Pension Asset-Liability Study

Pennsylvania Public School Employees’ Retirement System (PSERS)
December 2021

Aon
Empower Results®

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Executive Summary

Executive Summary
Current State Analysis

Funded Ratio

- Funded ratio as of June 30, 2021 estimated to be **61.3%**
  - Incorporates strong asset returns for FYE 2021 as well as actuarial assumption changes (e.g., reduction in expected return from 7.25% to 7.00%)

Asset Allocation

- The Current Policy has **79%** return-seeking assets with a net 21% of risk-reducing & financing assets
- A new allocation ("Portfolio 2A") has also been studied; it has **86%** return-seeking assets with a net 14% of risk-reducing & financing assets

Expected Return

- Using Aon's 30-year capital market assumptions…
  - Current Policy has an expected return of **6.85%**
  - Portfolio 2A has an expected return of **6.94%**

Hurdle Rate Analysis

- The hurdle rate is **14.44%**; assets must grow by this rate (via contributions and investments) to keep pace with liability growth
- **Asset growth is expected to exceed the hurdle rate**, which will exhibit positive funded ratio growth trends

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Executive Summary

Timeline of Previous Board Discussions

1 August 4, 2021

- As part of the Board Workshop and subsequent poll, the following key asset allocation goals were identified as the Board's areas of interest:
  - – Target an expected return of 7.0%
  - – Reduce (or eliminate):
    - Explicit leverage
    - Private (illiquid) asset classes
    - Absolute Return Strategies
    - Private Credit
    - Commodities
  - – Increase:
    - Public Equity

2 October 6, 2021

- Aon reviewed alternative portfolio strategies, reflecting the objectives articulated by the Board at the August 4, 2021 Workshop and subsequent Board poll conducted by the Investment Committee Chair
- Aon reviewed the proposed alternative portfolios to be tested in the asset-liability study
- After Board discussion, the Board requested a new portfolio (a slight modification of the alternatives presented) be run and presented at the continuation of the Investment Meeting on October 7, 2021

3 October 7, 2021

- Aon reviewed the new portfolio ("**Portfolio 2A**")
- Board agreed to have Aon run the Current Policy along with Portfolio 2A for purposes of the upcoming asset-liability study
- Aon to present the full asset-liability study results, stress testing results, and liquidity analysis of both portfolios at the upcoming December 17, 2021 Board meeting.

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Executive Summary

Portfolio Analysis

	Current Policy	Portfolio 2A	Delta *(from Current)*
US Equity	11.0%	21.0%	+10.0%
Non-US Dev, Unhedged	7.0%	5.1%	-1.9%
Non-US Dev, USD Hedged	2.0%	5.1%	+3.1%
Emerging Markets	7.0%	4.8%	-2.2%
Private Equity, Unhedged[1]	12.0%	12.0%	--
Total Equity	**39.0%**	**48.0%**	**+9.0%**
US Core Fixed Income	1.0%	4.0%	+3.0%
US Long-Term Treasury	7.0%	8.0%	+1.0%
Emerging Markets Debt, Hard	2.0%	2.0%	--
High Yield	2.0%	4.0%	+2.0%
Private Credit	8.0%	6.0%	-2.0%
US TIPS	12.0%	10.0%	-2.0%
Non-US Inflation-Linked	3.0%	**0.0%**	-3.0%
Total Fixed Income	**35.0%**	**34.0%**	**-1.0%**
Infrastructure: Private, Hedged	4.0%	5.0%	+1.0%
Infrastructure: Public, Hedged	4.0%	5.0%	+1.0%
Commodities: Diversified	3.0%	2.5%	-0.5%
Commodities: Gold	7.0%	2.5%	-4.5%
Private Non-Core Real Estate	7.0%	7.0%	--
Global REITs, USD Hedged	3.0%	4.0%	+1.0%
Total Real Assets	**28.0%**	**26.0%**	**-2.0%**
Hedge Funds[2]	**8.0%**	**0.0%**	**-8.0%**
Net Cash / Financing	**-10.0%**	**-8.0%**	**+2.0%**
Total Plan	**100.0%**	**100.0%**	
30-Year Exp. Nom. Return	**6.85%**	**6.94%**	**+0.09%**
30-Year Expected Risk	**12.14%**	**13.37%**	**+1.23%**
Sharpe Ratio	**0.408**	**0.377**	**-0.031**

Key Takeaways:

