Public pension plan funding policy: Effectiveness of amortization methods under stochastic returns

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One of the most important decisions made for public sector pension plans is adopting a funding policy that balances the needs of all stakeholders. In general, larger benefits require larger contributions. For a given benefit level, the purpose of a funding policy is to balance the level and volatility of contributions with the funded ratio of the plan.

In this article, we continue to explore, compare, and contrast various methods of amortizing liabilities and their impact on the contribution rates allocated to employers.

Plan sponsors use a variety of methods to determine the amortization amount. This article examines the following methods, with amortization periods varying from 10 years to 30 years.

- **Layered method**, where an additional layer of amortization is calculated each year based on the experience or assumption changes made that year. In this article, the first layer is the current unfunded liability, also known as the net pension liability, or the difference between the actuarial value of assets and the total pension liability.
- **Rolling method**, where the amortization is reset annually based upon the entire net pension liability. The amortization period remains constant, resulting in a consistent percentage of the net pension liability paid each year.
- **Aggregate cost method**, which considers the entire actuarial present value of benefits. The difference between the actuarial present value of benefits and the actuarial value of assets is divided by the actuarial present value of future salaries for members as of the valuation date to calculate the contribution rate. This contribution rate is then applied to current salaries.

In the first article of this series, Public pension plan funding policy: Effectiveness of amortization methods, we developed a framework to help plan sponsors understand the funding policy implications of their choice of amortization method if all actuarial assumptions are perfectly met. In the second article, Public pension plan funding policy: Effectiveness of amortization methods under projected investment scenarios, we studied how the various amortization methods reacted to different paths of asset returns. This article expands that discussion to focus on how the various amortization methods handle a larger set of deviations from expectations and react to volatility in investment markets.

Stochastic modeling

Stochastic modeling involves using a random number generator to perform a statistical analysis where 1,000 or more runs are created to test the likelihood of future events. This is also sometimes referred to as Monte Carlo analysis.

In this article, we focus on the volatility inherent in investment markets. We developed 1,000 “random walk” scenarios for the plan’s actual asset returns via stochastic projections using a random number generator. Throughout the remainder of this article, we review how each of the amortization methods react to these scenarios.

Stochastic projections over the 40-year period were generated using a normal distribution, a 7.00% geometric average annual return, and a standard deviation of 12.00%. The equivalent average arithmetic return is 7.72%.

Plan modeled

For purposes of this article, we modeled a "typical" public plan. We use a 7.0% expected return on assets, which is a common assumption among public pension plans, an entry age normal actuarial cost method, and a fresh start for the amortization of the unfunded liabilities. We then explored multiple amortization methodologies. We set assets equal to 79% of liabilities, which is the aggregated funding level in the Milliman Public Pension Funding Index (PPFI) as of January 1, 2021. Additional key methods, assumptions, and plan provisions are listed in our appendix.

In our projections, other than the actual investment returns, we assume that all assumptions are met and that there are no other actuarial experience gains or losses.

"Cones of uncertainty" for contribution rates and funded ratios

To give an idea of the potential range of future contribution rates and funded ratios, we ran a stochastic projection as described above and summarized the results to develop a "cone of uncertainty" for each amortization method studied. This type of projection allows the assessment of the likelihood of certain events in the 1,000 scenarios modeled. This stochastic projection uses these results to generate a distribution of future contribution rates and funded ratios.

Under this type of analysis, we review the probability of an event occurring rather than the specific results of any one scenario.

Figures 1 to 6 summarize the results over time. The median (or the 50th percentile) at any given time is shown by the red line. Half of the results are above the median each year, and half of the results are below the median. The light green and light blue shaded area reflects the 25th and 75th percentiles; 50% of the results are in the light green and light blue shaded area, while 25% are above and 25% are below. The dark green and dark blue shaded area reflects the 5th percentile and 95th percentile. Five percent of results are above the shaded area, and 5% are below.

Figures 1 and 2 show the projections of the funded ratios using both the Layered-15 and Rolling-15 amortization methods. While the shape of the cones under Layered-15 and Rolling-15 is similar, the funded ratio under Layered-15 generally tends to be higher than Rolling-15.

FIGURE 1: LAYERED-15 FUNDED RATIO CONES OF UNCERTAINTY

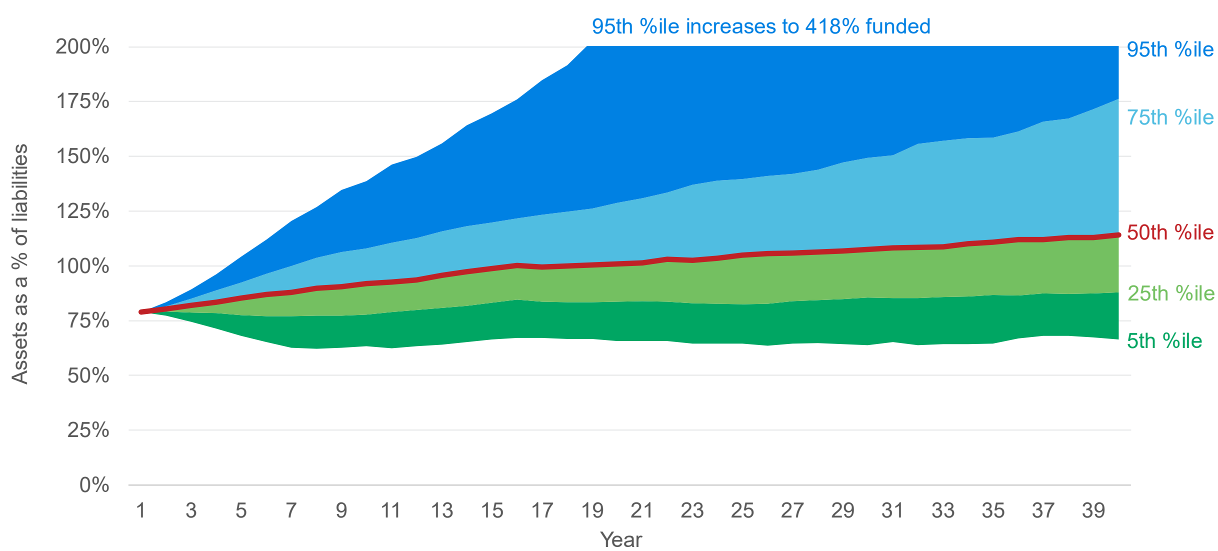
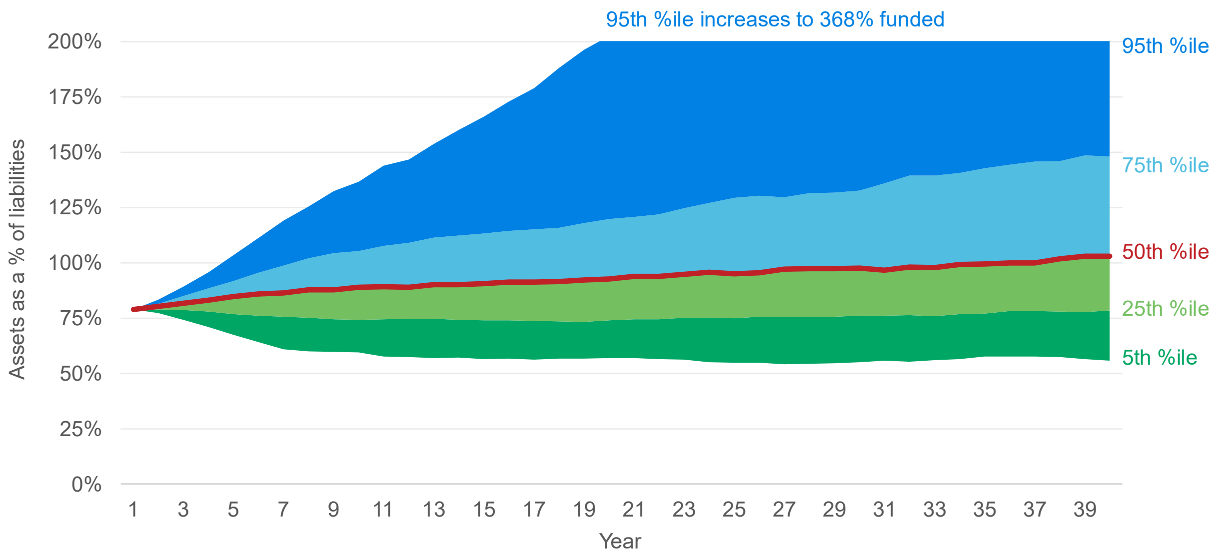


FIGURE 2: ROLLING-15 FUNDED RATIO CONES OF UNCERTAINTY



Next, in Figures 3 and 4, we examine the projections of the contribution rates again using both the Layered-15 and Rolling-15 amortization methods. Note the discontinuity after year 15 in the Layered-15 projection. As the plan modeled was 79% funded at the beginning of the projection a large initial amortization layer was established in year zero. This layer expires in year 15, which leads to the discontinuity.

