Can Public Pensions Fulfill Their Promises?

An Examination of Pennsylvania's Two Largest Public Pensions

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Abstract

Despite having assets of more than $75 billion, Pennsylvania's two largest public pension plans may be underfunded by as much as $100 billion. In fact, given their current funding ratios and an assumed distribution of asset returns, a 100 percent probability exists that both plans have sufficient assets to pay benefits without any increase in contributions for only the next five years. After five years, the probability declines; by 2030, the likelihood that both plans will be able to meet their promised obligations falls to 31 percent in the public schools plan and to just 16 percent in the state employees' plan. Although recent reforms may enhance funding ratios, even if fully funded, these plans have roughly a 50–50 chance of being able to meet their obligations given the volatility in their investment portfolios. Furthermore, depending on the system reforms, the paper shows that the plans could accumulate *too many* assets, which could lead to pressure to increase benefits and further compound the problem.

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I. Introduction

The financial health of state and local pension plans across the nation has received considerable attention in recent years. This paper examines the structure and funding history of Pennsylvania's two largest public pension plans. Despite having assets of more than $75 billion, the two plans may be underfunded by as much as $100 billion. This problem exists because the current stock of assets in both plans, even when considering future investment returns, is grossly insufficient to pay the retirement benefits that have already been earned. The *Patriot-News* (2014) has succinctly described the funding situation as a "time bomb."

The level of pension funding is often used as a proxy for the ability of a pension fund to pay all the benefits that it has promised to pay in the future. Despite the clear positive relationship between the current level of funding and the ability of a pension to pay its future liabilities, this paper explains the substantial probability that even a fully funded pension will be unable to pay all its future promised payments without additional contributions. In other words, the traditional accounting or actuarial terms *level of funding* or *funding ratio* merit emphasis with an additional, simple metric for gauging the likelihood that a pension will actually be able to make its future promised benefit payments. As the following sections demonstrate, even a fully funded pension has less than a 50–50 chance of being able to pay all future liabilities without the infusion of additional funds (e.g., an increase in taxes or contribution rates) or the use of funds designed to fund future accrued benefits. For pensions that are less than fully funded, such as Pennsylvania's two largest public pensions, the problem is even more severe.

Given the current funding ratios and asset allocations for Pennsylvania's Public School Employees' Retirement System (PSERS) and the State Employees' Retirement System (SERS), we calculate the probability that both plans will be able to pay their promised benefits at various time horizons on the basis of the return characteristics of their portfolio allocation. Because both systems are currently severely underfunded, the likelihood that each of the plans will be able to pay its future promised obligations is, not surprisingly, relatively small. In fact, given their current funding ratios and an assumed distribution of asset returns, both plans have sufficient assets to pay benefits, with complete certainty, for only the next five years.[1] After 2020, the probability that both plans will be able to make their obligated payments begins to fall precipitously. In fact, by 2025, PSERS has only a 77 percent chance of being able to meets its obligations, and SERS has less than a 60 percent chance of doing so. We estimate that to significantly increase the probability of meeting their future obligations, the pensions would need approximately three times as many assets as they currently hold.[2]

In addition to analyzing the current financial health of PSERS and SERS, we calculate the probability that each pension system will be able to make its future promised payments at various time horizons assuming that both systems are fully funded at present. Although this assumption does increase the probability that both systems will able to pay their future liabilities, the probabilities remain far short of 100 percent. That result casts significant doubt on the use of the accounting practices behind simple, traditional funding ratios as a metric for evaluating pension systems.

[1] The results presented in this paper are similar to those found by Munnell et al. (2011).
[2] Table 1 shows that to increase to 90 percent the probability of meeting all their future obligations, the pensions would need a funding ratio of approximately 180 percent. Currently, both pensions have funding ratios of approximately 60 percent.

Finally, recent research has demonstrated that the present value of state and local pension liabilities would actually be considerably larger if they discounted their future benefit payments using a lower, risk-free rate (Novy-Marx and Rauh 2009, 2011). Novy-Marx and Rauh argue that pension liabilities should be discounted by a (nearly) risk-free rate because finance theory suggests that the rate at which the liabilities are discounted should match the riskiness of the liabilities themselves. We estimate the likelihood that each pension system will be able to pay its future liabilities over various time periods if fully funded in the Novy-Marx–Rauh sense—that is, the assets of the pension plan equal the present value of its liabilities, discounted by a sequence of risk-free rates. Regardless of how the plans' liabilities are calculated, as the likelihood increases that the plan has sufficient assets to pay promised benefits, so too does the likelihood it will ultimately have a surplus of assets. This surplus of assets can lead to significant political pressure to raise pension benefits, which can exacerbate the pension funding problems. Therefore, although governments should not want plans to be underfunded, they should also be wary of overfunding them.

II. An Overview of Pennsylvania's Statewide Pension Plans and Funding History

The Commonwealth of Pennsylvania is home to more than 40 percent of the state and municipal pension plans that operate in the United States.[3] Two are state-administered plans: the Public Schools Employees' Retirement System and the State Employees' Retirement System. The

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[3] Pennsylvania has a relatively unique structure of fiscal federalism in which individual counties, cities, townships, and special district governments all have the authority to operate individual pension plans. Many municipalities offer separate municipal-level plans for fire fighters, police officers, and other municipal employees. According to the commonwealth's Public Employee Retirement Commission's Status Report on Local Government Pension Plans, municipalities in Pennsylvania operate nearly 3,200 separate pension plans (as of December 2014). Although there is no uniform practice across the states, other states have far fewer municipal pension plans. Many states tend to group similar local government employees into a single statewide pension plan for an entire group such as police officers. Alternatively, the state may group all state and local government employees into one or two pension plans.

commonwealth also has more than 3,200 municipal and county pension plans. The PSERS plan covers public school employees, such as administrators and teachers; SERS operates the retirement plan for the majority of state public-sector employees—such as members of the legislature, judiciary, and executive branch, as well as some employees of the commonwealth's higher education system.

