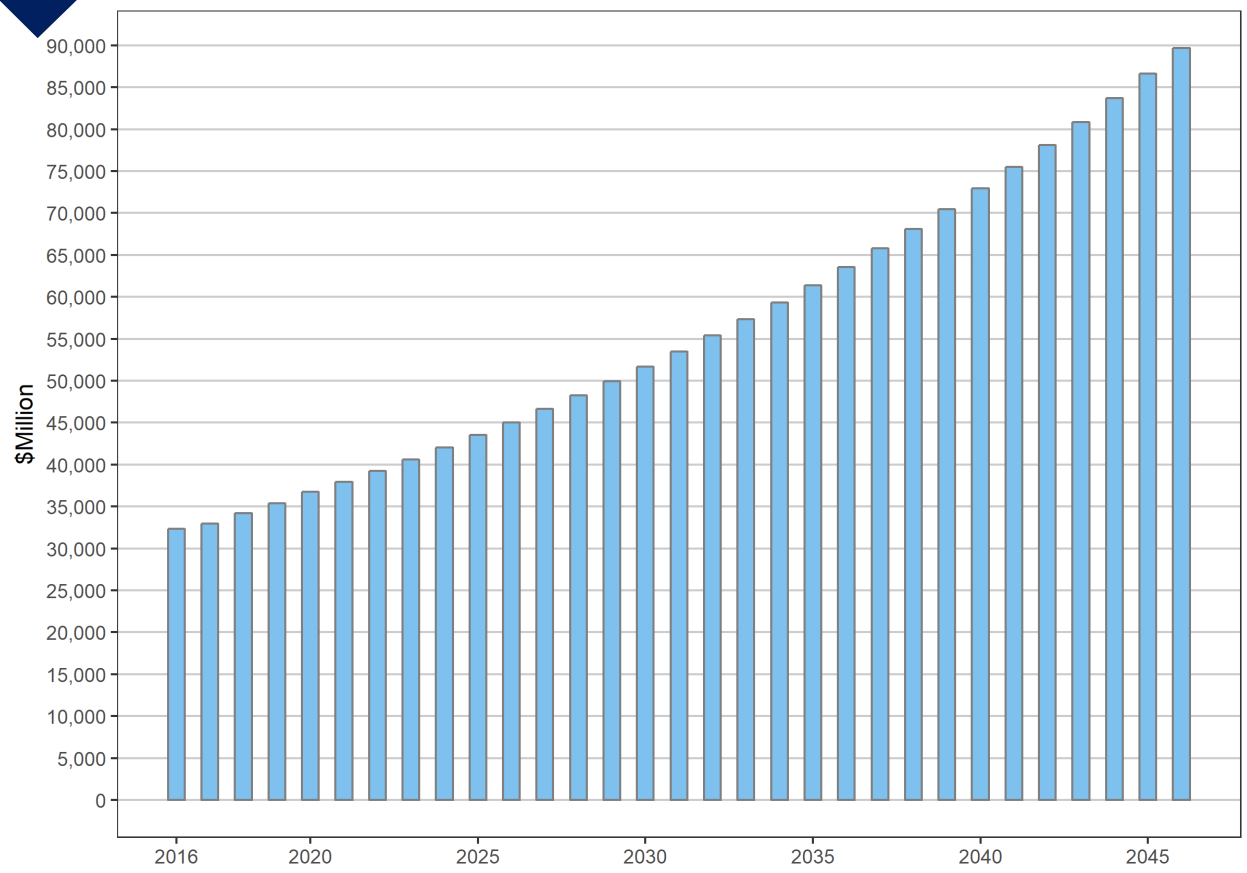
2,000 simulations of a given scenario, returns drawn from a normal distribution with mean 7.25%, standard deviation 12%

	Simulation year					
Simulation number	**1**	**2**	**3**	**…**	**49**	**50**
1	24.7%	17.1%	2.7%	…	10.8%	36.0%
2	5.5%	15.1%	-1.8%	…	39.4%	-0.7%
3	-15.3%	-11.4%	-0.9%	…	2.1%	-4.2%
…	…	…	…	…	…	…
1,999	7.9%	8.5%	18.2%	…	-20.2%	17.0%
2,000	15.6%	-1.4%	-8.9%	…	23.5%	-6.5%