FIGURE 3: LAYERED-15 EMPLOYER CONTRIBUTIONS CONES OF UNCERTAINTY

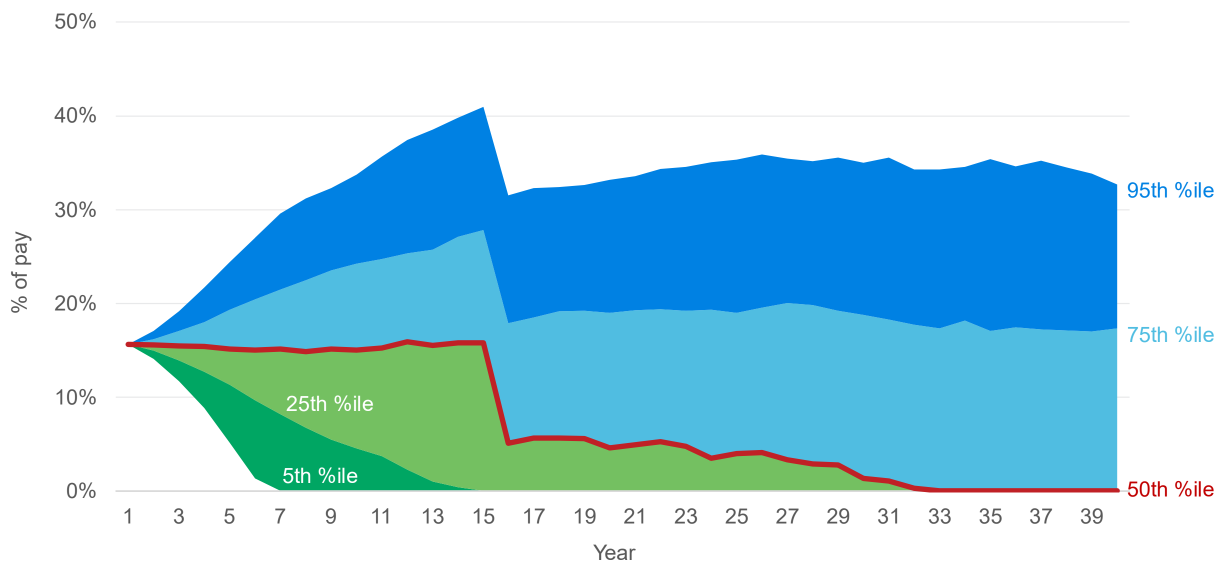
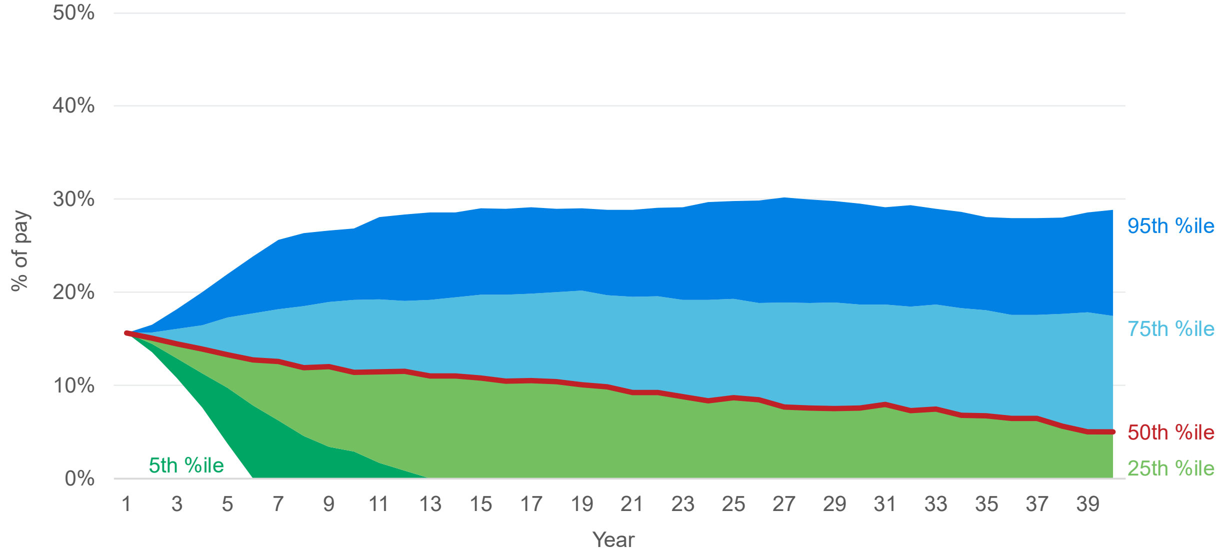


FIGURE 4: ROLLING-15 EMPLOYER CONTRIBUTIONS CONES OF UNCERTAINTY



One limitation of the cones is the illusion of smoothness. The path of a single scenario can be quite volatile. To highlight this volatility, we layer a single scenario on top of the cones of uncertainty in Figures 5 and 6.

The black line represents the funded ratio and employer contributions under Layered-15 for the 500th scenario compared to the cones of uncertainty. We selected the 500th scenario by ordering the scenarios from lowest to highest based on the cumulative return over the 40-year projection period. This median scenario had an annualized compound return of 6.93%, slightly less than the 7.0% expected. For more details, see Public pension plan funding policy: Effectiveness of amortization methods under projected investment scenarios, where we analyze the different methods under this scenario.

FIGURE 5: LAYERED-15 FUNDED RATIO CONES OF UNCERTAINTY AND 500TH SCENARIO

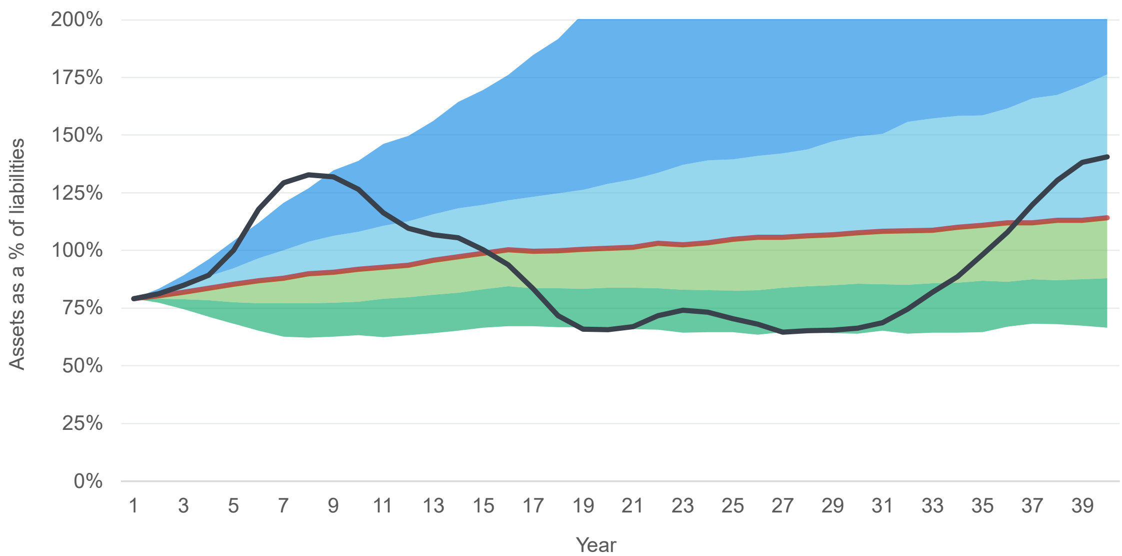
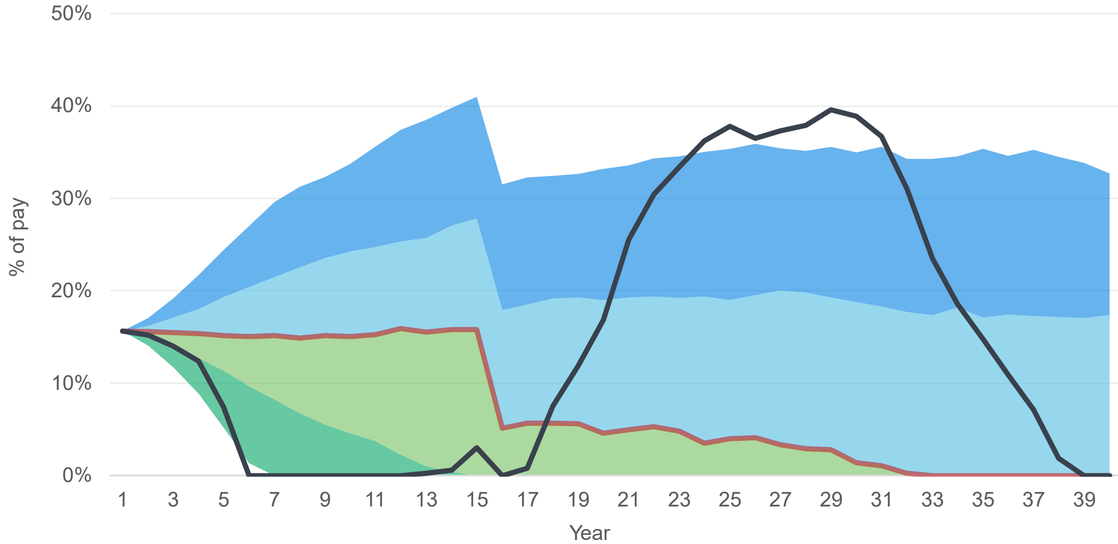


FIGURE 6: LAYERED-15 EMPLOYER CONTRIBUTIONS CONES OF UNCERTAINTY AND 500TH SCENARIO



The black line representing this scenario is an example of the volatility a plan may encounter. This volatility is hidden when examining all scenarios at once. Note that, under a single scenario, the plan may experience funded ratios and employer contributions both below and above the 95th percentile at some point during the 40-year projection period. The single scenario 500 highlighted above demonstrates this phenomenon.