The larger of the two statewide systems, PSERS, is the 18th largest state-sponsored plan in the nation, with approximately 267,000 active members, 209,000 retirees and beneficiaries, and actuarial assets in excess of $52 billion. Roughly half the size of PSERS, SERS currently has 105,000 active members, 120,000 retirees and beneficiaries, and actuarial assets of $27.6 billion. PSERS and SERS currently make annual benefit payments of approximately $5 billion and $3 billion, respectively.[4]

Both PSERS and SERS are defined benefit (DB) plans, which means that on retirement each beneficiary receives a predefined, fixed monthly payment that is guaranteed for the duration of his or her life and the life of a surviving spouse. In the case of PSERS and SERS, the monthly benefit depends on the employee's years of service, final average salary, and a multiplier. Although some exceptions exist, the typical employee's final average salary is determined under either plan by using the last three years of service, and the multiplier is either 2.0 percent or 2.5 percent. Thus, for an employee retiring after 30 years of service with a final average salary of $60,000 and a multiplier of 2.5 percent, the retirement benefit would be $45,000 a year or $3,750 a month ($0.025 \times 30 \times \$60,000 = \$45,000$).[5]

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[4] Unless otherwise noted, all financial and institutional data for PSERS and SERS was obtained from various years of the systems' Consolidated Annual Financial Reports (CAFR). The PSERS information may be obtained at http://www.psers.state.pa.us/publications/general/cafr.htm; the SERS reports are available at http://sers.pa.gov/newsroom_facts.aspx. The most recent CAFR available is the 2013 report for SERS and the 2014 report for PSERS.

[5] The basic pension formula was obtained from Office of the Budget (2012, 3).

Although DB plans are the norm for public-sector employees around the nation, private-sector employees with employer-sponsored retirement plans are overwhelmingly enrolled in defined contribution (DC) plans, the most common of which are 401(k) and 403(b) plans. DC plans are individual-based retirement plans, with annual contributions often made by both employees and employers. Benefit levels are uncertain and depend on the performance of the investment and ultimate accumulation of assets. The funds are invested, and on retirement the employee receives the balance of the account rather than a fixed retirement benefit. One key difference between a DB plan and a DC plan is that though individual employees bear the full risk of accumulating retirement funds in a DC plan, taxpayers ultimately bear the burden of financing the retirement of workers in a DB plan.

A pension plan's level of funding is the most commonly used metric to assess the financial health of a plan. In the most basic sense, a pension's funding level is the ratio of the plan's current assets to the present value of the plan's forecasted liabilities that have already been accrued. According to the most recent actuarial reports, PSERS and SERS currently have funding ratios of 63.8 percent and 59.2 percent, respectively, which means that each plan's current assets equal roughly 60 percent of the benefits each plan expects to pay out in the future (i.e., its expected liabilities). Although individual plan assumptions vary, each plan's liabilities are calculated by actuaries and depend on several factors—such as the current demographics of plan members, their work and life expectancy, and the expected performance of the plan's financial investments. Because no uniform standard exists for gauging pension funding levels, the terms *fully funded*, *underfunded*, and *overfunded* are somewhat ambiguous and therefore may be used differently by different groups. According to a recent report by the National Association of State Retirement Administrators, funding ratios below 80 percent have historically been considered to be underfunded, while ratios in excess of 100 percent have been considered to be overfunded (Brainard and Zorn 2012).[6] According to a recent report from Standard & Poor's, Pennsylvania's statewide pension plans are the 15th worst in the nation according to per capita funding levels (Sugden 2014).

As this paper will demonstrate, a pension plan's funding ratio is really only a proxy for what should truly matter to workers and voters: the probability that a plan will be able to make its promised future benefit payments. A plan's funding ratio and the probability of maintaining solvency are positively related; however, they are not the same. We will elaborate on their differences and their importance. But, first, a review of the consequences of pension underfunding and some of the institutional factors in Pennsylvania that have contributed to the massive underfunding of PSERS and SERS is worthwhile.

The two systems are funded through a combination of employee contributions (roughly 20 percent), commonwealth contributions (roughly 10 percent), and investment earnings (roughly 70 percent). This particular distribution of funding sources is normal for established pension systems. The commonwealth's contributions fluctuate annually because they depend on the benefits accrued in a given year by current plan members, any outstanding unfunded liability, and the difference between the plan's expected and actual rate of investment returns.[7] The contribution rates of employees vary by their hire date and other factors, but typical employees in PSERS and SERS contribute 7.5 percent and 6.25 percent of their annual salary to their pension fund, respectively.

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[6] The report claims the 80 percent funding threshold that is often cited may be due to a carryover from federal legislation governing private-sector pension plans, or it may be due to the thresholds employed by bond rating agencies (Brainard and Zorn 2012).
[7] Both PSERS and SERS currently assume annual investment returns of 7.5 percent.

The level of underfunding in both PSERS and SERS has already generated significant negative costs throughout the commonwealth that may have effects that last for generations. At a minimum, this underfunding will require one or both of the following changes: increases in contributions from employers (which would lower employees' take-home pay) or increases in contributions from the commonwealth and municipalities (which could lead to higher taxes or reductions in other government services as pensions crowd out other categories of government spending). In Philadelphia, for example, pension costs have risen from 13 percent of the city's general fund to more than 17 percent in just a few years, forcing other government services to shrink (Center on Regional Politics 2012).

As a result of Act 120 of 2010, future state employees face a less generous pension system than employees who came before them. Specifically, new employees (rather than all employees) face a 2.0 percent multiplier instead of 2.5 percent, a higher retirement age, and a longer period before they are fully vested. In addition, they no longer have a lump-sum withdrawal option on retirement. In addition, all employees are subject to contribution rate increases if the plan's investment returns fall short of expectations. Although these reforms should improve each plan's actuarial funding ratio, they also create intergenerational inequity because current retirees (and some future retirees) will receive retirement benefits that are far greater than those of newly hired employees and future employees. These reforms became effective for new employees in PSERS and SERS on July 1, 2011, and January 1, 2011, respectively.

In addition, the commonwealth's general obligation bond ratings have been lowered several times in recent years—partly because of the magnitude of the unfunded pension liabilities. As a recent example, Moody's—the bond credit rating service—lowered Pennsylvania's bond rating to Aa3 in July 2014 (Moody's Investors Service 2014); Fitch—another ratings organization—lowered its rating to AA– in September 2014. Both of those ratings are the fourth-highest investment grade rating for each service (Business Wire 2014). The downgrading means that investors will almost certainly require the commonwealth to pay a higher interest rate on newly issued general obligation debt, thereby raising the cost of many government services and activities, such as building and maintaining new roads, hospitals, and schools.[8]

Although investment earnings are the largest source of annual income to PSERS and SERS, several recent policy decisions have played a major role in the current funding crisis. For instance, because of strong investment returns in the late 1990s and first few years after 2000 (when economic growth was robust), both systems had self-reported funding levels in excess of 120 percent. As a result, the legislature and Governor Thomas Ridge enacted Act 9 of 2001. The new law greatly expanded pension benefits by raising the multiplier from 2.0 percent to 2.5 percent, applying the new multiplier retroactively to the starting employment date for all current members, and lowering the number of years required to vest in the systems. In the following year, Act 38 of 2002 further expanded benefits, increasing the cost-of-living adjustment for retirees by 25 percent. These large and permanent increases in benefits were not offset in any way by additional contributions from employees or the commonwealth.

