How Much Investment Risk Can a Government-Sponsored Pension Plan Afford?

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Abstract

Should the investment policy be the same for a pension plan sponsored by an entity that primarily relies on income and capital gains taxes as for a plan sponsored by an entity that primarily relies on property taxes? What about sales taxes? Should the investment policies be the same for a plan with assets equal to 10-times covered payroll as for a plan with assets equal to five-times covered payroll? Should the investment policies be the same for a plan with a declining population as for a plan with a growing population? Interestingly, financial economics purists and many current practitioners both seem to support one-size fits all approaches to investing, although they advocate very different investment policies. We believe that the specific risk factors of a plan should drive its investment policy.

Some financial economics purists argue that, in theory, public sector pension funds should minimize investment risk by using Treasury securities to match projected benefit payments. However, in actual practice, funds accept investment risk that is expected to be rewarded over the long term. As a result, most large public sector pension funds have a target fixed income allocation of 25 percent to 30 percent and an actuary's expected rate of return between 7.5 percent and 8 percent. Also, some funds have issued pension obligation bonds in order to fund their liabilities, based on the assumption that they can earn excess returns above the interest cost of the bonds over the long term.

While we are not convinced that future taxpayers would really prefer public pension funds to invest entirely in Treasury securities, we also find it surprising that different plans with very different risk characteristics would invest in essentially the same way. Insufficient consideration seems to be given to the different risk characteristics of the pension plan, the implications of those risks, or to the sponsor's ability to shoulder those risks. While pension plans are long-term investors, some risks may not be affordable.

This paper explores some characteristics of pension plans that affect the type and amount of investment risk a government sponsored pension plan can afford, including:

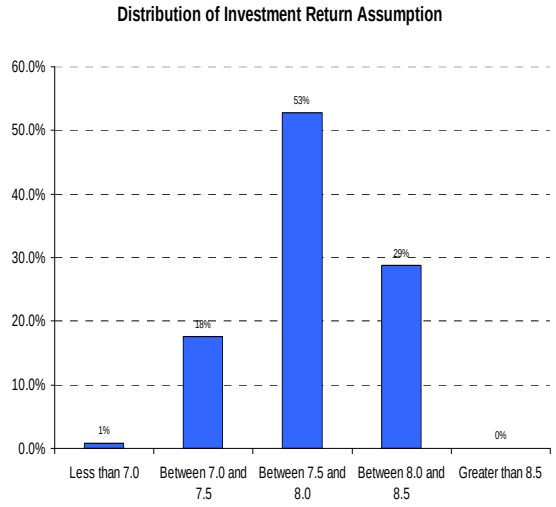
- size of plan compared to the size of the sponsoring entity,
- maturity of the pension plan,
- current funded status, and
- tax basis of sponsoring government entities.

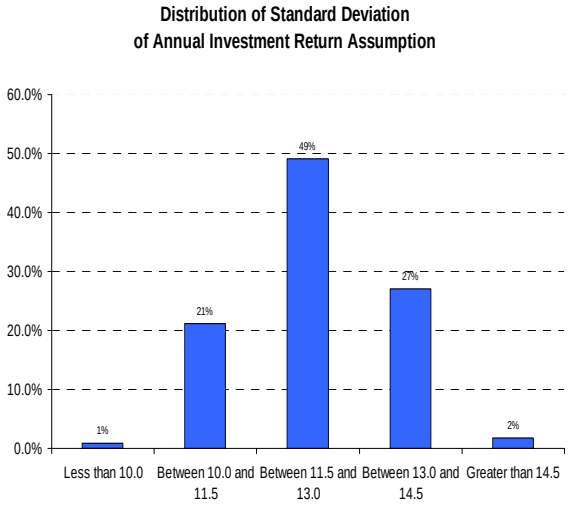
The analysis is based upon a stochastic model of capital markets applied to a variety of hypothetical situations to illustrate how investment risk affects different pension plans differently. We propose a framework for assessing how much investment risk a public pension plan can afford by defining the "pension event horizon," and we conclude with a discussion of how optimal investment allocations may vary based on the risk characteristics studied.

Introduction

Public sector pension plans across the country have remarkably similar investment policies. Funds compare their investment allocations to those of other public pension plans and rank themselves in terms of the rate of return achieved each year. Investment consultants work with actuaries to conduct asset-liability modeling studies for these funds but, in the end, the basic fixed income allocation for these funds tends to range between 25 percent and 30 percent of the portfolio. Deciding the pension investment strategy in this way could lead to a feedback loop where investment committees are encouraged to increase risk exposure, regardless of risk tolerance, in order to maintain investment performance relative to the peer group. This approach, and the associated way in which compensation is structured, may create an incentive to take risk rather than manage risk.

The chart below shows our estimate of the expected return and standard deviation of return for the funds reported in NASRA's Public Fund Survey. Over half of the funds have an expected return of between 7.5 percent and 8.0 percent with virtually all funds between 7.0 percent and 8.5 percent. The expected standard deviation of annual investment returns for just under half of the funds falls between 11.5 percent and 13 percent. The actuarial assumed return for 93 percent of these plans is between 7.5 percent and 8.5 percent.