Please see the appendix for a summary of the assumptions used and examples of the cones for the various amortization methodologies studied.

Pain points

We define a “pain point” as an event that would negatively impact the plan sponsor’s ability to continue to conduct its core functions. While a pension plan is an important benefit for the employees, if the funding of that plan requires unsustainably high or highly volatile contributions, then the plan may become a hindrance to conducting government business. Additionally, extreme or volatile funded ratios may be both a political and financial challenge.

PAIN POINTS FOR CONTRIBUTION RATES

How do the various methods of amortizing liabilities impact the contribution rates, both in terms of level of contribution and volatility of contributions? Both variables, level of contributions and volatility, are instrumental in a plan sponsor’s ability to budget.

In general, for a given benefit level, plan sponsors prefer stable rates at manageable levels. However, plan sponsors may differ substantially in their appetite for volatility. In this section, we show examples of how the various methods of amortization differ in their contribution requirements.

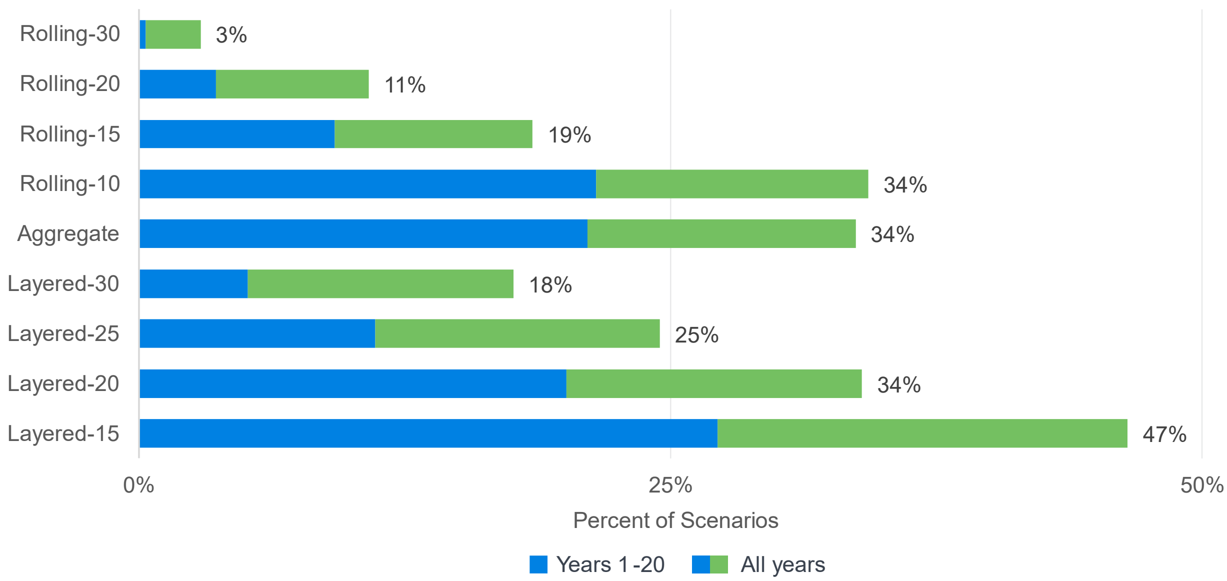
A high level of contributions may preclude the employer from providing its primary services, including being able to provide competitive salaries, while volatile contributions can make budgeting and forecasting difficult, and could require levying additional taxes. High contributions could also lead to benefit reductions. While benefit reductions will eventually lead to lower costs, all else equal, those decreases can be slow to materialize, as many states have laws that restrict the ability to adjust benefits for current employees.

We focus on "pain points" for contribution rates. Employers will have different thresholds, but high absolute contributions and large movements in contribution rates will be common areas of concern. Note that, in the plan modeled, the normal cost rate ranges from 11.4% of payroll to 12.6% of payroll over time, with the employee paying 6% of pay. The initial employer contribution rates range from 12% to 19% based on the amortization period. For this article, the pain points are defined as:

- Employer contribution rate in excess of 30% of payroll at some point in the projection period
- Increase in employer contribution rates of more than 10% of payroll over a five-year period at some point in the projection period
- Increases in employer contribution rates of more than 5% of payroll in a single year

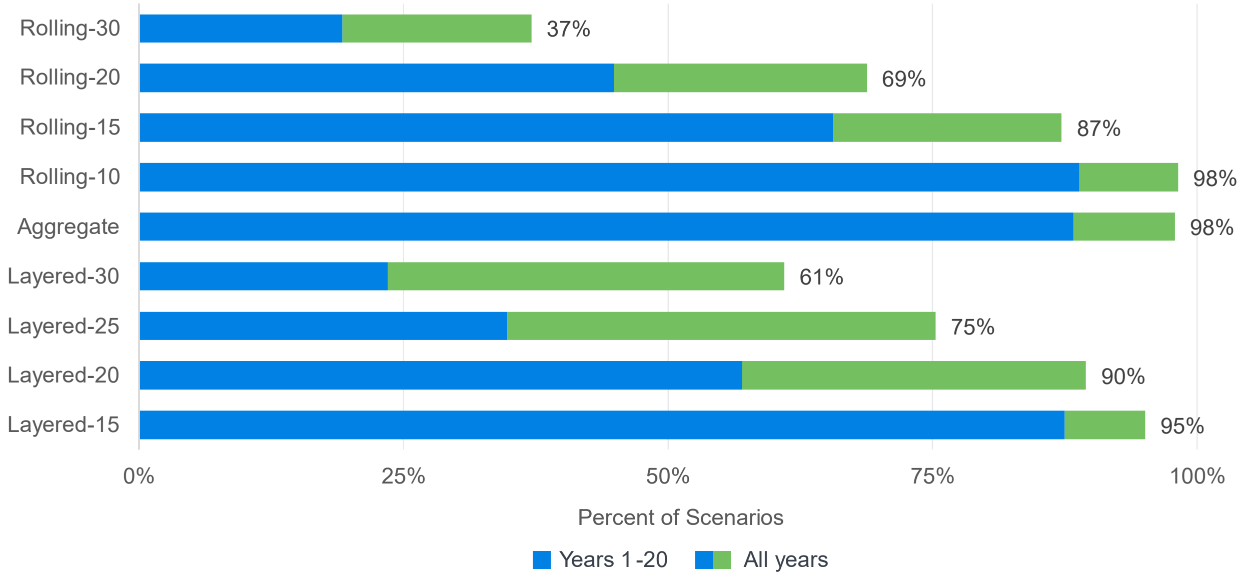
Figures 7 to 9 summarize the percentage of modeled scenarios that cross a pain point at some time during the 40-year horizon. Note that the larger the bars, the more likely that a pain point will be reached.

FIGURE 7: EMPLOYER CONTRIBUTION RATE IN EXCESS OF 30% OF PAYROLL AT SOME POINT IN THE PROJECTION PERIOD



As shown in Figure 7, in nearly half of the scenarios under Layered-15, the employer contribution rate exceeded 30% of pay at some point in the 40-year projection period. Yet this only occurred in 3% of the scenarios under Rolling-30. While this lower likelihood of reaching this pain point is desirable, it is worth noting that the average (mean) contribution rates over the entire projection are only about 1% higher under Layered-15 than under Rolling-30 and yet Layered-15 ends the projection with a much higher average funded ratio (114%) than Rolling-30 (90%), as shown in Figure 20 below.

FIGURE 8: INCREASE IN EMPLOYER CONTRIBUTION RATES OF MORE THAN 10% OF PAYROLL OVER A FIVE-YEAR PERIOD AT SOME POINT IN THE PROJECTION PERIOD



Under Rolling-10, Aggregate, and Layered-15, increases in employer contributions of more than 10% of payroll over any given five-year period are almost certain. Even under Rolling-30, this pain point is not uncommon. Plan sponsors should be prepared to experience this type of increase when sponsoring defined benefit (DB) plans. Note that in Figures 8 and 9 the scale has increased from the 0%-50% range in Figure 7 to a range of 0% to 100% of scenarios.