The economic downturn following 9/11 caused investment returns to shrink below historical norms and would have necessitated a larger contribution from the commonwealth to offset the lower investment returns. To avoid a large increase in pension contributions, the legislature responded

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[8] In extreme cases, such as those of Detroit, Michigan, and perhaps Scranton, Pennsylvania, bankruptcy is an option that may allow distressed municipalities to restructure their debt, including pension obligations. In November 2014, a federal judge ruled that current and future retirees in Detroit could have their pension benefits reduced even though the Michigan constitution expressly protects the benefits. This decision was based on federal bankruptcy laws, which supersede state statutes and property rights. However, federal bankruptcy laws do not provide for states filing for bankruptcy, and the Detroit ruling will almost certainly be appealed. Thus, what would happen to pension benefits in Pennsylvania should the commonwealth be unable to meet its obligations is unclear, and a definitive answer is likely several years away.

with legislation that ultimately compounded the underfunding. Act 40 of 2003 altered some of the actuarial assumptions in the pension plans and, effectively, allowed both plans to spread out losses over a longer period of time and to incorporate gains over a shorter period of time. These changes allowed the commonwealth to reduce its contributions to both pension systems until 2012. In other words, Act 40 forced both PSERS and SERS to make their pensions *appear* to be better funded (in an accounting sense only) so that the legislature would not have to allocate additional funds to the systems because of the investment losses in the early years after 2000.

Although investment losses in the first few years after 2000 and the Great Recession certainly contributed to the commonwealth's pension woes, politics has played at least as large of a role. Because even a severely underfunded pension will have sufficient funds on hand to make benefit payments for *some* period of time, pensions provide an easy mechanism to expand benefits to current and future retirees without requiring a corresponding increase in contributions. Examining 91 state and local pension plans for many states from 2001 to 2010, Elder and Wagner (2015) find that more politically competitive states are more likely to underfund their pensions. In fact, controlling for other factors, they find that pension funding ratios drop 1.5 percentage points during election years, presumably as funds are diverted to alternative uses. Recent research by Bagchi (2013) reveals a similar story in Pennsylvania's municipal pensions. After taking into account other measurable factors that affect pension funding, Bagchi finds that increased political competition in municipalities leads to higher average retirement benefits, higher actuarial discount rates, and overall lower funding ratios. One underlying problem, as we will demonstrate in the next section, is that while increasing benefits may be politically expedient when the systems appear to be fully funded or overfunded, such decisions greatly reduce the probability that the systems will be able to meet their future obligations.

III. Fundamentals and Issues in Financing Pensions

Over a relatively short time horizon, even a severely underfunded pension has a very high probability of being able to pay all its future liabilities. At more distant time horizons, the likelihood of a severely underfunded pension having sufficient assets to pay its liabilities decreases dramatically. The potential inability of a pension to pay future liabilities over a long time horizon is not unique to an underfunded pension; even a fully funded pension plan is not likely to have sufficient assets to pay all its liabilities because of the way *fully funded* is defined. In fact, given how the funding level of a pension is defined, there is less than a 50 percent chance that even a fully funded pension will have sufficient assets to pay its liabilities over a long time horizon.

The measurement of a pension's current assets is relatively straightforward. In a very basic sense, it is simply the market value of the assets the pension owns. The measurement of a pension's currently accrued liabilities is much more contentious. What matters is the present value of the liabilities, and debate continues over the appropriate discount rate. Typically, a pension promises to pay its retirees a sequence of future benefits. This sequence of payments is converted into a present value on the basis of the size of the payments, the timing of the payments, and the rate that is used to "discount" that stream of payments to present value. The present value of some future amount is the amount of money needed right now, which, if invested and earning a constant return equal to the discount rate, will yield the specified amount of money in the future. For example, if the discount rate is 5 percent, then to have $100 next year, one needs $95.24 right now. Thus, $95.24 is the present value of $100 next year.

The return used in this formula to calculate the present value of a pension's liabilities is often the expected (or average) return on the assets the pension currently holds, which is 7.5 percent for both PSERS and SERS. Two fundamental issues arise when using the expected return on the pension's assets as the discount rate for liabilities: (a) even a fully funded pension has a relatively high probability of not being able to pay promised future benefits because of the variability of actual returns, and (b) the expected return does not reflect the riskiness of future liabilities.

Consider this simple example of the first issue. Suppose the current stock of assets is invested in a risky asset; that raises the uncertainty of the actual return on the stock of assets. Even though the exact return is not known, suppose that three possible and equally likely returns for the risky asset are 2 percent, 7 percent, and 12 percent (so the distribution of returns for the risky asset is known). The average, or expected, return on the risky asset is 7 percent. For simplicity's sake, if we assume that the pension has a single $100 payment due next year, then if the pension discounts its future liabilities by the expected return, the present value of the liability is $\frac{100}{1.07} = \$93.46$. The pension may be classified as *fully funded* if the market value of the current stock of assets is $93.46, *underfunded* if the value of the current stock of assets is less than $93.46, and *overfunded* if the value of the current stock of assets is greater than $93.46.

If the pension plan is fully funded (it has $93.46 worth of assets) and the return on the risky asset turns out to be 7 percent, then the plan will have $100 next year (93.46 × 1.07 = 100). The plan will have exactly enough money to make its payment. If the return on the risky asset turns out to be 12 percent, then the $93.46 worth of assets this year will grow to $104.68, and again the plan will have sufficient money to make the $100 payment (with $4.68 left over). Unfortunately, if the return on the risky asset turns out to be only 2 percent, then the current stock of assets will grow to only $95.33, and the plan will not be able to pay the full $100 promised pension payment. Hence, even though this pension system is labeled fully funded with $93.46 in assets, it has only a two-out-of-three chance of having sufficient assets next year to make its promised pension payment of $100. This scenario is important because the term *fully* *funded pension* generally connotes sufficient assets to fund promised benefits without any additional contributions to the pension system. In fact, though, in this simple example, an additional contribution of funds from the state is necessary in one of three cases, and those additional funds will likely have to come from a reappropriation of funds originally designated for another purpose or from some sort of tax increase.

In a more realistic example, with a more complete and continuous distribution of returns for risky assets, a fully funded pension plan using the average return on its assets to discount its future liabilities will have less than a 50 percent chance of being able to pay all its expected future liabilities. This result occurs because 50 percent of the return sequences will average below the assumed average return, so a pension plan that experiences those sequences of returns will have insufficient initial assets to pay all the benefits. Additionally, even in the 50 percent of the sequences in which the realized return sequences average the assumed return or higher, the pension may not be able to pay all the benefits because a sequence of early poor returns may exhaust the assets before all benefits can be paid.