- Using Aon's Q3 2021 capital market assumptions…
  - Current Policy has an expected return of 6.85% with a volatility of 12.14%
  - Portfolio 2A has an expected return of 6.94% with a volatility of 13.37%
- Relative to the Current Policy, the Portfolio 2A…
  - Increases public equity, core fixed income, long-term Treasuries, high yield, and infrastructure
  - Reduces private credit, TIPS, and commodities
  - Eliminates hedge funds and non-US inflation-linked securities
  - Increases net liquidity by eliminating hedge funds

[1] Private Equity assumptions developed as follows: 72% Buyouts, 13% Venture Capital, 15% Distressed Debt

[2] Hedge Fund assumptions developed as follows: 14% Event Driven, 38% Global Macro, 20% Distressed Debt, 16% Fixed Income Arbitrage, 12% Cat. Bonds

Percentages in table may not sum to 100% due to rounding

Executive Summary
Asset-Liability Projection Analysis

All Scenarios (in $ billions)	30-year Present Value of Gross Contributions (Employee + Employer)		30-year Ending Funded Ratio (MVA / AL)		Expected Attainment of Full Funding
	Expected[1]	Downside[2]	Expected[1]	Downside[3]	
Current Policy	$73.1	$97.9	119%	38%	FYE 2041
Portfolio 2A	$72.9	$100.3	126%	35%	FYE 2040
- Delta from Current	*($0.2)*	*$2.4*	*7%*	*(3%)*	*1 Year*

Key Takeaways:

- Current Policy is expected to reach full funding in the median outcome by FYE 2041; Portfolio 2A is expected to reach full funding by FYE 2040
- Optimistic (or pessimistic) asset performance could lead to better (or worse) outcomes than the central expectation

Green = Savings/Funded Ratio Improvement from Current
Red = Increased Cost/Reduction in Funded Ratio from Current
[1] Expected = 50th percentile outcome or central expectation across all 5,000 simulations
[2] Downside = 95th percentile outcome across all 5,000 simulations
[3] Downside = 5th percentile outcome across all 5,000 simulations
Differences based on unrounded values so may not match the difference of rounded value

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Analysis

- Current State

Current State Asset-Liability Profile

Asset-Liability Snapshot				
Metric ($, Billions)	As of 6/30/2020		Est. as of 6/30/2021	
	Value	*Fund %*	*Value*	*Fund %*
Market Value of Assets	$58.56	54.3%	$69.59	61.3%
Actuarial Value of Assets	$63.80	59.2%	$66.01	58.1%
Liability Metrics				
Actuarial Liability (AL) – Funding[1]	$107.83		$113.53	

Target Asset Allocation as of 6/30/2021		
Metric ($, Billions)	Value	Alloc %
Return-Seeking		
- U.S. Equity	$7.65	11%
- International Equity	$9.74	14%
- Global Equity	$1.39	2%
- Private Equity	$8.35	12%
- Real Estate	$6.96	10%
- Commodities	$6.96	10%
- Infrastructure	$5.57	8%
- High Yield Bonds	$1.39	2%
- Emerging Market Debt	$1.39	2%
- Private Debt	$5.57	8%
- Total	$54.97	79%
Risk-Reducing		
- Inflation-Linked Bonds[2]	$10.44	15%
- Core Bonds	$0.70	1%
- Long Duration Fixed Income	$4.87	7%
- Hedge Funds[3]	$5.57	8%
- Total	$14.61	21%
Total	$69.59	100%

Key Observations:

- Pension plan is **61.3%** funded on a market value of assets basis as of June 30, 2021
- Asset hurdle rate of **14.44%**, via cash funding and investment returns, needed to maintain or improve actuarial funded status
- The Total Expected Asset Growth rate (EROA plus Contributions) exceeds the Liability Hurdle Rate by **85 bps** which will grow the Plan's funded ratio

Asset-Liability Growth Metrics for FYE 2022			
Metric ($, Billions)	Value	% Liability	% Assets
AL Discount Cost	$7.95	7.00%	11.42%
AL Normal Cost	$2.10	1.85%	3.02%
Total Liability Hurdle Rate	**$10.05**	**8.85%**	**14.44%**
Expected Return on Assets[4]	$4.77	4.20%	6.85%
Est. Total Contributions	$5.87	5.17%	8.44%
Total Exp. Asset Growth	**$10.64**	**9.37%**	**15.29%**
Hurdle Rate (Shortfall)/Surplus	**$0.59**	**0.52%**	**0.85%**
Est. Benefit Payments	$7.56	6.66%	10.87%