FIGURE 9: INCREASES IN EMPLOYER CONTRIBUTION RATES OF MORE THAN 5% OF PAYROLL IN A SINGLE YEAR

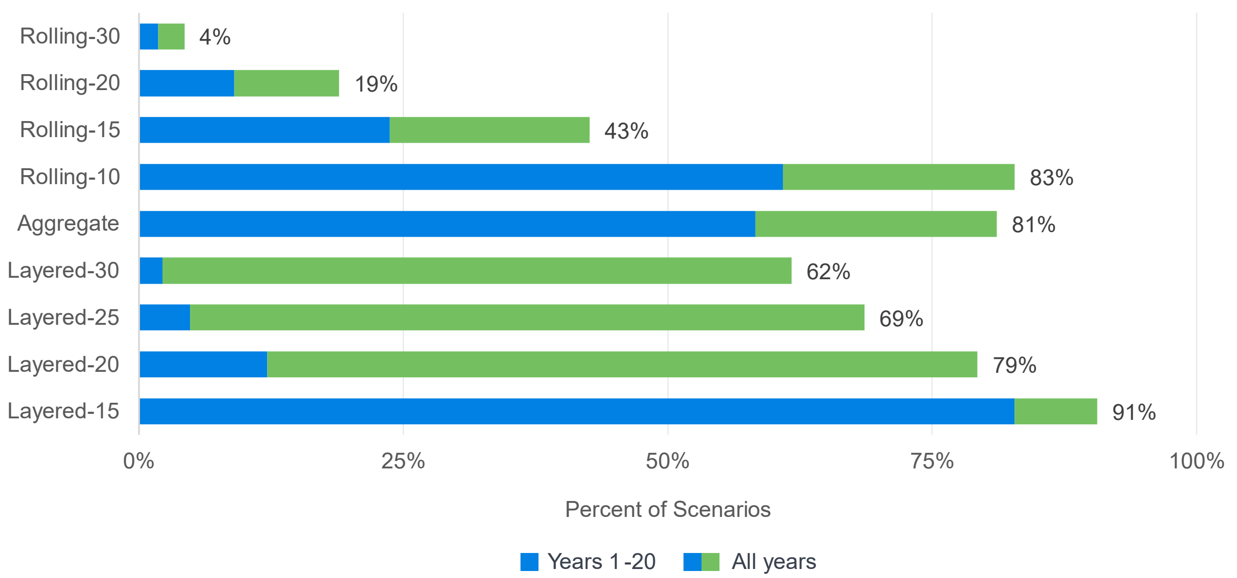


Figure 9 shows that a 5% contribution increase in a single year is also quite likely under the Rolling-10, Aggregate, and Layered-15 methods. This is in stark contrast to Rolling-30, where only 4% of the scenarios see a year-over-year increase of 5% at some point in the projection.

It is clear why Rolling-30 has been a popular method. Employer contributions under the Rolling-30 method are by far the least likely to hit pain points under all three employer contribution stress tests. In a vacuum, where only employer contribution rates are considered, Rolling-30 could be a preferable method. But while Rolling-30 minimizes the pain points for contributions, the method can lead to serious challenges in funding the benefits, as seen below.

PAIN POINTS FOR FUNDED RATIOS

The other side of the discussion is how many benefits those contributions pay for, as measured by how well they fund the promised plan benefits.

While plan sponsors' funding goals vary, for this article we consider a plan sponsor whose goal is to fund at 100%, with no cushion for adverse deviation. This implies that the amount of assets accumulated equals the present value of all future payments allocated to past service based on the actuarial assumptions. It is considered undesirable to have a low funded ratio, as it means that the benefit cost allocated to past and present employees based on the funding policy will need to be paid by future generations.

In addition to generational equity issues, low funding levels can be a pain point for plan sponsors for multiple reasons. First, a low funding level implies high (or increasing) levels of required contributions, which reduces the plan sponsor's ability to provide its primary services. Second, low funding levels may impact the plan sponsor's financial flexibility by impairing its ability to issue debt.

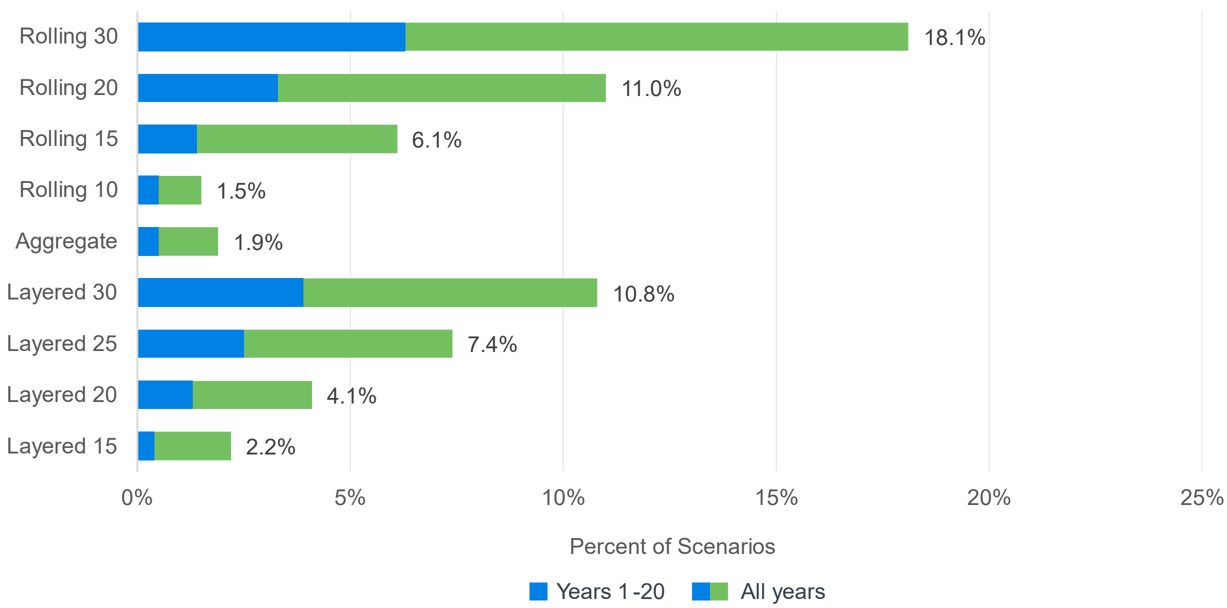
For this article, the pain points are defined as:

- A market value of assets less than six times the benefits paid during the year
- A funded ratio less than 60%
- A funded ratio over 120%
- Failure to achieve a 100% funded status at any time during the projection period

Note that the larger the bars, the more likely that a pain point will be hit.

Figure 10 shows the percentage of scenarios that at some point during the 40-year projection have a market value of assets less than six times the benefits paid during the year. There may be concerns about the ability of a plan to pay for benefits when the market value of assets is this low.

FIGURE 10: MARKET VALUE OF ASSETS LESS THAN SIX TIMES THE ANNUAL BENEFIT PAYMENTS AT SOME POINT IN THE PROJECTION PERIOD



Rolling-30 performs extremely poorly in this metric. In nearly 20% of the scenarios, there would have been serious concerns about the plan's ability to pay benefits. Plan sponsors who utilize Rolling-30 need to be aware of this potential pain point.

FIGURE 11: LESS THAN 60% FUNDED AT ANY TIME

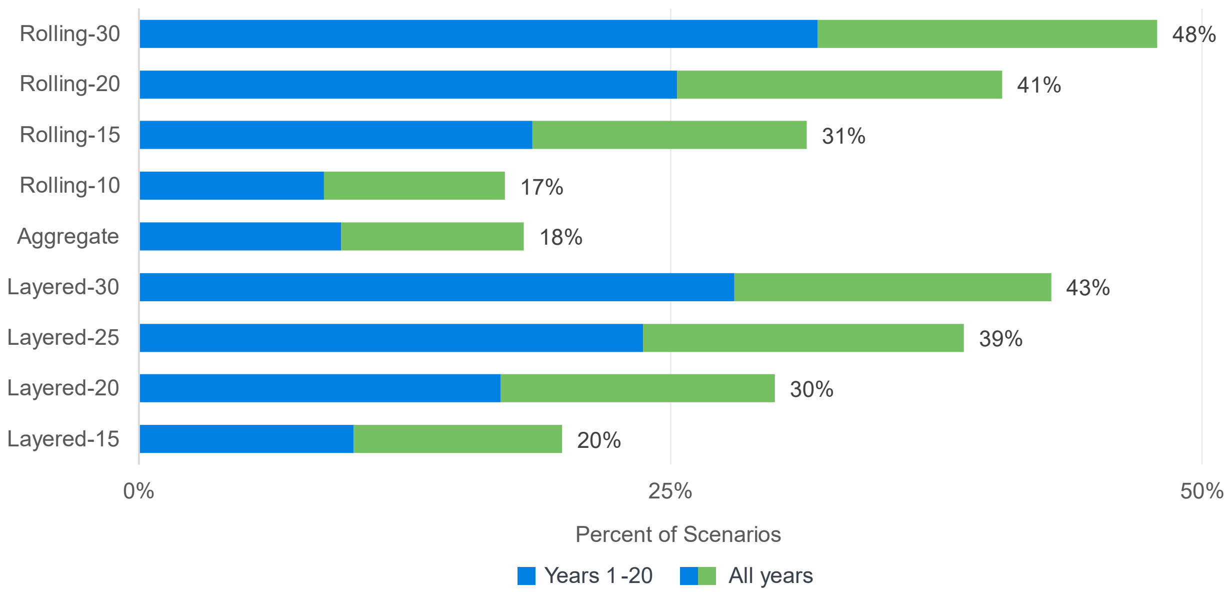


Figure 11 summarizes the percentage of modeled scenarios that drop below the pain point of a 60% funded ratio at some time during the 40-year horizon after starting with a 79% funded ratio.

Rolling-30 is almost three times as likely as Rolling-10 to be under 60% funded at some point in the projection period and crosses this pain point in nearly half of the scenarios. Stakeholders may question the choice of an amortization method with such a high probability of significant underfunding.