A second issue with using the average return on a pension plan's assets to discount promised benefits also arises: finance theory suggests that a sequence of payments should be discounted by a rate that reflects the riskiness of those cash flows, not by the expected returns of the assets that are dedicated to finance those cash flows (Modigliani and Miller 1958). The logic underlying this theory is simple. Any level of assets could theoretically be sufficient to finance any level of future payments if the initial assets are invested in assets that are risky enough. An alternative way to explain why the discount rate should *not* be the expected return on the assets is as follows: For a given sequence of future liabilities, the present value of those liabilities could be lowered simply by investing the fund backing them in riskier assets. The fund is likely to earn more over time, but this higher rate of return merely reflects the higher degree of risk that the plan is assuming. The higher risk lowers the present value of future liabilities even though the actual sequence of expected future payments remains unchanged. In other words, discounting a pension plan's future liabilities with a higher discount rate will "improve" the plan's actuarial funding ratio even though the plan's future payments are unchanged. Novy-Marx and Rauh (2009, 2011) suggest discounting future benefits by a risk-free rate because, in many cases, pension benefits are virtually guaranteed by law, by legal precedent, or by state constitution (which is the case in Pennsylvania). Using risk-free Treasury rates to discount future liabilities and actuarial figures from 2009, Novy-Marx and Rauh (2011) estimate that PSERS and SERS have liabilities nearly 50 percent larger than their self-reported values. That finding implies the two plans' unfunded liabilities total more than $100 billion.

If a pension plan has assets equal to the present value of future liabilities, discounted using risk-free rates (as Novy-Marx and Rauh propose), and if the plan's assets are invested in the risk-free asset, then by definition the plan will have a 100 percent chance of being able to pay its liabilities at any time horizon. Alternatively, and much more realistically, if the pension plan's assets are invested in a risky asset, then some small positive probability still exists that the system will have insufficient assets to pay future liabilities. For example, if the risk-free return is 5 percent, then using the simple one-period example presented earlier, the present value of the pension's single $100 payment, discounted by the risk-free rate, is $\frac{100}{1.05} = \$95.24$. Therefore, even if the pension plan has $95.24 worth of assets right now, if they are invested in the (simple) risky asset described earlier, then the plan still faces a one-third probability that the risky asset's return will be 2 percent. In that case, the pension plan will not have sufficient assets to make the promised payment.

As already mentioned, if the pension plan has a stock of current assets equal to its future liabilities, discounted using risk-free rates, and the assets are invested in a risk-free asset, then—and only then—will the plan be able to pay future liabilities with certainty. If the assets are invested in a risky asset, some probability exists that the plan will not be able to pay all the future liabilities. At the other end of the spectrum is the possibility that the plan will have too many assets. If the probability is very low that the pension plan *will not* be able to pay expected future liabilities, then the probability is a very high that the plan *will* have sufficient assets to pay all future liabilities. One major concern, which has largely been ignored in the research on pension funding, is that when a pension plan has sufficient assets to pay all future liabilities, the system likely has too many assets. That scenario can lead to political pressure for benefit increases. In the previous example, if the pension plan has current assets equal to its future $100 payment discounted by the risk-free rate of 5 percent (meaning it currently has $95.24 worth of assets), and those assets are invested in a risky asset, then the plan will have $101.91 next year if the return on the risky asset is 7 percent. If the return on the risky asset is 12 percent, then the plan will have $106.67 next year. Although the plan will have sufficient funds in both cases, the excess funds create a different set of problems in each example.

If the pension is going to maintain its investment in risky assets, one alternative is to increase the level of pension funding such that the probability of not being able to pay its future liabilities is still effectively zero. In the previous example, if the pension plan has assets of $98.04 (the $100 required payment discounted by the low return of 2 percent), then the plan will have sufficient assets to make its promised payment with certainty regardless of the investment in the risky asset. The obvious problem with this solution is that the plan may end up with an even greater excess of funds than it would have had in the previous cases.

Clearly, pension plans face a tradeoff between the probability of being able to cover their liabilities and the probability of having too many assets—unless the assets are invested in risk-free, low-return investments that require a higher level of contributions. In addition to the political pressure to pay additional benefits if and when a pension plan becomes overfunded, a system that generates too many assets also implies that the pension sponsor or employees have borne an unnecessarily large cost in terms of excessive current contributions. Alternatively, not having sufficient assets to pay future liabilities imposes an obvious cost on future generations and new employees, as was the case with the reforms implemented by Act 120 in 2010.

IV. Will PSERS and SERS Be Able to Make Their Promised Payments?

To calculate the likelihood that both PSERS and SERS will be able to pay their future liabilities and to examine each system's level of assets at the end of our time horizons, we generate a single sequence of 65 returns for each plan. We draw the returns from an assumed distribution of asset returns, which is based on the asset allocation for each plan. Given this sequence of annual returns, each plan's current level of assets, and the year-by-year expected liabilities of each plan, we can model the evolution of the plan's assets over time as well as calculate the probability that each plan will have assets sufficient to cover its liabilities.[9] Because the exact sequence of future liabilities is not public information, we assume that the sequence of liabilities follows the pattern reported by Meder and Staub (2006).[10] The process of generating a sequence of returns is repeated 100,000 times, which allows for the calculation, for each period, of the likelihood that a plan will be able to pay its liabilities as well as the distribution of the level of assets the pension

[9] In the calculations, we assume that the pension plan enters the period with a given amount of assets, makes the required payments to the beneficiaries, and then earns a return on the remaining assets, which are then carried over to the following period.
[10] This pattern of liabilities is based on a pension that does not pay cost-of-living adjustments.

plan will have at the end of the time horizon. PSERS and SERS both hold a variety of assets, including domestic and foreign equity, short- and long-term bonds, and real estate. According to SERS's 2014–2015 Strategic Investment Plan, the expected return on SERS's portfolio is 7.5 percent, with an expected standard deviation of 13.46 percent (SERS 2014, 9, table 3). This distribution of returns is used through the remainder of this section.[11] The results that follow, unless otherwise noted, are based on liabilities being discounted using the assumed portfolio return of 7.5 percent.

As previously noted, the PSERS plan currently has a funding ratio of 63.8 percent, and the SERS plan currently has a funding ratio of 59.2 percent. The plans also currently have $52.9 billion and $27.6 billion in actuarial assets, respectively. Given the current level of funding, current asset allocation, and the assumed distribution of asset returns, figure 1 (page 27) shows the probability that each plan will be able to pay its expected future liabilities.