A given plan's current investment policy may be fine, but this close clustering suggests that systems may not be assessing the risks to the specific plan or the ability of the specific sponsoring entity to tolerate such risks.

In a widely cited issue brief, Boston College's Center for Retirement Research estimated that the funded status of state and local government pension plans declined from approximately 87 percent in 2007 to about 65 percent as of October 9, 2008, based on the market value of assets. As of this writing, the S&P 500 has lost an additional 5 percent since October 9, 2008. We suspect that some sponsors will find these losses painful while others will find them debilitating.

The intent of this paper is to explore the different dynamics that result from the interaction of certain risk characteristics of the plan sponsor with investment risk in the plans themselves. These interactions are a starting point that we believe point plan sponsors in the general direction of a sustainable retirement program. The dynamics raise the question of whether or not the investment risks are affordable. The plan sponsor will need to analyze the specifics of their situation in more detail to develop the right benefit, funding and investment policies for them.

Basic Plan Model

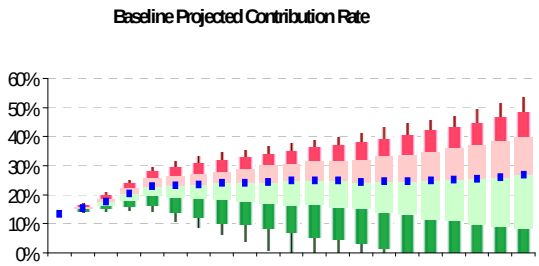
To explore these different characteristics, we begin with a baseline plan with the following starting characteristics.

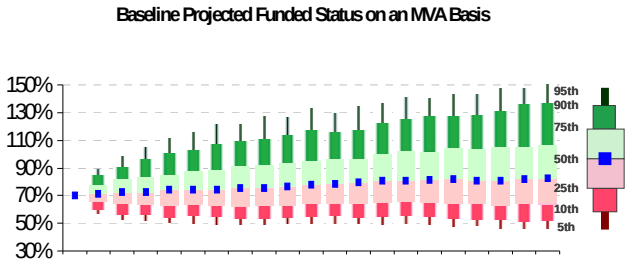
Market Value of Assets	$14,000
Actuarial Value of Assets (five-year smoothing)	$19,274
Actuarial Accrued Liability	
Actives	$8,000
Vested, Terminated	$2,000
Retired	$10,000
Total	$20,000
Payroll	$4,000
Normal Cost Rate	12%

The baseline plan develops a contribution rate by amortizing the unfunded actuarial accrued liability over an open period of 20 years as a level percentage of payroll. It is invested in a portfolio that is 75-percent equity and 25-percent fixed income with an expected rate of return of 8.0 percent.

To recognize a pattern in public pension plans of using surpluses to improve benefits, benefits under the baseline plan are increased whenever the funded status on both a market value basis and an actuarial value basis exceeds 150 percent until the funded status on a market value basis has been reduced to 150 percent. Anecdotal evidence indicates that benefit improvements are often granted far earlier than the attainment of 150-percentfunded status.

The normal cost rate and amortization method remain constant throughout our analysis as we vary other plan characteristics. The charts below show the distribution (from fifth to 95th percentile) of projected contribution rates and funded status over a 20-year horizon for the baseline plan.



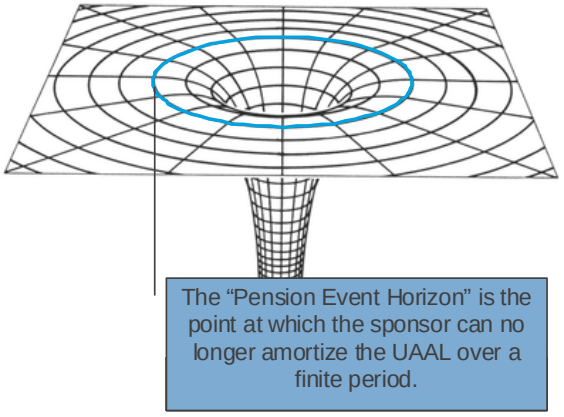


The median contribution rate of the baseline plan increases from 12 percent to 27 percent of pay at the end of the projection, with a 5 percent probability that the contribution rate will exceed 54 percent of pay. Is this level of investment risk affordable?

In the public sector, GASB mandates the accounting disclosures, but the only requirements to actually fund the benefits are created by the state or local government—often the plan sponsor. Some public entities do not allocate the funds to make the contributions recommended by the actuary. As such one might argue that a contribution rate of 54 percent does not represent the proper risk metric because the sponsoring government will simply contribute less. But when the government does not contribute enough, at some point the plan becomes unsustainable. The actual day of reckoning only comes when there are insufficient assets to make the promised benefit payments, but the momentum toward a day of reckoning is set much earlier. Postponing contribution increases until the day of reckoning causes required contribution rates to increase far beyond 54 percent.

For our purposes, we borrow a term from physics for the point at which one inescapably enters a black hole and define the "pension event horizon" as the point at which the plan sponsor's maximum sustainable contribution is insufficient to pay normal cost and amortize the unfunded liability over a finite period.