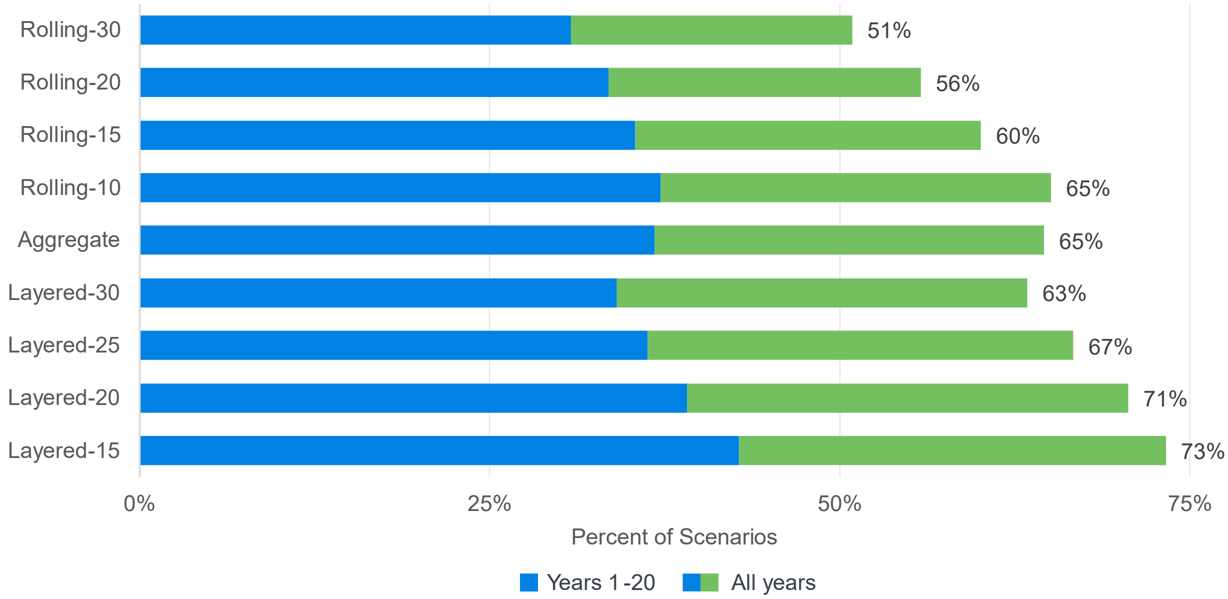
As you might expect, an amortization method that does well by avoiding the 60% funded pain point typically does poorly at avoiding the 30% employer contribution rate threshold in Figure 7 above. There are a couple of notable exceptions. Rolling-10 is the least likely of all scenarios to result in a funded ratio under 60%, yet it does significantly better than Layered-15 at avoiding the 30% employer contribution rate. In addition, it outperforms Layered-20 at avoiding a 60% funded ratio while having the same likelihood of requiring a 30% employer contribution rate.

"Overfunding" can also be a concern. Because assets accumulate in a dedicated trust, excess assets cannot be returned to the plan sponsor until the system has no more members. In an overfunded situation, the plan sponsor cannot use the excess assets for other government purposes. Excess assets can be used to improve benefits or de-risk the plan. High funding levels may put pressure on a plan sponsor to increase benefits, which exposes them to larger risks during a financial downturn.[1] In our projections, we assumed that plan sponsors did not improve benefits or change the plan's asset allocation to de-risk the portfolio.

Figure 12 summarizes the percentage of modeled scenarios that attain 120% funded at some time during the 40-year horizon. Note that, the larger the bars, the more likely it is that the plan will attain a funded ratio of 120%.

[1] As an example of how common benefit improvements are when funded ratios are high, we look back to the last time that funded ratios were as high as 120%, just before the 2000-2002 dot-com crash. Consider findings of a survey conducted by the Wisconsin Legislative Council, entitled the "2002 Comparative Study of Major Public Retirement Systems." The report compared significant features of major state and local public employee retirement systems in the United States. The report considered retirement benefits provided to general employees and teachers. According to the survey, 30 of 85 plans increased their benefit multipliers between 2000 and 2002. In addition, 32 of the 85 plans studied increased their benefit multipliers between 1996 and 2000 (some appeared both times).

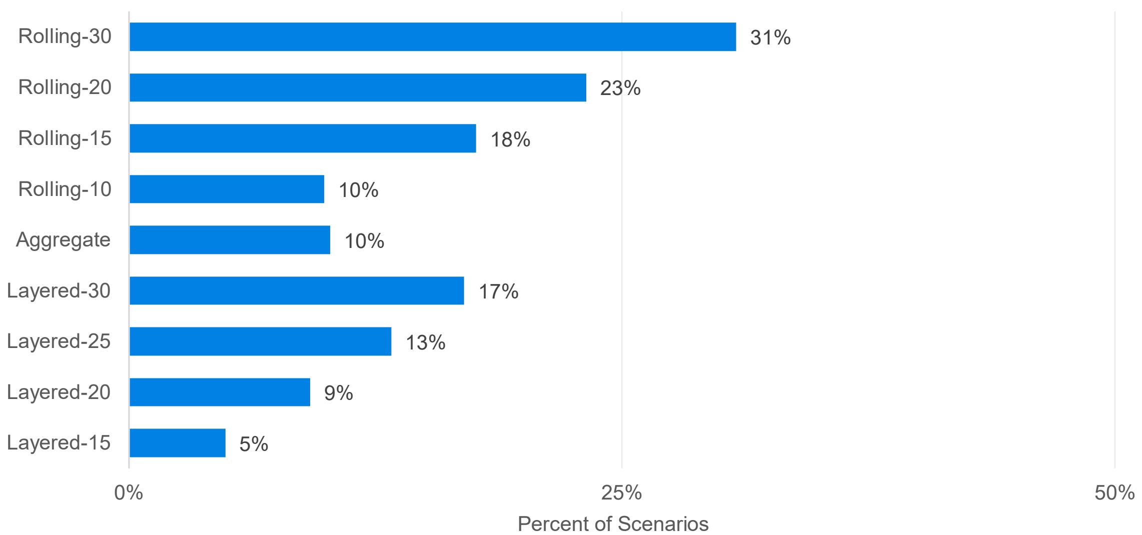
FIGURE 12: OVER 120% FUNDED AT ANY TIME



This pain point may actually be an opportunity as some plan sponsors would find this level of funding desirable and use the opportunity to reduce investment risk. While this would likely reduce the funded ratio (the assumed discount rate is directly tied to the expected rate return on assets), the plan would be better able to weather market downturns. Other plan sponsors may prefer to increase benefits, which would also reduce the funded ratio, but adds more risk.

Figure 13 summarizes the percentage of modeled scenarios that fail to achieve 100% funded at any time during the 40-year horizon. The larger the bars, the more likely that the plan will fail to achieve a funded ratio of 100%.

FIGURE 13: FAILURE TO ACHIEVE 100% FUNDED AT ANY TIME



In over 30% of the scenarios, Rolling-30 never attains 100% funded at any point during the 40-year projection period.

It is now clear why many plan sponsors are moving away from the once common Rolling-30 method even though it provides significant stability in contribution rates. These funded ratio pain points highlight the weakness of the

Rolling-30 method as it produces the highest probability of painful underfunding and the lowest probability of hitting 100% or 120% funded. Stakeholders may question the prudence of an amortization method that struggles to meet the goal of a 100% funded ratio over a 40-year projection and that puts the ability of the plan to pay benefits at risk.

In comparison, Rolling-10 attains a 100% funded ratio in approximately 90% of scenarios, outperforming both Layered-30 and Layered-25. However, there is another consideration when setting an amortization policy, particularly when considering a rolling method. Under Governmental Accounting Standards Board (GASB) 67/68, there is a specific methodology for determining a “depletion date.” Due to the GASB methodology, rolling amortizations are more likely to result in depletion dates than layered amortizations. A future article in this series will provide more detail about this calculation, including examples and some ideas to avoid having a depletion date.

VOLATILITY OF FUNDED RATIOS

While we highlighted potential issues with overfunding above, it is important to note that achieving a positive goal for funding does not mean that there will not be a low funded ratio “pain point” in the future. One measure of the volatility in the funded ratios is how much fluctuation there is over time.

Figure 14 summarizes the percentage of modeled scenarios that cross these pain points at some time during the 40-year horizon. Note that the larger the bars, the more likely that a pain point will be hit.