Not surprisingly, because PSERS has a higher current funding ratio, it has a slightly higher probability of solvency at each time horizon than does SERS. Neither plan performs well. Because of their low funding ratios and the volatility of returns, both plans have a 100 percent probability of making future payments for only the next five years. After that point, the likelihood of meeting their promised obligations begins to fall rapidly. For example, though PSERS and SERS have, respectively, an 87 percent and 73 percent likelihood of making all pension payments in 2024, these figures fall to just 31 percent and 16 percent by 2030. In one generation (25 years), both PSERS and SERS will have less than a 10 percent probability of meeting all their promised obligations given their current assets and investment allocations. In

[11] Because the PSERS Consolidated Annual Financial Report for financial year 2014 states only the plan's expected rate of return (7.5 percent) and omits the expected standard deviation of those returns, we assume the expected standard deviation to be equal to the SERS expected standard deviation (13.46 percent) given the similarities in the composition of their investment portfolios.

the next two generations (50 years), SERS and PSERS have less than a 1.5 percent and 4 percent chance, respectively, of being able to finance their promised benefit payments.

Furthermore, even if the two pension plans are funded at levels that exceed their current level, the additional funding will not ensure that the systems have sufficient assets to pay all their expected future liabilities. Figure 2 (page 28) shows the likelihood that the pensions would be able to pay their future liabilities if the current level of funding were 80 percent, 100 percent, or 120 percent of liabilities.

As figure 2 illustrates, if the pensions are funded to a greater extent, the likelihood increases that their assets will cover their future liabilities. However, the additional funding alone does not guarantee that the plans will have sufficient assets. In fact, a current funding ratio of 100 percent or 120 percent guarantees sufficient funds to meet future obligations for roughly the next decade. If the pensions are funded at 80 percent (or become funded at that level in the future), the probability is only 14 percent that the plans will have sufficient assets to cover their expected liability in 65 years. A pension funded at the 80 percent level has less than a 25 percent probability of meeting its obligations by 2040. As the level of funding increases, the probability that the pension will be able to pay all future promised liabilities also increases. Again, assuming the plans were fully funded today, which means that the plans have assets *on hand* that equal the present value of their future liabilities, they would still have only a 51 percent probability of making their promised payments by 2040 and only a 35 percent probability of covering all their currently promised benefits.[12] For an overfunded system—one with 20 percent more assets on hand than the expected value of its future liabilities—this same probability is only 73 percent in 2040, and overall the probability is only 57 percent of making all future promised payments.

[12] The 35 percent figure is consistent with that estimated by Biggs (2010).

If we assume that the actual benefits closely reflect the forecasted level of benefits, an examination of the evolution of a plan's assets yields some interesting insights into the funding probabilities previously discussed. Figures 3 and 4 (pages 29 and 30) show the evolution of the median level of assets along with the distribution of assets over 65 years under various hypothetical current funding levels. Specifically, the figures show the evolution of the median level of assets along with the 10th, 25th, and 75th percentiles. The 10th percentile indicates that the level of assets is less than the median 10 percent of the time or, alternatively, that the level of assets is greater than the median 90 percent of the time.

Figure 3 pertains to a fully funded pension plan. As the figure shows, the median level of assets goes to zero by 2041 (26 years from now) suggesting a 50–50 chance that assets will not be sufficient in year 26 and beyond to pay promised benefits. As already mentioned, even for a fully funded system in which the liabilities are discounted by the expected return, assets will be insufficient to make all future payments more than 50 percent of the time because of the possibility of a sequence of returns that averages less than the expected return and the possibility of a sequence of early returns that are below expectations and that exhaust the stock of assets. The 25th percentile level of assets goes to zero by 2033, indicating a 25 percent chance that assets will be insufficient to cover liabilities beyond 18 years. Alternatively, and equally likely, the pension plan will end up in 2079 with more than seven times the assets that the fully funded plan initially started with.

Figure 4 shows the distribution of assets for a pension that is initially funded at the 120 percent level. Even if the pension is currently funded at the 120 percent level, the 25th percentile wealth level goes to zero in 25 years, suggesting a 25 percent chance that assets will be insufficient to pay promised benefits after 2039. The median level of assets in the final period

(2079) is almost three times the pension's starting level of assets. Although not shown in the figure, the 75th percentile asset level in 2079 is approximately 24 times the initial level of assets! Not surprisingly, as the level of current funding increases, so does the expected ending distribution of assets.

As alluded to earlier, Novy-Marx and Rauh (2009, 2011) have suggested that because public pension liabilities are virtually guaranteed, future liabilities should be discounted by risk-free interest rates instead of the assumed rate of return on the portfolio the pension plan is holding (which is 7.5 percent). Discounting by a risk-free rate instead of a higher rate significantly increases the present value of the pensions' future liabilities. If the Treasury yield curve is used to discount the year-by-year liabilities, the present value of the sequence of 65 annual payments is 88.2 percent greater than the present value of the sequence discounted using an interest rate of 7.5 percent.[13]

Even if the pensions were funded at this level, as long as their portfolios included risky assets, they still might not be able to pay all of the promised future liabilities because of the randomness in asset returns. In fact, 2079 (or 64 years from now), the plans face an approximately 8 percent chance that their assets will be insufficient to pay the promised benefits. In accordance with the previously discussed reasoning, if the pensions had these amounts of assets currently, the likelihood is 92 percent that they would ultimately have too many assets. Figure 5 (page 31) shows the distribution of assets assuming a pension is fully funded in the Novy-Marx–Rauh sense.

The median ending asset value equals 24 times the initial level of assets and 45 times the initial assets that a traditionally defined fully funded pension would have when, ideally, the pension plan should have zero assets.

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[13] Yields are as of October 1, 2014.

As these figures demonstrate, fully funding a pension plan (on the basis of discounting liabilities by the expected return) does not guarantee that a pension fund will have sufficient assets to pay all its promised future liabilities. Therefore, to the extent that a plan's level of funding is used as a proxy for solvency or for ability to pay future benefits, the pension funding level is incomplete; the ability to make future payments depends on the amount of the pension's assets as well as the performance of the portfolio of the assets that the pension plan is holding. Thus, a key question should be, "Given the portfolio of the pension plan, how many assets would the plan need to have to provide a certain level of confidence that it will be able to pay all promised benefits?" For a given portfolio of assets, table 1 (page 33) shows the amount of assets that each of the pension plans must have to achieve a certain degree of confidence that it would be able to pay all future benefits.[14] Specifically, the table shows the minimum level of assets a pension would need to have to be 90 percent, 95 percent, and 99 percent confident that its assets are sufficient to pay all future benefits.

For a pension such as PSERS or SERS to have a 10 percent chance of failing to have sufficient assets to pay all its future liabilities (or a 90 percent chance of success), the fund would need assets equal to 181 percent of the present value of its liabilities. For the plan to achieve a higher level of confidence, such as 95 percent or 99 percent, the funding ratio explodes to 210 percent and 282 percent, respectively. Increasing the confidence level from 90 percent to 99 percent requires an additional increase in the initial pension funding level of 100 percent.