Pension Event Horizon

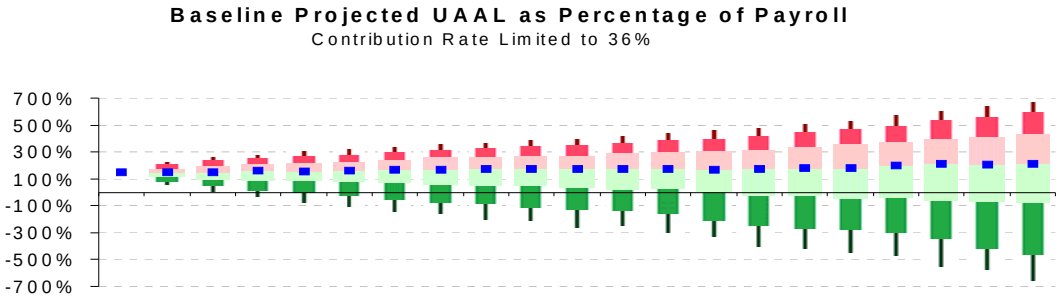


The plan sponsor's maximum sustainable contribution does not necessarily equal a current statutory maximum contribution rate. It is the maximum rate that can be sustained over a long period of time. It will vary by entity and is subjective. While a contribution of 50 percent of pay may be possible over a short time period, it is difficult to see how such a contribution rate could be sustained over a long period of time except, perhaps, for a small or closed group of participants.

For purposes of this paper, we define the maximum sustainable contribution rate as 36 percent of pay. Given a normal cost rate of 12 percent in our basic model, the maximum sustainable contribution provides a payment on the unfunded liability of 24 percent of pay. Our basic plan model crosses the pension event horizon when the unfunded liability exceeds approximately 576 percent of payroll. From this statistic, we can anticipate that the size of the pension obligation relative to payroll will be influential in assessing the amount of risk that can be tolerated.

Now that we have defined a pension event horizon, we need to determine what probability of crossing the "pension event horizon" is acceptable. Certainly, the probability should be low and some may argue near zero, but for our analysis, we will use a 5-percent probability as tolerable.

The chart below shows the projected unfunded liability for the baseline plan assuming contribution rates are capped at 36 percent of payroll.



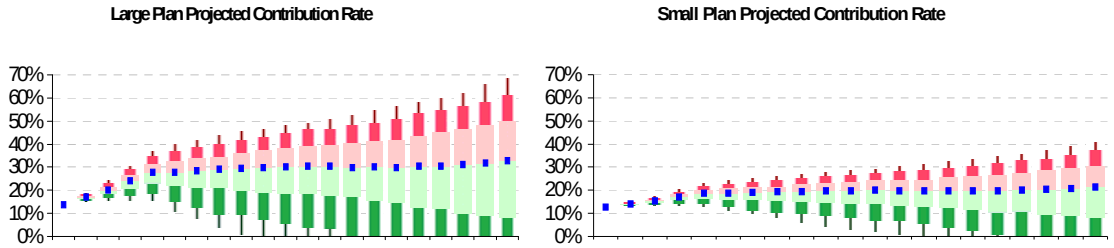
The chart shows a 10 percent probability after 20 years reaching our defined “pension event horizon”. When a plan does not meet the defined affordability criteria, the sponsor has four options to consider:

1. Change the maximum sustainable contribution rate (i.e., recognize that the risk being taken requires a flexibility to pay a sustained contribution at a higher rate).
2. Contribute more than the recommended contribution rate when it is lower than the maximum sustainable contribution rate.
   - This creates an additional cushion against potential losses, although it also increases the amount exposed to investment risk, as we will discuss later.
3. Change investment policy to reduce the probability of crossing the “pension event horizon.”
4. Change benefits by either reducing the level of benefits or sharing the investment risk on the benefits to reduce the probability of crossing the “pension event horizon.”
   - Mature pension plans may find that only changing future benefit accruals will have limited effect because the legacy risk, the required amortization of the unfunded liability already accrued, can be much larger than the normal cost. (This can be the case even when the only contribution toward reducing the unfunded liability is payment of interest on the unfunded liability).

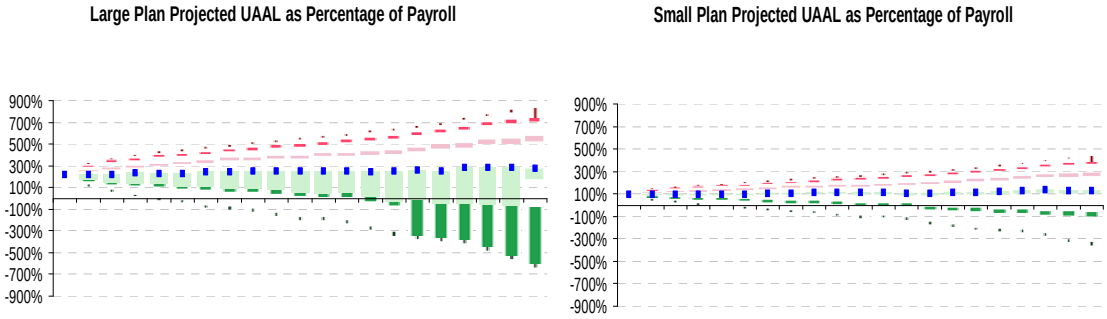
Implications of Plan Size

Moving away from the baseline, the first characteristic we examine is the size of the plan's assets compared to the sponsoring entity as measured by payroll or tax revenue. Any variability in investment returns affects contribution rates through the amortization of the unfunded actuarial accrued liability (UAAL). For a plan with twice the payroll of another plan, investment returns will have half the effect on contribution rates. Consequently, such a plan could take on twice the investment risk of the plan with a smaller payroll for the same effect on contribution rates.