FIGURE 14: BOTH DROP BELOW 60% AND ACHIEVE 100% FUNDED STATUS

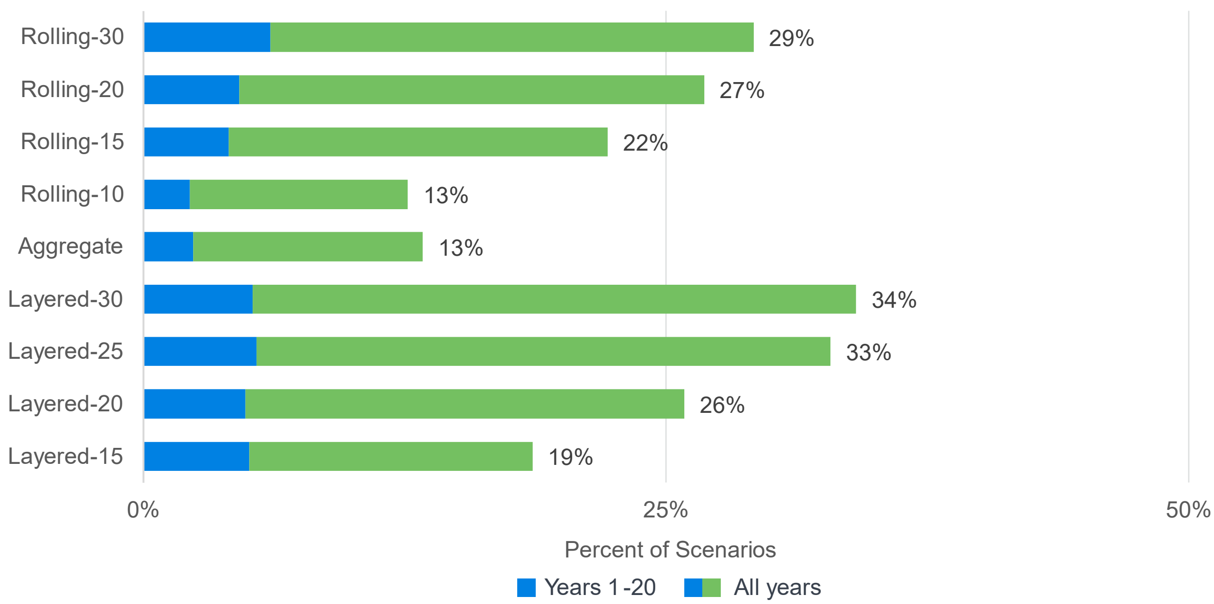


Figure 14 shows the percentage of scenarios which, after starting at 79% funded, both drop below 60% funded and achieve at least 100% funded at some point during the projection (not necessarily in that order). Under this measure of volatility, methods with longer amortization periods tend to be more volatile, compared to methods with shorter amortization periods.

Contribution rate volatility by another metric

Another way to study contribution rate volatility is to look at the distribution of year-over-year changes in employer contribution rates as a percentage of pay. Figures 15 through 18 present the distributions of the 40,000 year-over-year changes from the 1,000 scenarios with 40 years in each scenario. The right-hand side of the graphs present the likelihood of increases in the contribution rates, with decreases on the left-hand side. Note that we have excluded the years that employer contributions remain unchanged at 0% in both one period and the next one.

As could be expected, the longer the amortization period, the more frequently there are small changes in the contribution rates. This is the reason long durations have higher peaks around zero and thinner tails.

Looking at the four different lengths studied for rolling amortizations, in Figure 15, we see similar likelihoods for changes of approximately 2%. However, the longer amortization periods (in green) have significantly more changes within 2%, and significant declines in frequency outside of that (thinner tails).

FIGURE 15: ONE-YEAR CHANGE IN EMPLOYER CONTRIBUTIONS UNDER ROLLING METHODS

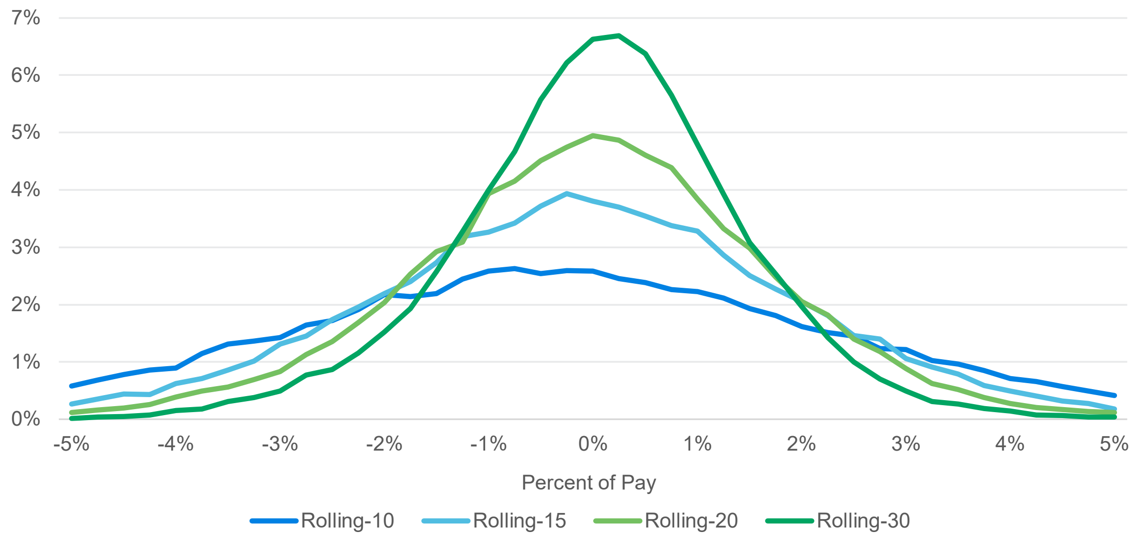
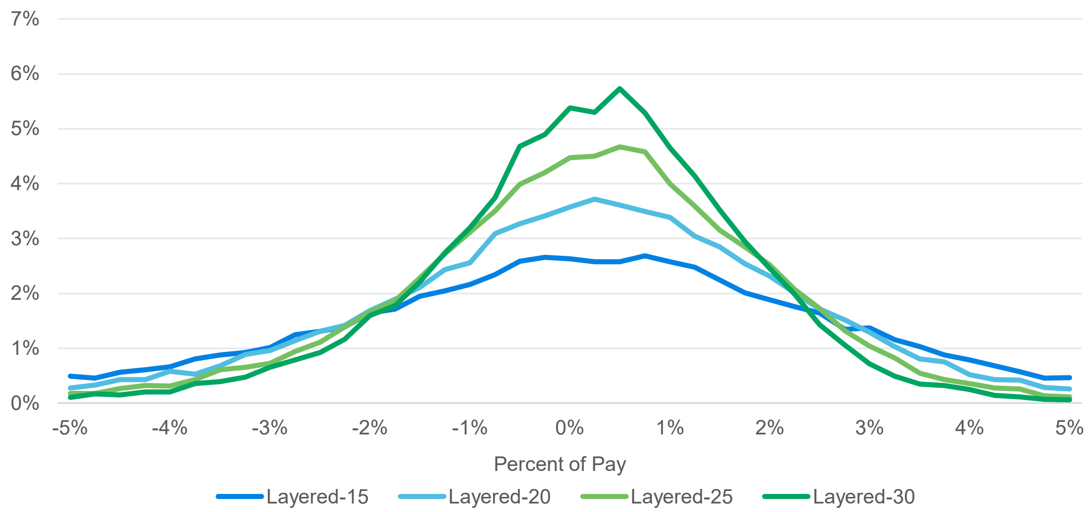


Figure 16 compares the one-year change in employer contributions for various layered amortizations. It is similar to the graph for rolling amortizations (Figure 15), although the peak around zero is not as high and the distribution is not as smooth. The peak is a little right of zero due to the fact that, if the employer contribution rate gets down to 0% then there can be an increase, but there are no decreases below zero. As shown in Figure 19, layered methods have more years of unchanged 0% contributions than rolling methods of a similar amortization length. However, they are also more likely to have more years with 4% or higher increases in employer contributions.

FIGURE 16: ONE-YEAR CHANGE IN EMPLOYER CONTRIBUTIONS UNDER LAYERED METHODS



In Figure 17, we have compared the distributions for Rolling-15 and Layered-20 amortizations. This demonstrates that Rolling-15 and Layered-20 see very similar distributions in terms of the annual change in contribution rates. Eventually, the Layered-20 amortization consists of layers that range in length from one to 20, while Rolling-15 has just one layer of length 15. Figure 17 shows more small declines for Rolling-15 than Layered-20. For Layered-20, it is worth noting that, due to the scale of Figures 15 to 18, the impact of the initial amortization charge being fully amortized 20 years after the first base is established is not shown. The loss of the initial base typically lowers employer contributions by more than 5% in year 21.