[1] Based on a 7.25% discount rate for FYE 2020; 7.00% for FYE 2021
[2] Inflation-Linked modelled as 12% US TIPS and 3% Non-US Inflation-Linked
[3] Hedge funds have elements of both return-seeking and risk-reducing assets. Hedge funds have been categorized as risk-reducing based on the composition of the hedge funds within the PSERS portfolio.
[4] Using Aon Investments' Q3 2021 30 year capital market assumptions

Analysis

- Portfolio Analysis

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Portfolios Evaluated

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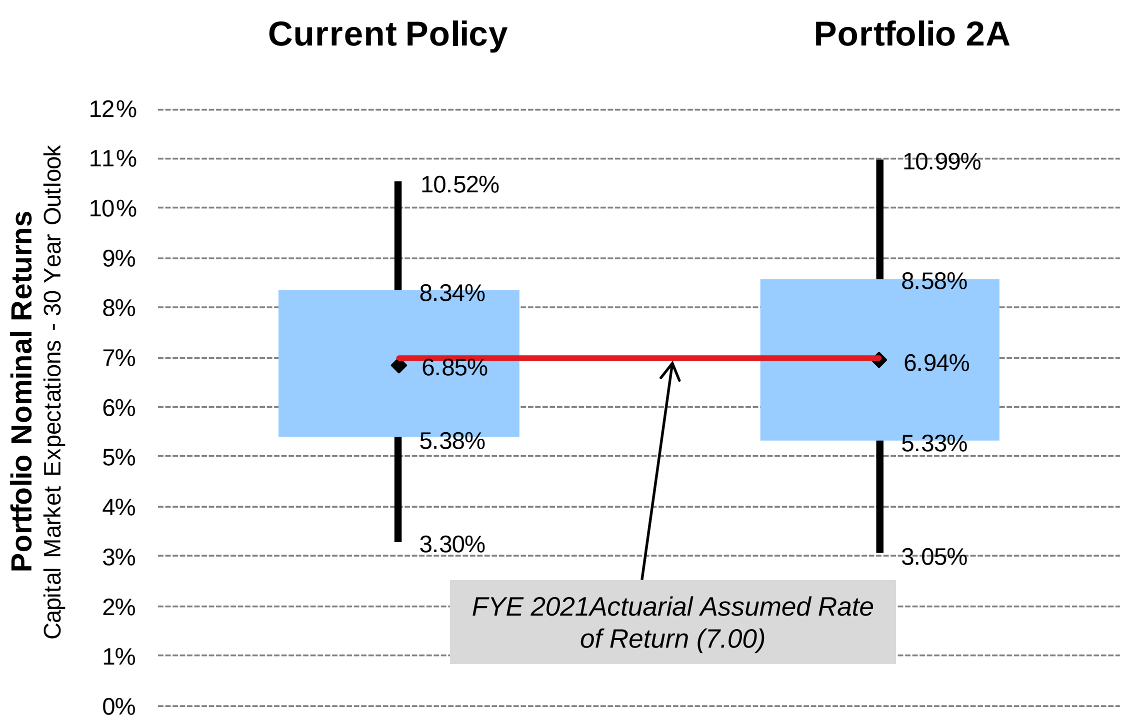
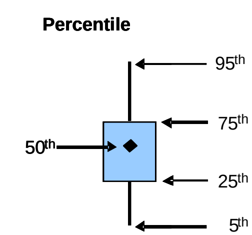
Portfolio Analysis
Range of Nominal Returns



Key Takeaway:

- Portfolio 2A is projected to have a higher cumulative 30-year expected return along with more upside and downside compared to the Current Policy