To illustrate this, we kept all baseline characteristics constant in our model except total payroll. To simulate a large plan compared to the sponsor, we reduced payroll from $4,000 to $2,800. To simulate a small plan compared to the sponsor, we increased payroll from $4,000 to $6,600. The charts below show the effect on the range of contribution rates and the range of the UAAL as a percentage of payroll.



Not surprisingly, the projected contribution rate is 1.5 times higher for the large plan because the contribution needed to pay off the UAAL increases predictably. More significantly, the downside variability of outcomes is 1.9 times greater for the large plan.

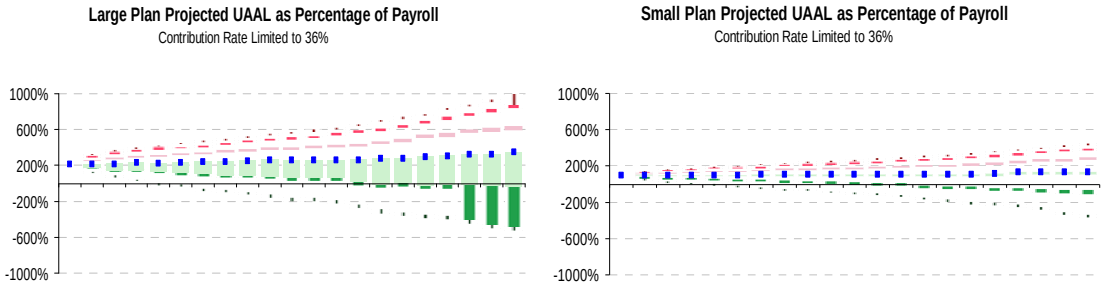


The UAAL percentage is ~2.1 times higher for the large plan. Similarly, the downside variability of outcomes is ~1.8 times greater for the large plan.

In the large plan, a 5-percent probability exists that contributions will exceed 68 percent of payroll by the end of the projection period. The corresponding figure for the small plan is 41 percent. The median contribution rate is 33 percent of payroll for the large plan and 22 percent for the small plan. In both cases, the same dollar amount of contribution is being made to fund the UAAL, but the different sizes of payroll translate to very different contribution rates.

The UAAL for the large plan starts at 214 percent of payroll, and at the end of the 20-year projection, a 5 percent probability exists that it is greater than 830 percent of payroll. For the small plan, the UAAL starts at 91 percent, and at the end of the 20-year projection, there is a 5 percent probability of it exceeding 431 percent.

Using the affordability criteria developed above, the charts below shows the UAAL as a percentage of payroll for the large and small plans with the contribution rate limited to no more than 36 percent of payroll.

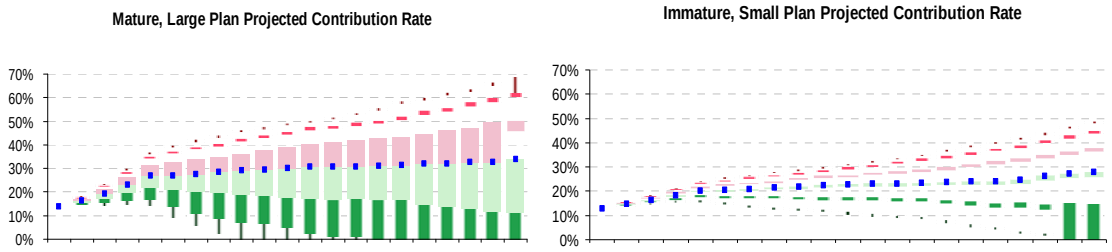


The UAAL percentage is 2.7 times higher for the large plan. The downside variability of outcomes is 2.0 times greater for the large plan.

For the small plan, there is a 5 percent probability that the UAAL exceeds 441 percent of payroll. This is within the affordability parameters we defined. However, for the large plan, there is a 25 percent probability that the UAAL exceeds 642 percent of payroll, which is well outside our defined affordability parameters. Clearly, the large plan, relative to payroll, cannot tolerate as much investment risk as the small plan.