If a pension plan were funded at these levels, the amount of assets that the plan might ultimately end up with is likely to be astronomically high. For example, if a pension wants to have only a 5 percent chance of not having sufficient assets to pay all its liabilities, it will have a

[14] Table 1 assumes the return of the pension plan's portfolio is normally distributed with a mean of 7.5 percent and a standard deviation of 13.46 percent, and the liabilities are discounted at 7.5 percent.

95 percent chance of accumulating an excess of assets by the end of the 65-year sample period. Figures 6 and 7 (pages 33 and 34) show the evolution of the distribution of assets (the median, 25th percentile, and 10th percentile) for the 95 percent and 99 percent confidence levels (the 5 percent and 1 percent failure rates).

For a failure rate of 5 percent or a confidence level of 95 percent, the 10th percentile asset level in the final period is approximately five times the initial assets in a fully funded system. In that scenario the pension has a 90 percent chance of ending up with this amount of assets or more. The 75th percentile level of assets is almost 21 times the initial assets of a fully funded pension.

As expected, the result is even more extreme for a 1 percent failure rate or 99 percent level of confidence (figure 7). Although a target level of confidence of 99 percent in a pension system may appeal to the future recipients of the pension benefits, it will nearly always lead to extreme levels of overfunding and an accumulation of an unnecessarily large amount of assets. Given the political pressure that is likely to be associated with gross pension overfunding, this scenario is—and should be—a very real concern for the citizens of the commonwealth.

V. Conclusions

The Commonwealth of Pennsylvania's two largest public pension systems, the Public Schools Employees' Retirement System and the State Employees' Retirement System, are severely underfunded according to traditional metrics and are guaranteed to be able to finance their promised obligations only for roughly the next decade. Although the reforms enacted in 2010 should boost funding levels if investment returns follow the assumed distribution of asset returns and benefits remain unchanged, the funding ratio metric is only a proxy for the probability that the systems will be able to pay their future liabilities. In fact, even if both systems were fully funded today such that they had assets on hand equal to the present value of their promised benefit payments (discounted at the expected return of the pensions' portfolios), both systems would have roughly a 50–50 chance of being able to fulfill their promises in 2040.

This paper has demonstrated a critical issue: whereas pension underfunding can impose significant costs (on employees, the commonwealth, and current and future taxpayers), pension modifications may also generate systems that are significantly overfunded. This possibility holds true whether future liabilities are discounted using each plan's 7.5 percent assumed rate of return or more conservative risk-free rates. Given the pressure that grows when systems are overfunded (in the traditional sense), any reform considerations must balance this inherent tradeoff. Finally, the commonwealth might consider including calculations similar to those provided in this paper in each pension's Consolidated Annual Financial Report. Doing so would allow pension participants and other constituents to better understand the likelihood of potential changes to the system.

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Figure 1. PSERS and SERS: Probability of Having Sufficient Assets

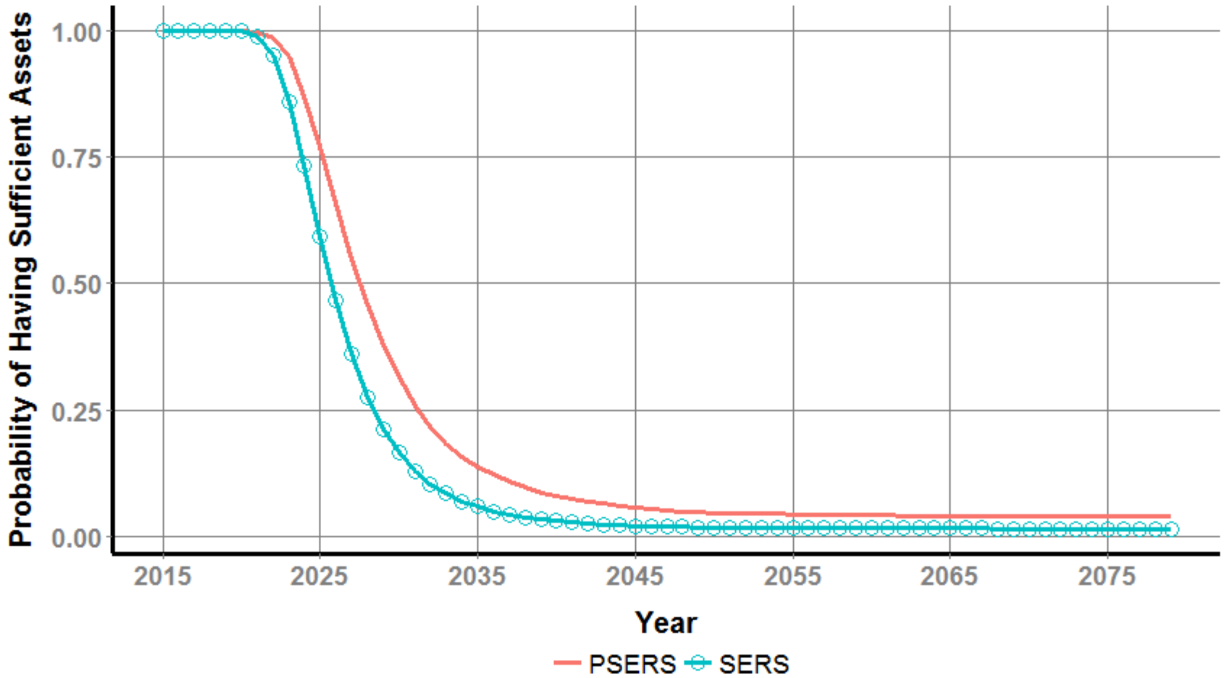

Figure 2. PSERS and SERS: Probability of Having Sufficient Assets under Hypothetical Funding Ratios