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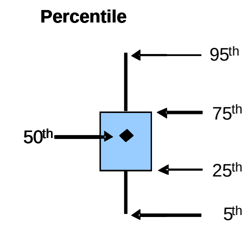
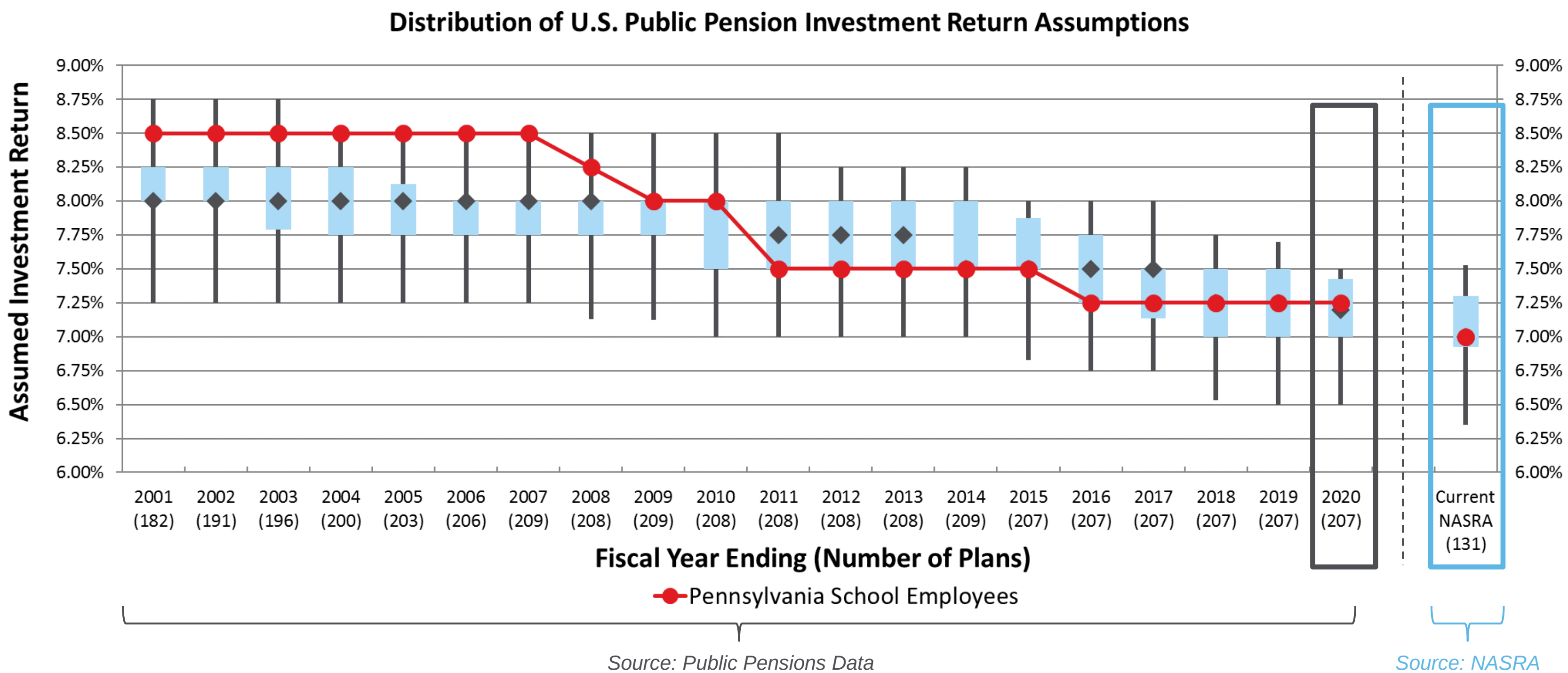
Portfolio Analysis

Distribution of Investment Return Assumptions for U.S. Public Pension Plans

Key Takeaways:

- The historical actuarial assumption trend for investment returns has declined from an 8.00% median in FYE 2001-2010 to **7.20%** as of FYE 2020, per Public Plans Data[1]
- Current actuarial assumptions, as tracked by NASRA as of October 2021, have a median actuarial assumption of **7.00%**





Sources: Public Plans Data (publicplansdata.org) as of October 2021; NASRA downloadable investment return assumptions as of October 2021