Implications of Plan Maturity

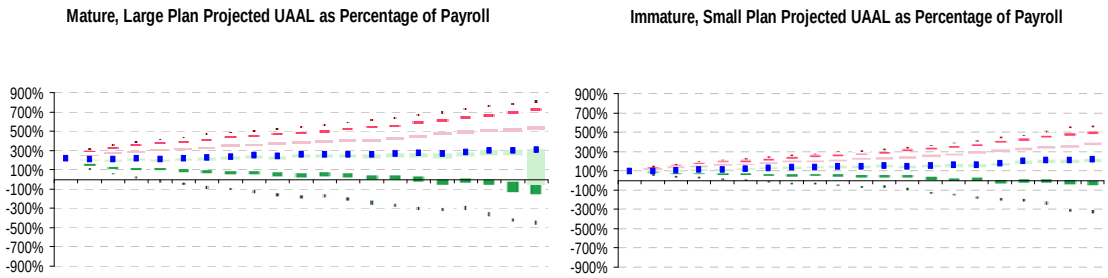
To assess the effect of plan maturity on risk tolerance, we used the large and small plans described above, but adjusted the population profile so that 80 percent of the liability in the mature, large plan is for benefits in payment status, compared to only 20 percent in the immature, small plan and 50 percent in the baseline. In addition, we assumed the active population increased at a rate of 2 percent per year for the immature plan and decreased at a rate of 2 percent per year for the mature plan. The charts below show the effect on the range of contribution rates.



The projected contribution rate is 1.2 times higher for the mature, large plan because of the predictable increases in the UAAL percentage. More significantly, the downside variability of outcomes is 1.6 times greater for the mature, large plan.

In the mature plan, there is a 5-percent probability that contributions will exceed 68 percent of payroll by the end of the projection compared to 49% of payroll for the immature plan. The median contribution rate is 34 percent of payroll for the mature plan and 28 percent for the immature plan.

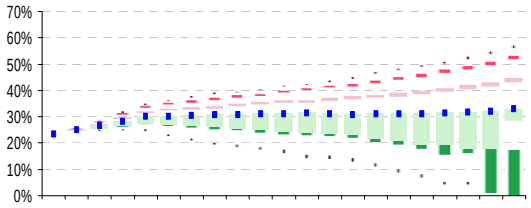
The charts below show the effect on the range of UAAL as a percentage of payroll.



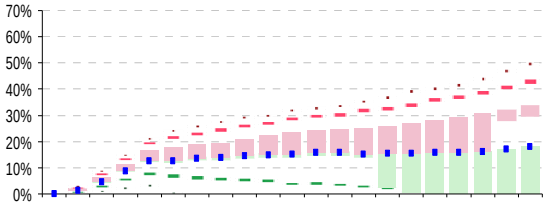
The UAAL percentage is 1.4 times higher for the mature, large plan. Similarly, the downside variability of outcomes is 1.5 times greater for the mature, large plan.

The UAAL for the mature plan starts at 214 percent of payroll, and at the end of the 20-year projection, there is a 5-percent probability that it is greater than 810-percent of payroll. For the immature plan, the UAAL starts at 91 percent, and at the end of the 20-year projection, there is a 5 percent probability that it is greater than 562 percent.

Poorly Funded Projected Contribution Rate



Well Funded Plan Projected Contribution Rate



Even without limiting contribution rates to 36 percent, the mature plan exceeds the affordability parameters we defined and the immature plan begins to approach the affordability parameters as the plan grows in size.

All else equal, any fund with positive net cash flow can be more tolerant of volatility than a fund with negative net cash flow. Pension plans gradually become more mature and larger relative to the sponsor, but the same investment risk exposure might be retained without adjustment, even though it represents an increasing risk to the sponsor.

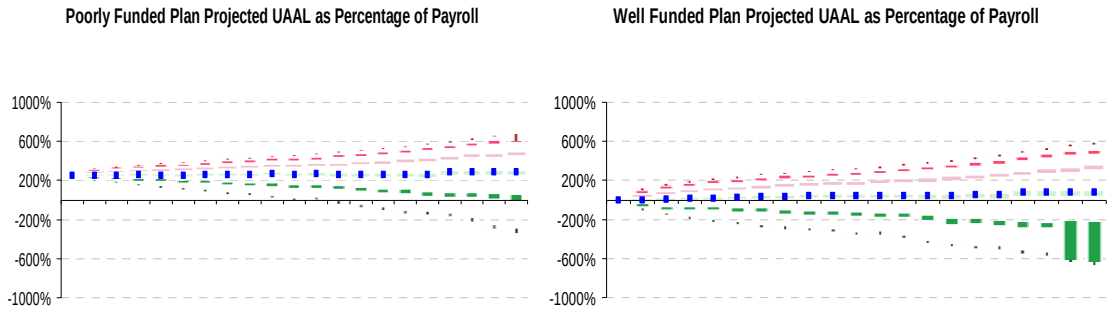
Implications of Funded Status

To assess the effect of funded status on risk tolerance, we return to the baseline plan described above, but adjust the assets so that in one case the plan is 100-percent funded and in the other case it is only 50-percent funded on a market value of assets basis. The charts below show the effect of funded status on the range of contribution rates.

The projected contribution rate is 1.8 times higher for the poorly funded plan. The downside variability of outcomes is 1.3 times greater for the well-funded plan.