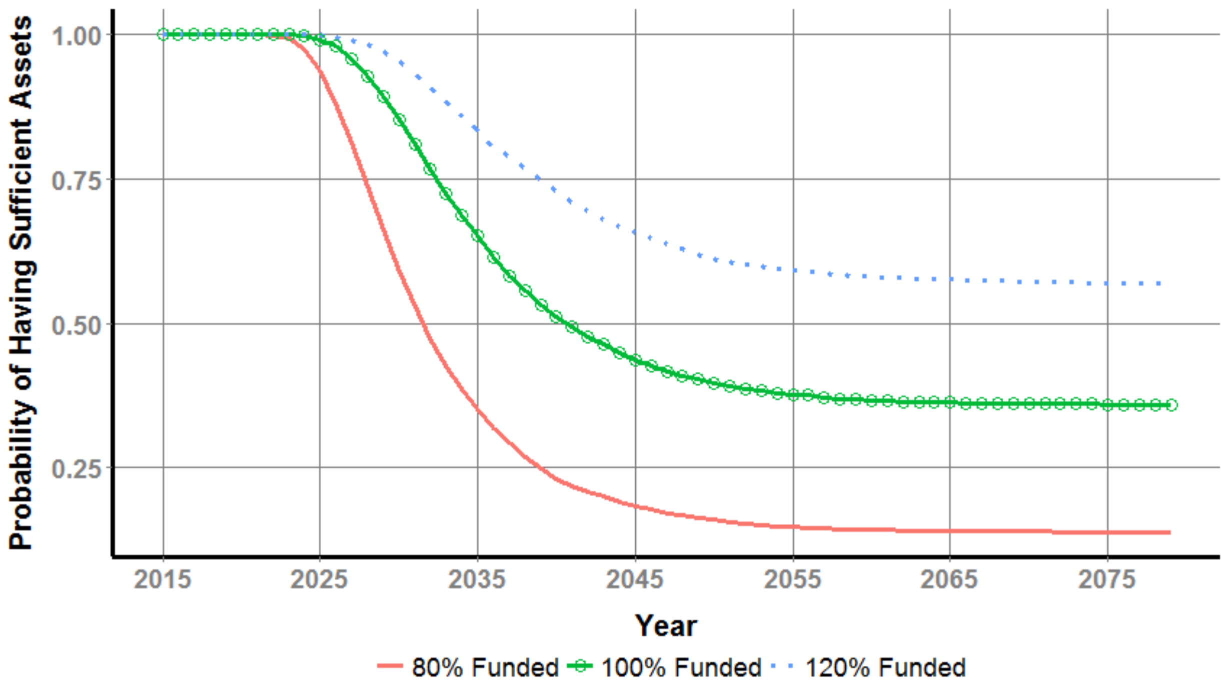

Figure 3. Asset Evolution for Fully Funded Pension

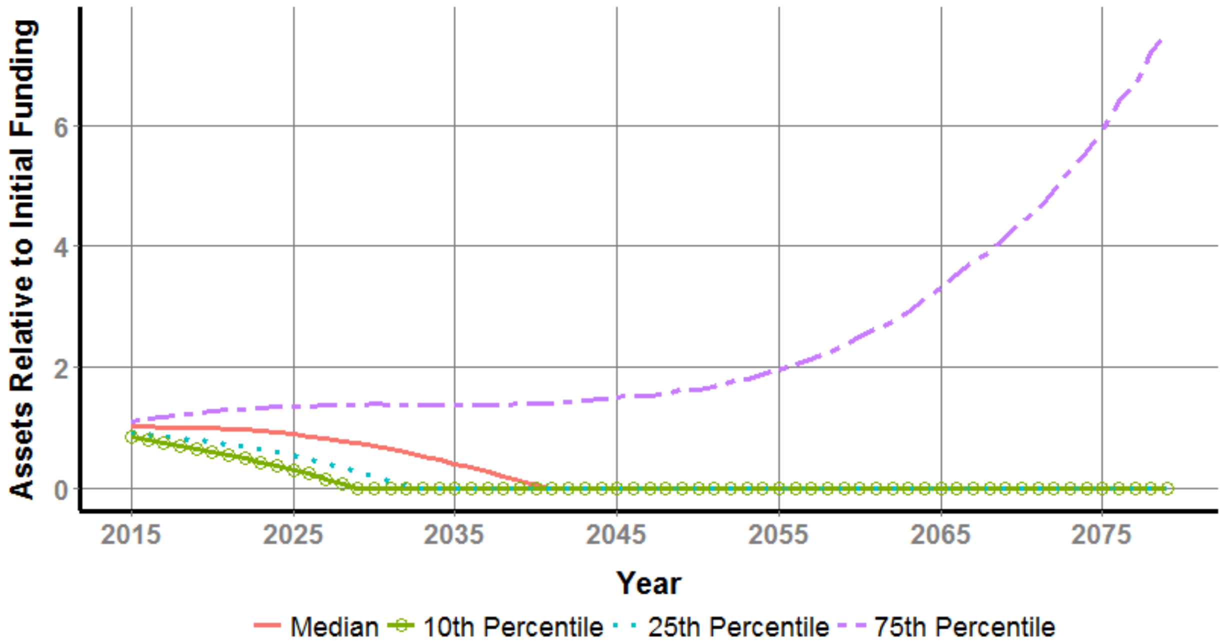

Figure 4. Asset Evolution for Overfunded Pension

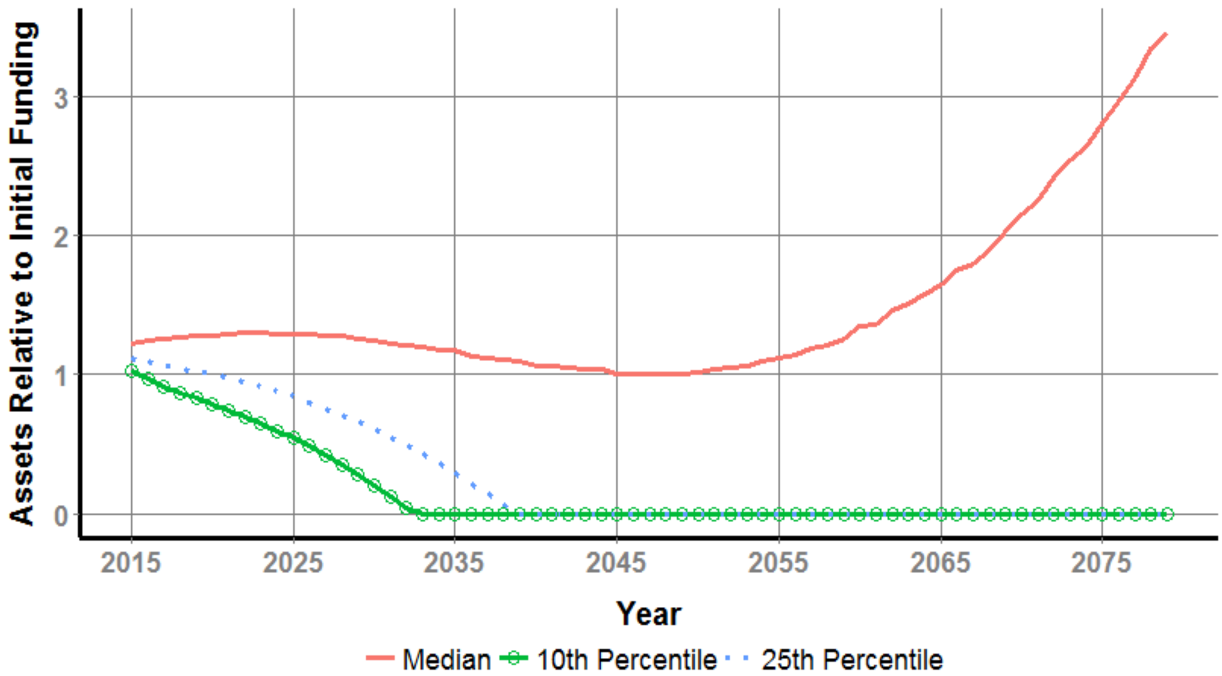

Figure 5. Asset Evolution for a Novy-Marx–Rauh Fully Funded Pension

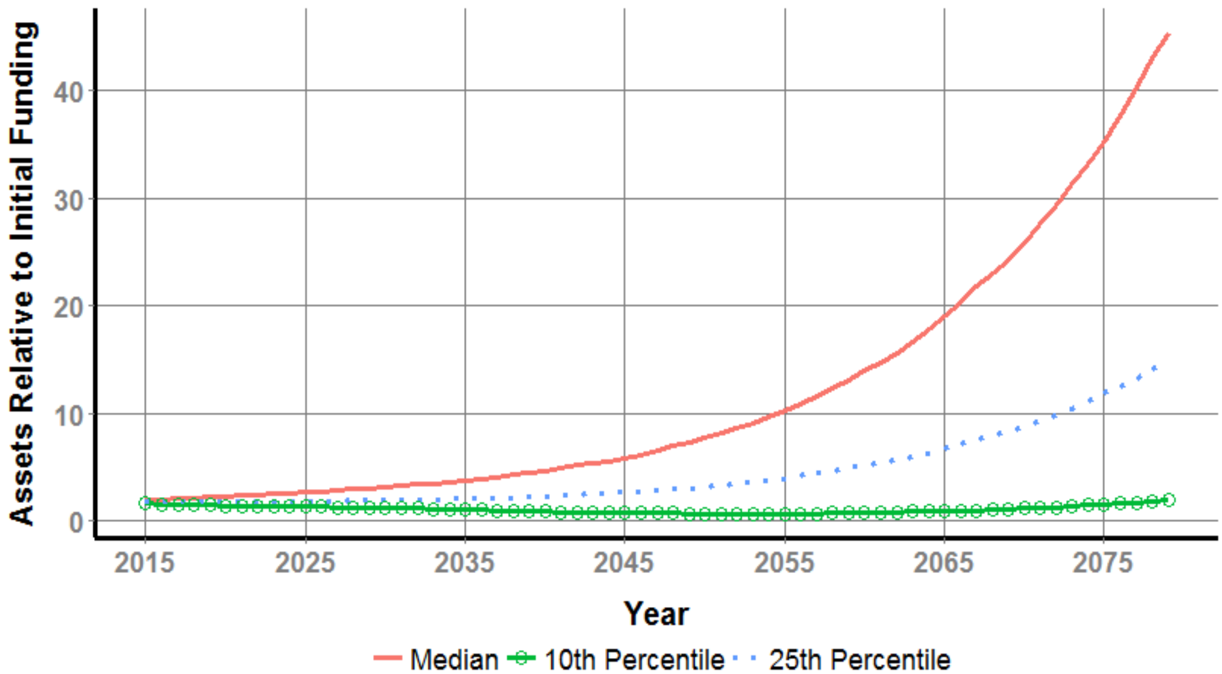

Table 1. Confidence Levels and Pension Funding Levels