FIGURE 17: ONE-YEAR CHANGE IN EMPLOYER CONTRIBUTIONS UNDER LAYERED-20 AND ROLLING-15

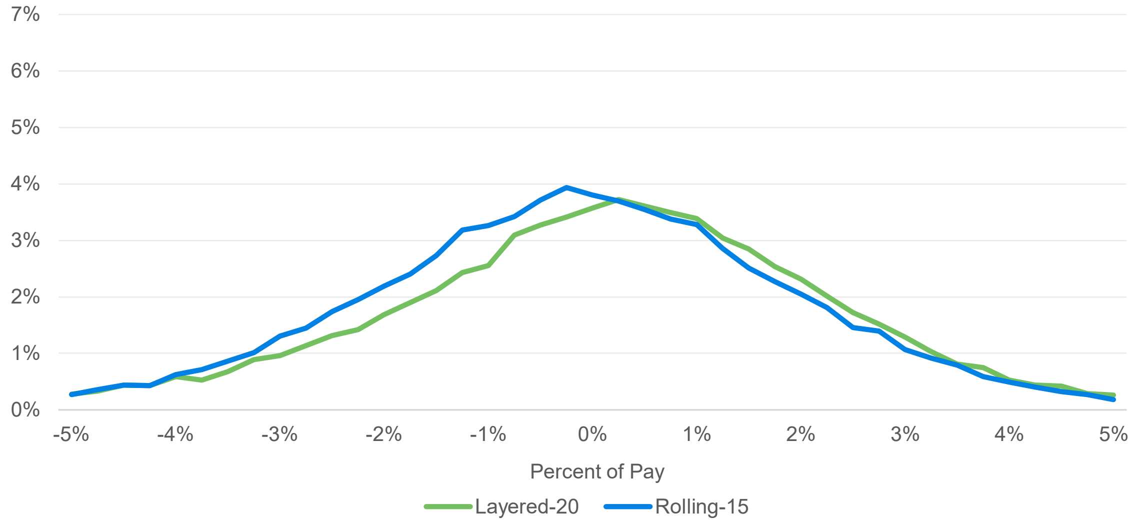
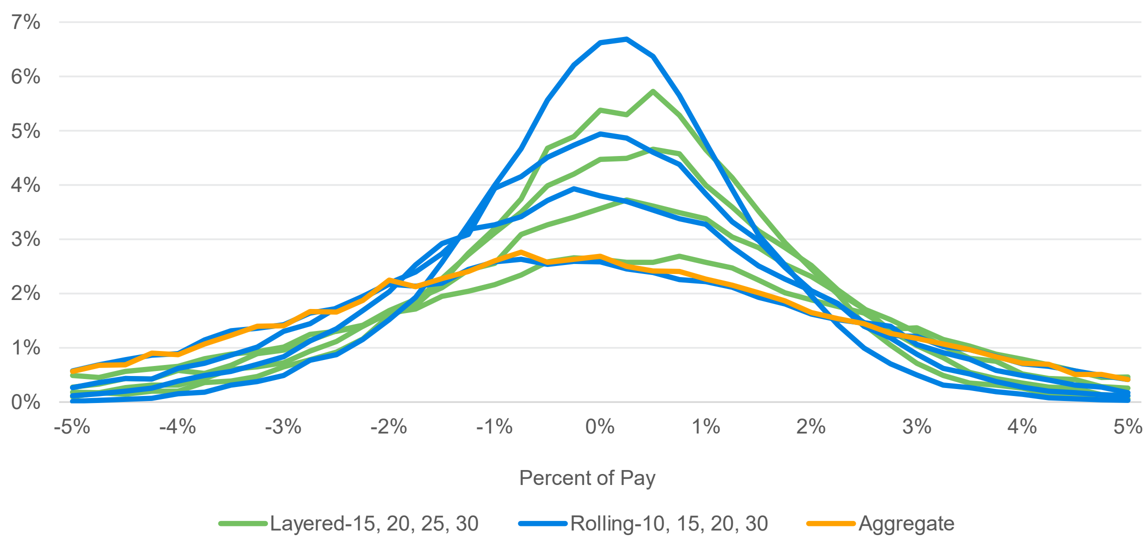


Figure 18 shows the one-year change in employer contribution rates under all methods.

FIGURE 18: ONE-YEAR CHANGE IN EMPLOYER CONTRIBUTIONS

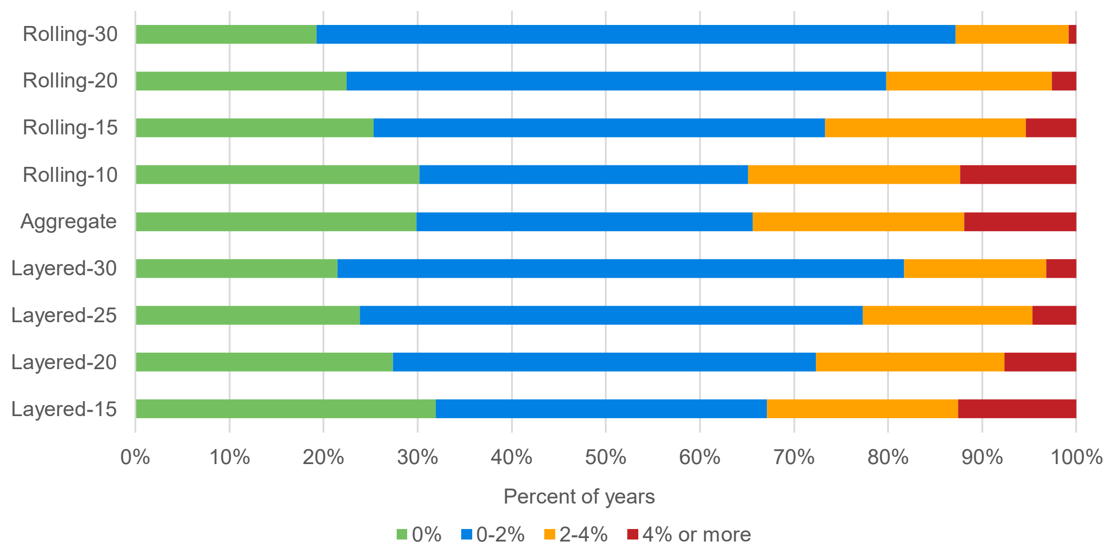


In general, methods with longer amortization periods have more years with changes near 0% (a higher peak) and fewer years with large changes (thinner tails) when compared to methods with shorter amortization periods. Rolling methods have a smoother distribution of results than layered methods with similar amortization periods.

Figure 19 summarizes the absolute value of the one-year changes in employer contributions. Once again, this considers all 40,000 one-year changes based on 40 years and 1,000 scenarios. The green sections of the bars are for years where the employer contributions rates remain 0% in consecutive years. The orange and red sections are for increases over 2% and 4%, respectively. The methods with longer amortization periods are the least likely to have large year-to-year swings but are also the least likely to be funded well enough to have results in the green bars.

As mentioned above, layered methods have more years of unchanged 0% contributions than rolling methods of similar amortization lengths. However, it is worth noting they are also more likely to have more years with 4% or higher increases in employer contributions.

FIGURE 19: ABSOLUTE VALUE OF A ONE-YEAR CHANGE IN EMPLOYER CONTRIBUTIONS



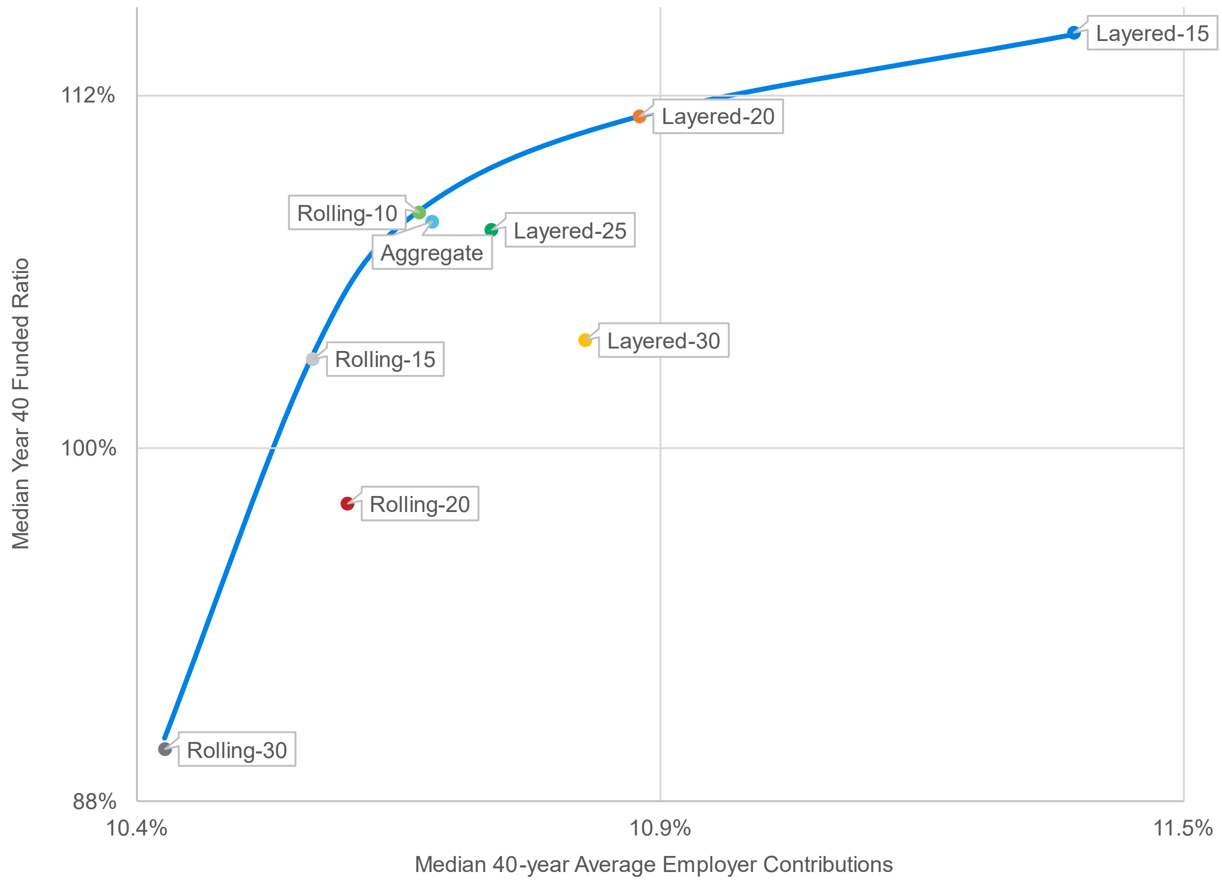
Combining funded ratio and average contribution

Figure 20 combines the median funded ratio with the average contribution rate over the 40-year projection. In general, both higher funded ratio and lower average contribution rates are preferable. Therefore, in general a method that is in the upper left corner would be preferable.