In the poorly funded plan, there is a 5-percent probability that contributions will exceed 57 percent of payroll by the end of the projection compared to 50 percent of payroll for the well-funded plan. The median contribution rate is 33 percent of payroll for the poorly funded plan and 18 percent for the well-funded plan. The wider range of contribution rates for the well-funded plan compared to the poorly funded plan indicates greater exposure to the same investment risk in the well-funded plan.

The charts below show the effect on the range of UAAL as a percentage of payroll.



The UAAL percentage is 3.7 times higher for the poorly funded plan. The downside variability of outcomes is 1.3 times greater for the well-funded plan.

The UAAL for the poorly funded plan starts at 250 percent of payroll, and at the end of the 20-year projection, there is a 5-percent probability that it is greater than 664 percent of payroll. For the well-funded plan, the UAAL starts at 0 percent, and at the end of the 20-year projection, there is a 5 percent probability that it is greater than 573 percent.

Even though the well-funded plan starts with no UAAL, it approaches the affordability parameters we established if we allow contribution rates to exceed 36 percent during the 20-year projection period. If we did not allow contribution rates to exceed our defined ceiling, the well-funded plan would exceed the affordability parameters. The well-funded plan exhibits greater uncertainty of outcomes because it has a larger pool of assets exposed to investment risk.

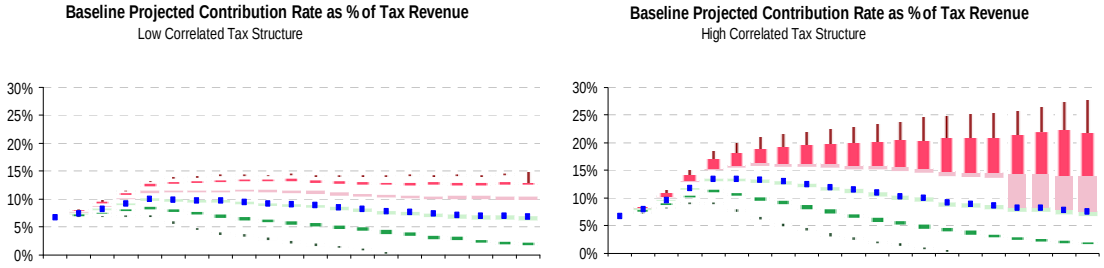
Although the effect of investment risk is smaller on the poorly funded plan, because the plan has a significant UAAL to start with, it still exceeds the affordability parameters. As a result, it may not be appropriate to take the investment risk it was hoping to take to get back to a reasonable funding level.

Implications of Revenue Base

Up to now, our analysis has focused on measurements as a percentage of payroll, but the true assessment of affordability should be based on the revenue of the plan sponsor. In large, multiemployer public retirement systems, the revenue source of each employer may vary and be difficult to measure. For most purposes, payroll can be used as a reasonable proxy under the assumption that the relationship between payroll and revenue is fairly constant. However, using costs as a percentage of payroll does not take into account the correlation between pension investment performance and tax revenues. Different tax structures will correlate to a greater or lesser degree with investment returns, but the three major forms of taxes (income, property, and sales taxes) all have potentially significant correlation with investment performance. The degree of correlation depends on the exact structure of the tax. For example, assessed property values may be less volatile than the actual market value of property, reducing the volatility of property taxes and their correlation with investment returns.

The variability we have shown so far as a percentage of payroll understates the variability as a percentage of tax revenue because of the potential correlation between poor investment returns in the pension plan and poor growth (or decreases) in tax revenue. The pension plan may need additional contributions just when the tax revenues of the plan sponsor are in decline. When tax revenues increase, investment returns are also likely to increase and the pension plan may require lower contributions. This correlation is only somewhat offset by the smoothing and amortizing of investment losses.

To illustrate this dynamic, we modeled two different tax structures with different correlations to investment returns. The chart below shows the projection of contribution rates for our baseline plan as a percentage of tax revenue for a low-correlation and a high-correlation tax structure.



The projected contribution rate is similar for both, but the downside variability of outcomes is 2.6 times greater for the high-correlation tax structure.

Risk Mitigation Strategies

As noted in the beginning, a plan sponsor has a number of options to consider if the current policy structure doesn't manage investment risk within the parameters established. The first option is to revisit the parameters (e.g. can higher sustained contributions be tolerated?)) to determine whether or not more risk can be tolerated. For these purposes, assume that the parameters are fixed and cannot be adjusted to accommodate more risk.

The second option is to contribute more than the recommended contribution rate, when possible. The viability of this depends upon the difference between the recommended and maximum sustainable contribution rates and, as we saw, a better funding position does not remove the risk of the "pension event horizon" while the investment risk persists. We will see that reducing investment risk will reduce the expected investment return and therefore immediately increase the contribution rate. So this option effectively becomes an element of the third option too.