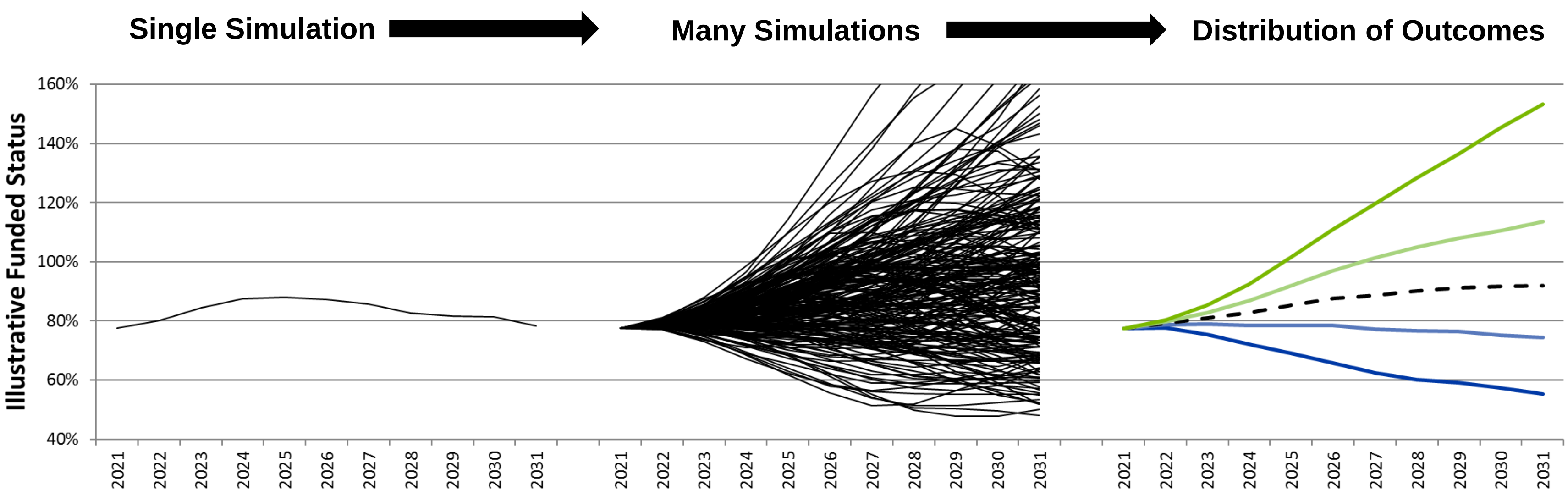
[1] Peers defined as public funds published within publicplansdata.org as of October 2021; Number of plans per year are shown in parentheses

Analysis

- Asset-Liability Projection Results (Stochastic Results)

Asset-Liability Simulation Overview

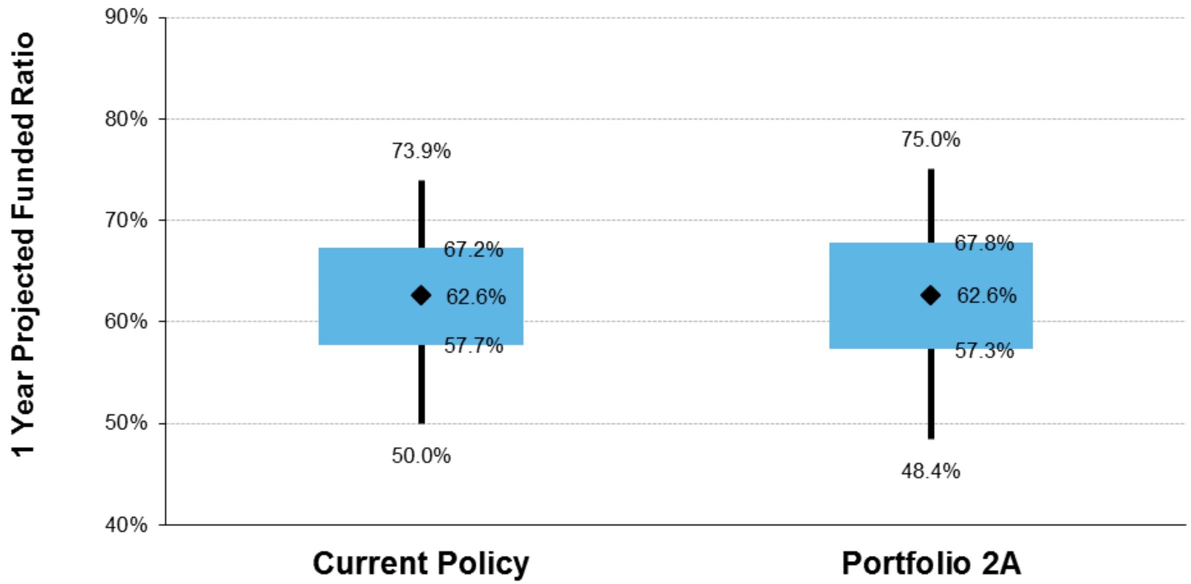
- Thousands of simulations plotted in one graph would be impossible to interpret
- Instead, we rank the simulations at each point over the future
- This produces a distribution of outcomes illustrating the degree of uncertainty of a plan's financial position over the projection period
- Different investment strategies will produce different distributions of outcomes