Source: Authors' generation of random investment returns

Projected general fund revenue of the state of Pennsylvania

Figure 11. Projected General Fund Revenue of the State of Pennsylvania For Models Examining Potential Fiscal Pressure That PSERS May Create For the State Government



How the Share of the Hybrid Plan in PSERS Would Grow Over Time

Table 10. By 2048, the Hybrid Plan Members Will Account for the Vast Majority of the Workforce, While the Liability of the Hybrid Plan Will Still Account for Only 40 Percent of the Total Liability

	Hybrid Plan as a Percentage of PSERS		
	Share of hybrid plan members in		
Year	Workforce	Payroll	Liability
2017	0%	0%	0%
2020	24%	14%	0%
2025	48%	32%	2%
2030	65%	48%	6%
2035	78%	65%	11%
2040	88%	80%	20%
2045	95%	92%	31%
2048	98%	96%	40%

Risk Transfer Assuming All Current and Future Members Are Affected by the Hybrid Plan Reform: Modeling Details

To illustrate the full impact of the hybrid plan reform, we perform simulations under a hypothetical policy scenario in which all current and future members of PSERS are enrolled in the DB-DC hybrid plan. For the current plan members in these simulations, not only will their future benefits be accrued under the hybrid benefit provisions, the benefits they have already accrued are also calculated as if they have been in the hybrid plan since joining the workforce. The provisions of the hybrid plan are the same as those used in the section, "How Would Transitioning to a DB-DC Hybrid Pension Plan Affect the Funding Risks of PSERS?" benefit factors and employee contribution rates are half of those in the pure DB plan for all types of members; total DC contribution rate is 5 percent and the DC employee contribution rates are equal to the DB employee contribution rate. The plan under the hypothetical policy starts off with the same 50 percent funded ratio as the pure DB plan, although its starting liability and unfunded liability is less than those under the pure DB plan because of the lower benefit factor.

Endnotes

1 Donald J. Boyd and Yimeng Yin, *Appropriateness of Risk-Taking by Public Pension Plans* (Albany: The Nelson A. Rockefeller Institute of Government, February 2017), http://www.rockinst.org/pdf/government_finance/2017-02-01-Risk_Taking_Appropriateness.pdf.

2 The Institute's pension-related reports can be found at http://www.rockinst.org/government_finance/pension.aspx.

3 Except where noted, data in this section are from either *Pennsylvania Public School Employees' Retirement System: Actuarial Valuation: June 30, 2016* (Florham Park: Conduent Human Resource Services, April 2017), http://www.psers.pa.gov/FPP/Publications/General/Documents/June%2030,%202016%20Actuarial%20Valuation.pdf, or from *Pennsylvania Public School Employees' Retirement System Comprehensive Annual Financial Report for the Fiscal Years Ended June 30, 2016 and 2015* (Harrisburg: Pennsylvania Public School Employees' Retirement System, Office of Financial Management Staff, 2016), http://www.media.pa.gov/Lists/Public%20School%20Employees%20Retirement%20System/Attachments/6/2016%20CAFR%20-%20FINAL.pdf.

4 According to the Public Plans Database (PPD), the 25th percentile for the 2015 actuarial-value-of-assets funded ratio of 160 large plans was 62 percent. (The market-assets funded ratio is not reported in the PPD.) PSERS' actuarial funded ratio in 2016 was 57.3 percent, according to the 2016 actuarial valuation.

5 Under the Act 120 provisions, the shared-risk employee contribution rates cannot go below the base rates. The Act 5 passed in 2017 modifies the provisions to allow the shared-risk employee contributions to go 2 percentage points below the base rates. These modifications are incorporated in our model.