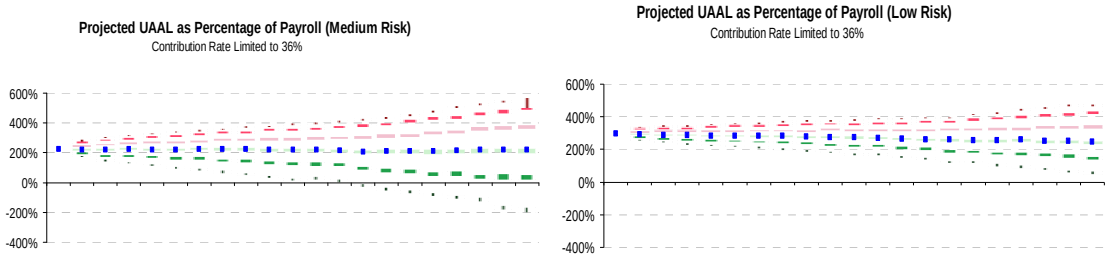
The third option is to explore different investment policies. A more conservative investment policy will result in less volatility, but will also reduce the expected return. Since liabilities are measured using the expected return, reducing the expected return will increase the normal cost and the actuarial accrued liability of the plan.

For our study, we examined three very different investment policies:

Policy	**Baseline**	**50%/50%**	**25%/75%**
Equity Allocation	75%	50%	25%
Fixed Income Allocation	25%	50%	75%
Expected Return	8.0%	7.0%	6.0%
AAL	$20,000	$23,000	$26,000
Normal Cost Rate	12.0%	14.4%	16.8%
UAAL	$6,000	$9,000	$12,000
UAAL as % of Payroll	150%	224%	298%
Max. UAAL Amortization Rate	24.0%	21.6%	19.2%
Pension Event Horizon	576%	660%	814%

Because the interest cost on the UAAL is lower when the assumed rate of return is lower, a smaller percentage of payroll amortization rate can actually support a larger UAAL before crossing the "pension event horizon."

For our baseline plan, we showed that the parameters established for risk tolerance were not satisfied. The charts below show the UAAL as a percentage of pay using the different investment policies. For both, the fifth percentile outcome is well below the "pension event horizon," especially so for the low risk investment policy.



The *UAAL percentage is 1.1 times higher for the low risk portfolio as the UAAL percentage increases predictably. However, the downside variability of outcomes is 1.6 times greater for the medium risk portfolio.*

The table below summarizes the key results of this comparison in terms of our risk tolerance parameters.

Baseline Plan			
Investment Policy	**75%/25%**	**50%/50%**	**25%/75%**
Initial UAAL as % of Payroll	150%	224%	298%
5th Percentile after 20 years	669%	562%	467%
Pension Event Horizon	576%	660%	814%
Satisfies Risk Tolerance Parameters	**No**	**Yes**	**Yes**
Initial Contribution Rate	13.3%	24.4%	33.3%
Median Contribution Rate in 5 Years	23.2%	28.8%	33.9%
Median Contribution Rate in 20 Years	27.4%	29.4%	32.6%

The trade-offs between these policies are fairly clear. Significantly higher contribution rates now combined with a more conservative investment policy can reduce the risk of crossing the event horizon to tolerable levels. While the short-term cost is high, the difference in median contribution rates in five or 20 years is much smaller. The remaining difference at that point is largely due to the difference in the normal cost rate at different funding interest rates.

We showed above that the small plan satisfied the risk tolerance parameters, but that the large plan did not. The table below shows the results of an analysis of different investment policies for the large plan.

Large Plan			
Investment Policy	**75%/25%**	**50%/50%**	**25%/75%**
Initial UAAL as % of Payroll	214%	320%	426%
5th Percentile after 20 years	987%	856%	822%
Pension Event Horizon	576%	660%	814%
Satisfies Risk Tolerance Parameters	**No**	**No**	**No**
Initial Contribution Rate	13.9%	28.6%	36.0%
Median Contribution Rate in 5 Years	27.8%	34.9%	36.0%
Median Contribution Rate in 20 Years	36.0%	36.0%	36.0%

For the large plan, none of the alternatives satisfies the risk tolerance parameters, although the 25-percent/75-percent allocation comes close. The cost of this alternative, however, is to immediately raise the level of contributions to the maximum sustainable amount.

A plan sponsor in this situation will need to seriously consider both whether it can tolerate an even higher contribution rate for a sustained period, and whether the benefits promised are sustainable.

Benefits can be adjusted either by modifying the level of benefits or by greater sharing of the investment risk with employees and retirees. Investment risk can be shared with employees in a variety of ways, including transforming part of the benefit into either a defined-contribution benefit or a variable annuity. Given the efficiency of a defined benefit structure and the public policy benefits of providing lifetime benefits, we would encourage sponsors seeking to share more investment risk with employees and retirees to consider some form of variable annuity structure.

Conclusions

The current predominant practice for selecting an investment policy for public sector pension plans takes into account the long-term horizon for the sponsoring entity or entities, but does not recognize the unique characteristics of each plan and sponsor that affect the amount of investment risk the plan sponsor can tolerate. The result is a one-size-fits-all approach to selecting investment policy. This approach further seems to be based on the assumption that the sponsor has an infinite appetite for risk as long as they expect to be compensated over the long term.

Financial economics purists argue that public plan sponsors should have minimal appetite for investment risk, resulting in a very different one-size fits all investment policy. This approach would result in significantly higher expected costs to fund pension promises; requiring tax increases, reductions in current services, reductions in other investments such as infrastructure, reductions in benefit levels (to the extent permitted), or some combination of these. It should be noted that the negative consequences of risk exposure can require the very same things.