* The path of a given scenario will follow a much less smooth pattern than the distribution suggests, as illustrated above

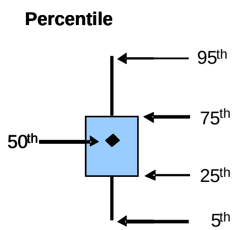
Asset-Liability Projection Results (Stochastic Results)

Market Value of Assets / Actuarial Liability Funded Ratio | Short-Term Risk



Key Takeaway:

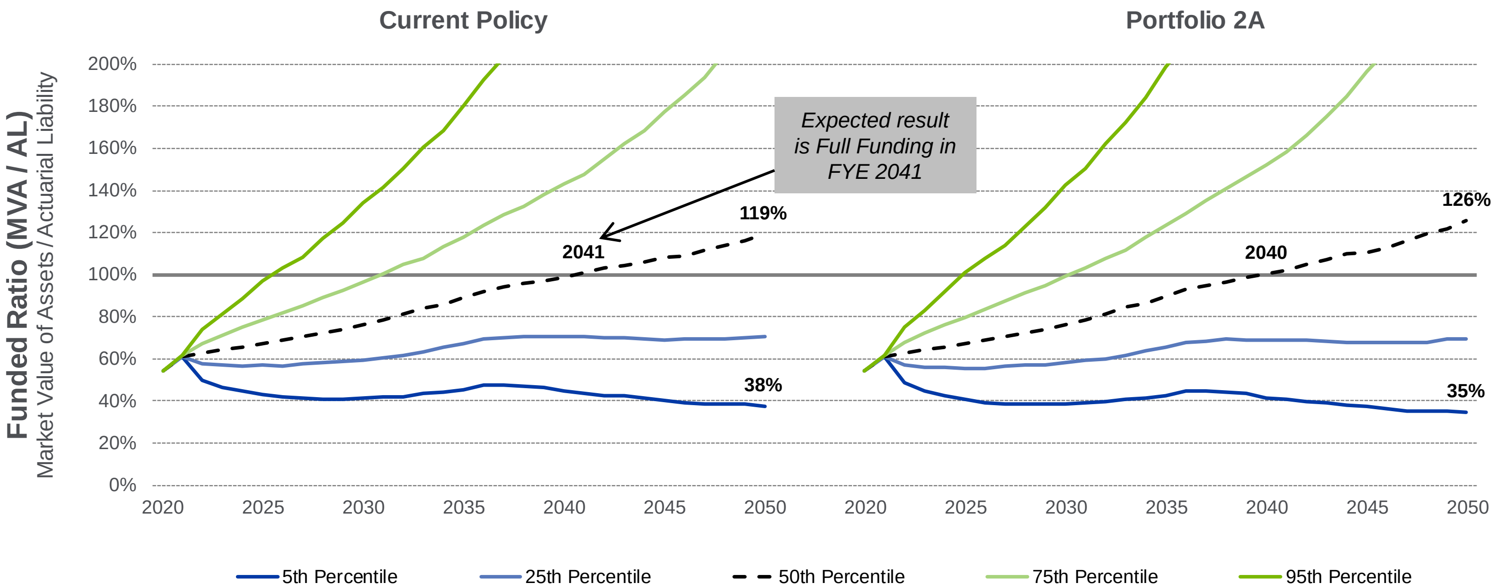
- Over a 1-year time horizon (starting June 30, 2021), Portfolio 2A is projected to have a similar median funded ratio as the Current Policy along with more volatility (both on the upside and downside)



Funded ratio assumes the market value of assets with a starting point of June 30, 2021; Liability projections assume discount rates of 7.25% (FYE 2020) and 7.00% (FYE 2021+) for all investment policies studied

Asset-Liability Projection Results (Stochastic Results)

Market Value of Assets / Actuarial Liability Funded Ratio | Long-Term Trends



Strategy	Current Policy			Portfolio 2A		
Year	**2030**	**2040**	**2050**	**2030**	**2040**	**2050**
5th Percentile	41%	45%	38%	39%	42%	35%
25th Percentile	59%	71%	70%	58%	69%	69%
50th Percentile	76%	99%	119%	76%	101%	126%
75th Percentile	96%	143%	>200%	99%	152%	>200%
95th Percentile	134%	>200%	>200%	143%	>200%	>200%
Probability > 100%	23%	49%	60%	25%	50%	61%