6 There were different caps on contribution growth in earlier years.

7 The assumption of a constant workforce size only serves as a modeling benchmark and is not a projection of the growth of the covered workforce of PSERS. In recent years, the PSERS-covered workforce has declined. According to data and projections from the National Center on Education Statistics, K-12 pupil enrollment in Pennsylvania declined in recent years, but is likely to grow slowly in the years ahead. See William J. Hussar and Tabitha M. Bailey, *Projections of Education Statistics to 2024*, Forty-third Edition (Washington, DC: U.S. Department of Education, National Center for Education Statistics, September 2016): 38, Table 3, https://nces.ed.gov/pubs2016/2016013.pdf), which is reasonably consistent with a constant workforce assumption. This assumption is unlikely to have a material impact on results — for analysis of plan demographics and investment risk, see Donald J. Boyd and Yimeng Yin, *How Public Pension Plan Demographic Characteristics Affect Funding and Contribution Risk* (Albany: The Nelson A. Rockefeller Institute of Government, December 2016), http://www.rockinst.org/pdf/government_finance/2016-12-07-Pension_Demographic_Characteristics.pdf.

8 When we use the term "expected long-term compound return," we mean it in a statistical sense, where investment return is a "random variable" — we do not know what the return will be in any given year or even over a long period of time, but we know what it is likely to be. We are not referring to what a pension plan actuary expects or assumes. In fact, the statistical or true "expected return" could be different from what the actuary expects, and we model such a scenario later in this report. It is important to understand that the "expectation" is taken across simulations, meaning in any single simulation the realized compound return can be higher or lower than the "expected long-term compound return," but the mean compound return of a large number of simulations will be close to the "expected long-term compound return." That is one of the reasons we typically run at least 1,000 simulations of any particular analysis.

9 When investment returns are variable, the long-run compound return will be lower than the expected annual return. Thus, we use an annual expected return that is greater than 7.25 percent but is designed to achieve a long-run compound return of 7.25 percent in the average simulation. We calculate the annual expected return via a widely used approximation formula under which the long-run compound return equals the annual expected return minus one half of the annual variance.

10 This is broadly consistent with other estimates of risk associated with public pension plan portfolios. CalPERS has used a 12.96 percent standard deviation, Biggs assumed a 14 percent standard deviation, and Bonafede et al. estimated a 12.5 percent standard deviation. See *Annual Review of Funding Levels and Risks as of June 30, 2012* (Sacramento: California Public Employees' Retirement System, March 2013), https://www.calpers.ca.gov/docs/forms-publications/annual-review-funding-2012.pdf; Andrew G. Biggs, "The Public Pension Quadrilemma: The Intersection of Investment Risk and Contribution Risk," *Journal of Retirement* 2, 1 (2014): 115-27; 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.

11 It is quite consistent with 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, Markets section, 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.

12 A note on nomenclature: In the tables and graphs that follow, we label each plan fiscal year by the year in which it begins. For example, 2016 is the year beginning July 1, 2016, also called the 2016-17 fiscal year. The year labeled 2045 is the 2045-46 fiscal year.

13 For a more detailed discussion of the trade-off between these two kinds of risk, see 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* (Albany: The Nelson A. Rockefeller Institute of Government, June 2016), http://www.rockinst.org/pdf/government_finance/2016-06-02-Pension_Funding_Practices.pdf.

14 The Public Plans Data (PPD) website is developed and maintained through a collaboration of the Center for Retirement Research at Boston College, the Center for State and Local Government Excellence, and the National Association of State Retirement Administrators, http://publicplansdata.org/.

15 The distribution of funded ratios is asymmetric around the median and skewed upward: the distance between the 75th percentile funded ratio and the median is much larger than the distance between the 25th percentile and the median. This skewness is partly caused by the fact that the employer is not allowed to withdraw from the fund when the fund is overfunded. Thus, the lower bound for employer contributions is zero but the upper bound is infinite (in the model). Although the funded ratio can become very high in simulations with good returns, the probability of the funded ratio being above the median and the probability of the funded ratio being below the median are both 50 percent.

16 The employer contribution increases in part because payroll in our model grows more slowly than PSERS assumes payroll will grow. As a result, the amortization component of the employer contribution is too low in the early years and must rise over time.