FIGURE 20: FUNDED RATIO AND EMPLOYER CONTRIBUTIONS

	Layered-15	Layered-20	Layered-25	Layered-30	Aggregate	Rolling-10	Rolling-15	Rolling-20	Rolling-30
Year 40 Funded Status									
Median	114%	111%	107%	104%	108%	108%	103%	98%	90%
40-year Average Employer Contributions									
Median	11.4%	10.9%	10.7%	10.8%	10.7%	10.7%	10.5%	10.6%	10.4%
Average	11.9%	11.8%	11.7%	11.6%	11.5%	11.5%	11.3%	11.1%	10.8%

FIGURE 20: FUNDED RATIO AND EMPLOYER CONTRIBUTIONS (CONTINUED)



While low contribution rates under Rolling-30 translate to a low median funded ratio (90%) and the high contribution rates under Layered-15 translate to a higher median funded ratio (114%), higher contribution rates don't always lead to higher funded ratios.

For example, Rolling-15 and Rolling-20 have similar average contribution rates, yet Rolling-15 has a higher median funded ratio at the end of the projection period. Similarly, Layered-20 and Layered-30 also have consistent median contribution rates, but Layered-20 ends with a higher median funded ratio. Methods with shorter amortization periods are more reactive, and thus recover over a shorter period. As a result, when there are periods with high returns, these methods have more assets that increase, resulting in funded ratios exceeding 100%.

It is interesting to note that there is very little difference in the average contribution rates by length of amortization period when considering all 1,000 scenarios over 40 years. Within the family of layered contributions, the Layered-15 contribution averages 11.9% employer contributions, while the Layered-30 contribution averages 11.6%. There are higher initial contribution rates with the shorter amortization periods, but the benefits need to be financed eventually, typically resulting in higher contributions in later years for the longer amortization periods. For perspective, we assume that employee contributions are 6% of pay, and that the total service cost averages 16.2% of pay.

Despite the comparable levels of average contributions, shorter durations do result in higher median funded ratios after 40 years. The higher initial contributions, with lower contributions later, tend to fare better, as investment returns are greater than the increases in payroll in most scenarios.

The average contribution rates for the rolling amortization methods are lower than for the layered methods and the median funded ratio after 40 years tends to be lower. As with the layered amortization methods, the average contribution rates vary little by amortization period within the family of rolling amortizations.

The Rolling-10 method results in lower average contribution levels than all of the layered amortization methods. Despite this, the median funded ratio after 40 years is actually a bit higher for this method than the Layered-25 and Layered-30 methods. The higher initial contribution rates are more than offset, on average, by lower contribution rates in later years. One potential downside of the Rolling-10 method compared to the layered amortizations of longer periods is the greater volatility from year to year.

Conclusion

Developing a funding policy is one of the most important decisions for a public plan sponsor. Unfortunately, balancing the needs of all stakeholders can also make it one of the most challenging. This article highlights the relative strengths and weaknesses of various amortization methods. Many of them are intuitive. For example, shorter amortization periods tend to be more responsive to market events, therefore they have more contribution volatility and a higher probability of reaching a contribution "pain point." All methods have similar average contribution rates, but methods with shorter amortization periods are the most likely to reach funding goals at the end of the projection period.

In the end, the choice of funding policy is a balance of stakeholder needs and each plan sponsor will need to make the best decision to meet these needs.

In our prior article, Public pension plan funding policy: Effectiveness of amortization methods under projected investment scenarios, we discussed the potential for counterintuitive results of layered amortization methods. In our next article, we will discuss a major challenge of rolling amortization methods, the GASB-defined "depletion date."

Future articles will examine how these amortization methods react to the situation where the expected return of assets used for setting the contribution rate overestimates actual underlying market expectations and we will expand the discussion of funding policies beyond simple amortization methods. We will explore adaptive policies that change amortization methods based on funded ratio, "sticky" contribution rates, and other variations.

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Appendix – Key methods, provisions, and assumptions

PROJECTIONS

Assets: Assets are valued based on their fair value, with a five-year smoothing of all fair value gains and losses. The expected return is determined for each year based on the fair value at the beginning of the year and actual cash flows during the year. Any difference between the expected fair value return and the actual fair value return is recognized evenly over a period of five years.

Initial asset values are such that the funded ratio of the plan at the beginning of the projection period is 79%.

Investment earnings: Stochastic projections over the 40-year period were generated using a normal distribution, a 7.00% geometric average annual return, and a standard deviation of 12.00%. The equivalent average arithmetic return is 7.72%.

We generated 1,000 scenarios. The median annualized compound return over the 40-year period is 6.93%. The mean annualized compound return over the 40-year period is 7.00%.

Actuarial cost method: Liabilities are valued using the entry age actuarial cost method.

Data: The population is made up of 50% active members, 15% terminated vested members, and 35% retired and in-pay members. Within each status group, males and females are equally weighted by count.

The population is not assumed to grow or decline. Future members are assumed to have the same ages at entry and distribution by sex of the present members that they replace.

Plan provisions: Normal retirement benefits are equal to 2% of the highest consecutive three years of pay per year of service, up to 30 years. Normal retirement benefits are payable at age 65. Upon retirement, benefits increase annually at 2%.

Early retirement benefits and optional forms of benefits are actuarially equivalent to the normal form of payment.

YEAR-OVER-YEAR RETURNS

We highlighted a single scenario. We ordered the scenarios from lowest to highest based on the annualized compound return over the 40-year period and defined the "median" as the 500th scenario. The returns by year under this scenario are in the table in Figure 21.

FIGURE 21: 500TH (MEDIAN) SCENARIO RETURNS

Mean return: 7.78%

Annualized compound return: 6.93%

Year	Return	Year	Return	Year	Return	Year	Return
1	12.65%	11	1.04%	21	2.09%	31	22.49%
2	15.98%	12	8.51%	22	-19.38%	32	18.76%
3	10.23%	13	3.47%	23	15.82%	33	7.19%
4	42.06%	14	-4.91%	24	-4.38%	34	20.98%
5	31.45%	15	-0.81%	25	-1.44%	35	11.14%
6	-8.53%	16	-18.65%	26	-6.82%	36	26.34%
7	-7.40%	17	1.00%	27	13.31%	37	6.95%
8	-2.44%	18	45.60%	28	5.91%	38	2.41%
9	15.19%	19	18.84%	29	-1.84%	39	1.47%
10	5.16%	20	-1.37%	30	11.54%	40	11.39%

VALUATION ASSUMPTIONS

Contributions

- **Member contributions**: Employee's contributions are 6% of pay annually, regardless of the funded ratio of the plan.
- **Employer contributions**: Service cost plus amortization of net pension liability (NPL) minus employee contributions, but not less than zero. Note that, for the aggregate actuarial cost method, the service cost is defined under that actuarial cost method and there is no component for the amortization of the NPL.

DEMOGRAPHIC ASSUMPTIONS

- **Mortality**: PubG-2010 General Amount-Weighted Mortality Rates Projected with MP-2019.
- **Termination**: Service-based rates starting at 20% in the first year of service and grading to 1.5% at 22 or more years of service.
- **Retirement**: Rates vary by age and service based on retirement eligibility up to 100% at ages 70 or older.
- **Disability**: Age-based rates starting at 0% and grading to 0.1% at retirement eligibility.
- **Discount rate**: Based on a 7.0% annual investment return.
- **Projected payroll increases**: Total plan payroll increases by 3.0% per year. Individual members receive increases due to promotion and longevity.

DEFINED TERMS

- **Actuarial value of assets:** The actuarial value of assets is a smoothed asset value, based on the market value of assets but recognizing gains and losses over five years
- **Amortization methods:** Closed, layered, and open/rolling.
  - **Closed amortization methods:** Under a closed amortization method, the entire net pension liability is amortized by a specific date. Each year after the actuarial valuation, the remaining number of years over which to pay the net pension liability decreases by one year.
  - **Layered amortization methods:** Under the layered method, an additional layer of amortization is calculated each year based on the experience or assumption changes made that year. Each year the remaining number of years over which to pay each individual layer decreases by one year.
  - **Rolling amortization methods:** Under a "rolling" method the amortization is reset annually based upon the entire net pension liability.
- **Contribution rates:** The percentage of salary contributed to pay for pension benefits. Typically, actuarially calculated contribution rates are comprised of two pieces. The first piece is equal to the service cost and the second is an amortization of the difference between the current funded ratio of the plan and the target funded ratio. The target funded ratio is usually 100%, the point where the net pension liability is zero, where the actuarial value of assets is equal to the total pension liability.
- **Funded ratio**: The ratio of the assets to the measured liabilities.
- **GASB:** Governmental Accounting Standards Board
- **Individual entry age actuarial cost method:** The individual entry age actuarial cost method assigns the expected cost of benefits to the years of service for each individual covered by the pension plan. This is the only actuarial cost method permissible for financial reporting under current standards of the GASB. Under this method, a service cost is calculated based on the percentage of pay required to fund contributions, if all actuarial assumptions were exactly realized from hire date until retirement date. The total pension liability is the share of the actuarial present value of benefits assigned to past service based on prior service costs.
- **Median**: The midpoint of a frequency distribution of observed values. The median value of a data set means that half of the values are larger and half are smaller than the median.
- **Stochastic modeling (Monte Carlo analysis):** "Stochastic testing" involves using a random number generator to perform a statistical analysis where 1,000 or more runs are created to test the likelihood of future events. This is also sometimes referred to as Monte Carlo analysis.