Confidence level (%)	Failure rate (%)	Initial pension funding level (%)
90	10	181
95	5	210
99	1	282

Source: Authors' simulations using PSERS and SERS data following methodology of Meder and Staub (2006).

Figure 6. Asset Evolution with 95 Percent Confidence Level

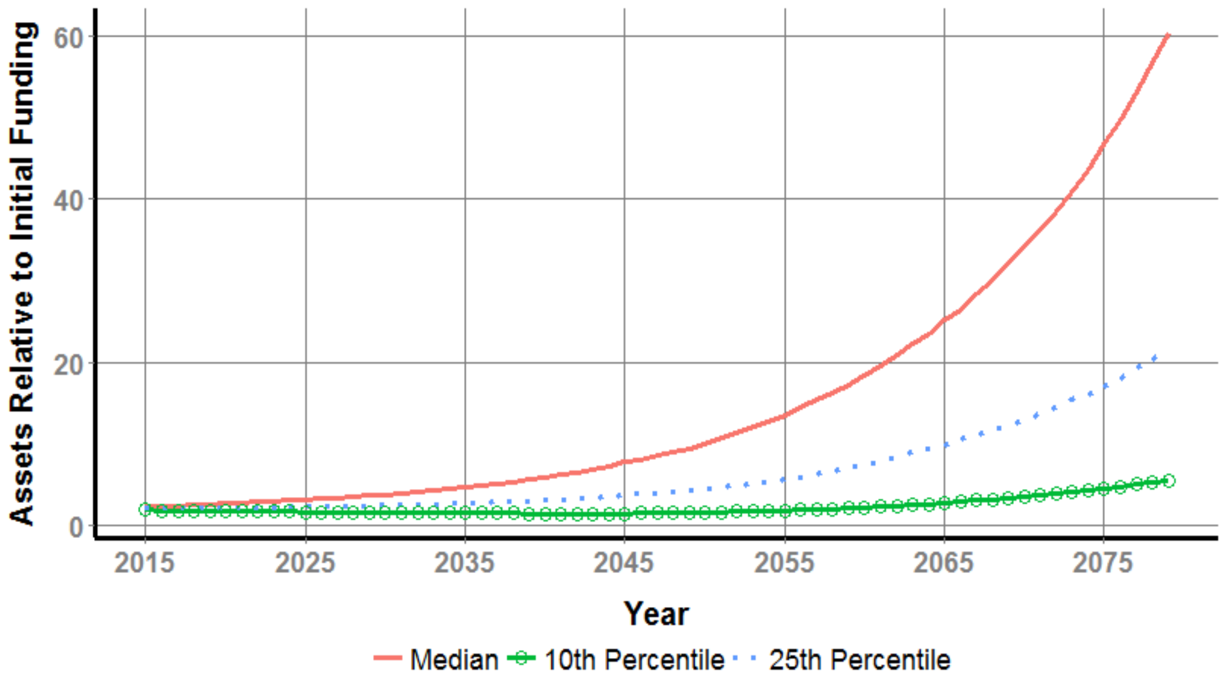

Figure 7. Asset Evolution with 99 Percent Confidence Level