17 Employer contribution rate decreases significantly during 2035 to 2041, when the pre-2017 unfunded liabilities are paid off and becomes relatively stable thereafter. In the calculation of sharp increases in employer contribution, we compute the difference between the year-one base employer contribution rate and the year-five employer contribution rate in a five-year period, and check if it is greater than 10 percent. For the five five-year periods ending in 2041 through 2045, the base years are 2036 through 2040, respectively, in which the employer contribution rates are high. With the high year-one base employer contribution rates, it is less likely for the employer contributions to rise by more than 10 percent of payroll in the five five-year periods ending in 2041 to 2045. By 2046, the pre-2017 unfunded liability has been fully paid off for five years and base employer contributions have been low for five years, so the risk that contributions can rise sharply from this new lower base again rises. In fact, the probability of sharp increases in employer contribution will continue to rise in the next couple of years.

18 If the amortization period is reduced to five years, the employer contribution constraint is triggered in 221 out of the 2,000 simulations in Scenario 1 and 1,044 out of the 2,000 simulations in Scenario 3.

19 See *Commonwealth of Pennsylvania Economic & Budget Outlook: Fiscal Years 2016-17 to 2021-22* (Harrisburg: Pennsylvania Independent Fiscal Office, November 2016), http://www.ifo.state.pa.us/download.cfm?file=/Resources/Documents/Five_Year_Outlook_2016.pdf.

20 A caveat about using deterministic revenue growth rates: Rather than allowing them to vary as investment returns vary, it ignores the potential correlation between tax revenues and the employer contributions. If investment returns and taxes both are correlated with economic growth, then investment returns and taxes will be higher when the economy grows rapidly, and lower when the economy does poorly. Contribution increases resulting from investment-income shortfalls might be required in an already fiscally stressed period. Therefore, ignoring the correlation between tax revenues and contributions may lead to an underestimate of fiscal pressure. We leave to future research a modeling approach that takes into account the correlation between taxes and contributions.

21 The median employer contribution as a percentage of general fund revenue is stable, even though the median contribution as a percentage of payroll rises (as shown earlier in the analysis) because payroll is expected to grow more slowly than general fund revenue.

22 See: “Actuarial Note Transmittal," Amendments 01354 and 01558 to Senate Bill 1, Printer’s Number 853” (Harrisburg: Pennsylvania Independent Fiscal Office, June 3, 2017), http://www.senatorbaker.com/wp-content/uploads/sites/28/2017/06/SB-1-Actuarial-Note-Transmittal.pdf, and “Analysis of SB 1082 for the Public Employee Retirement Commission” (Philadelphia: The Pew Charitable Trusts, December 17, 2015), https://www.psba.org/wp-content/uploads/2014/09/Pew-SB-1082-Analysis-Dec17.Final_.pdf.

23 We also calculated risk transfer based on present values of future employer pension costs with discount rates of 3.7 percent and 7.25 percent. The present-value-based risk transfer is of conceptual value because a particular amount of nominal pension cost (no discounting) would pose less fiscal pressure on the sponsoring government in the future, when the fiscal revenue is expected to be higher. The values, in percentage terms, of the present-value-based risk transfer are similar to those based on nominal costs and do not affect our general conclusions, therefore they are not presented in this report.

24 The plan’s investment return assumption does not change. All that happens is that actual investment returns fall short of the assumed return.

25 We also compute the risk-transfer measures with the annual investment return of 5.25 percent in the low-return scenario, which is 2 percentage points lower than the assumed return. Compared with the results for a 1 percentage point change in annual return, the dollar values of risk transfer are approximately doubled for the 2 percentage points change in return, while the percentage values of risk transfer remain almost the same.
26 This is true as long as the employer and employee normal cost rates are also scaled down accordingly.
27 This is consistent with the results of the benefit analysis of the Pennsylvania Independent Fiscal Office.
28 This scenario is only used for illustrating the variability of investment returns, and is different from the scenarios that are used in our analysis in the following sections.

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The mission of the Fiscal Studies Program is to help fill this important gap. The Program conducts research on the trends affecting all fifty states and serves as a national resource for public officials, the media, public affairs experts, researchers, and others.

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