In this paper, we have illustrated the effect of different risk characteristics on the ability of a plan sponsor to tolerate investment risk. We have shown that these risk characteristics can have a dramatic effect on the ability of a plan sponsor to support a pension plan. We believe the size of the plan compared to the tax revenues of the plan sponsor is the most critical measure to consider. When tax revenues, particularly for a multiemployer plan, are too difficult to measure or monitor, sometimes payroll can sometimes be used as a reasonable proxy.

Although considerable focus has been placed on funded status as a measure of whether or not a plan is soundly funded, we suggest an alternate framework for establishing a sustainable retirement program that takes into account possible changes to the funding policy, the investment policy and the benefit policy of the system. The framework is based on criteria established by the plan sponsor for the maximum sustainable contribution rate. While these criteria are subjective, they force the sponsor to establish reasonable expectations about long-term contribution rates that might be required to fund the promised benefits if the investment risk turns against the sponsor.

We have borrowed a term from physics, the “event horizon” for the point at which one enters a black hole, to describe the point at which payment of the UAAL is unsustainable given the sponsor’s maximum sustainable contribution rate. While the analogy may not be completely accurate because a pension plan sponsor still has a choice of unpalatable actions it can take when it crosses what we have defined as the “pension event horizon”, the analogy conveys a sense of urgency regarding understanding risk implications that we are concerned may be missing in the current environment.

Given the recent market downturn, we urge all public plan sponsors to undertake a risk analysis in order to develop a combination of funding, investment and benefit policies to avoid crossing the pension event horizon.

Appendix

Methods and Assumptions for Study

We produced 20-year stochastic forecasts under the three investment policies for each of the following scenarios:

Scenarios	Funded Status 1/1/09 (MVA)	Payroll as % of Liability	Normal Cost Rate	Annual Growth in Active Population	Payroll as % of Tax Revenue	Cap on Contribution Rate	Tax Revenue Type		
							Income Tax	Property Tax	Sales Tax
Baseline	70%	20%	12%	0%	50%	1000%	40%	30%	30%
Baseline (max 36%)	70%	20%	12%	0%	50%	36%	40%	30%	30%
Large Plan	70%	14%	12%	0%	50%	1000%	40%	30%	30%
Small Plan	70%	33%	12%	0%	50%	1000%	40%	30%	30%
Large Plan (max 36%)	70%	14%	12%	0%	50%	36%	40%	30%	30%
Small Plan (max 36%)	70%	33%	12%	0%	50%	36%	40%	30%	30%
Mature & Large	70%	14%	12%	-2%	50%	1000%	40%	30%	30%
Immature & Small	70%	33%	12%	2%	50%	1000%	40%	30%	30%
Poorly Funded	50%	20%	12%	0%	50%	1000%	40%	30%	30%
Well Funded	100%	20%	12%	0%	50%	1000%	40%	30%	30%
Income Tax	70%	20%	12%	0%	50%	1000%	100%	0%	0%
Property Tax	70%	20%	12%	0%	50%	1000%	0%	100%	0%
Sales Tax	70%	20%	12%	0%	50%	1000%	0%	0%	100%

The actuarial value of assets uses five year smoothing. The other details of the liability and investment policy are described within the body of the paper.

Our stochastic forecast of investment performance reflects the following 20-year capital market outlook assumptions:

	Arithmetic Annual Expected Return	Geometric Annual Expected Return	Standard Deviation of Annual Return	Correlation		
				US All Cap Equity	US Core Fixed Income	Inflation
US All Cap Equity	9.90%	8.40%	18.60%	1.0	0.2	0.0
US Core Fixed Income	4.80%	4.70%	5.50%	0.2	1.0	-0.1
Inflation	2.80%	2.80%	1.50%	0.0	-0.1	1.0

Because the modeling framework is relatively simple, the results should not be particularly sensitive to the specification of the stochastic simulation model. Any simulation model reflecting similar capital market assumptions should produce similar results demonstrating similar trends. The liability is not marked to a simulation of market yields, although it will vary with simulated inflation experience affecting the COLA on annuity benefits. The investment policies are expressed in very simple terms. By looking no further than the fifth and 95th percentile in the distribution of simulated outcomes, we do not consider extreme tail events, and most simulation models are likely to be reasonably consistent within that confidence interval.

The liability was assumed to have duration 15 for the purposes of the changes to funding interest rate. The mature, large plan and the immature, small plan were assumed to have durations 12 and 18 respectively, consistent with the change in population profile as described within the main body of the paper.

The formulae for the tax revenue sources, and particularly their correlation to economic conditions, cannot be disclosed in detail because they are based upon analyses for actual clients of the authors. These would be highly idiosyncratic by individual taxing authority and there is insufficient data available to estimate generic formulae that could be claimed as indicative of a “typical” situation. We have therefore de-emphasized this factor in our conclusions, but we would suggest that it can be a significant factor in any actual risk analysis. From an enterprise risk management perspective, it is clear that the availability of tax revenue and the demands of non-pension budget items will contribute to any assessment of the affordability of pension risk.

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