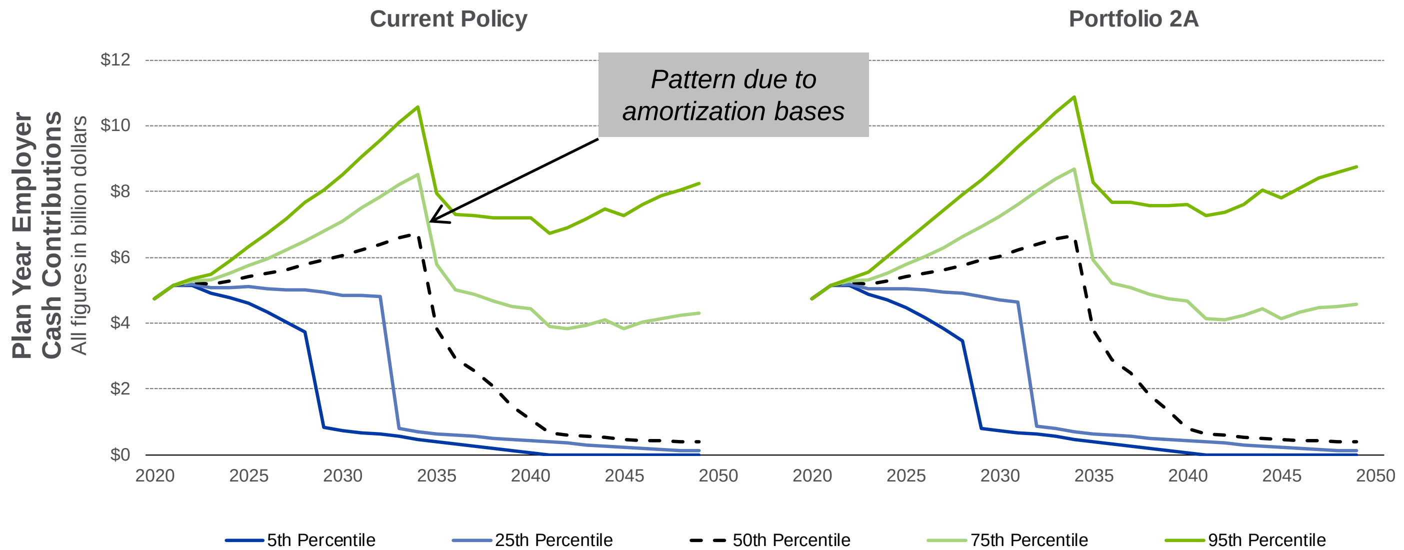
Key Takeaways:

- The funded ratio is projected to trend toward full funding over the course of the projection period
- Relative to the Current Policy, Portfolio 2A is projected to have a higher median outcome with increased volatility
- Adverse market experience could significantly impact the funded status of the Plan

* Liability projections assume discount rates of 7.25% (FYE 2020) and 7.00% (FYE 2021+) for all investment policies studied

Asset-Liability Projection Results (Stochastic Results)

Employer Contribution Amount

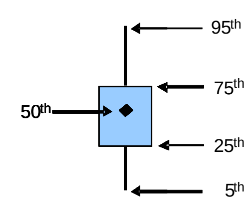


Strategy	Current Policy			Portfolio 2A		
Year	**2029**	**2039**	**2049**	**2029**	**2039**	**2049**
5th Percentile	$0.82	$0.12	$0.00	$0.80	$0.12	$0.00
25th Percentile	$4.94	$0.46	$0.11	$4.81	$0.47	$0.12
50th Percentile	$5.91	$1.47	$0.38	$5.91	$1.33	$0.38
75th Percentile	$6.80	$4.51	$4.29	$6.92	$4.76	$4.57
95th Percentile	$8.06	$7.19	$8.26	$8.35	$7.58	$8.76

Key Takeaways:

- Contributions in the central expectation (50th percentile outcomes) are projected to increase from their current levels until the expiration of individual amortization bases or when the plan reaches a funded status of at least 100% on an actuarial value of assets basis
- Portfolio 2A is expected to have a slight reduction in expected costs with more volatility (both on the upside and downside) compared to the Current Policy

Percentile



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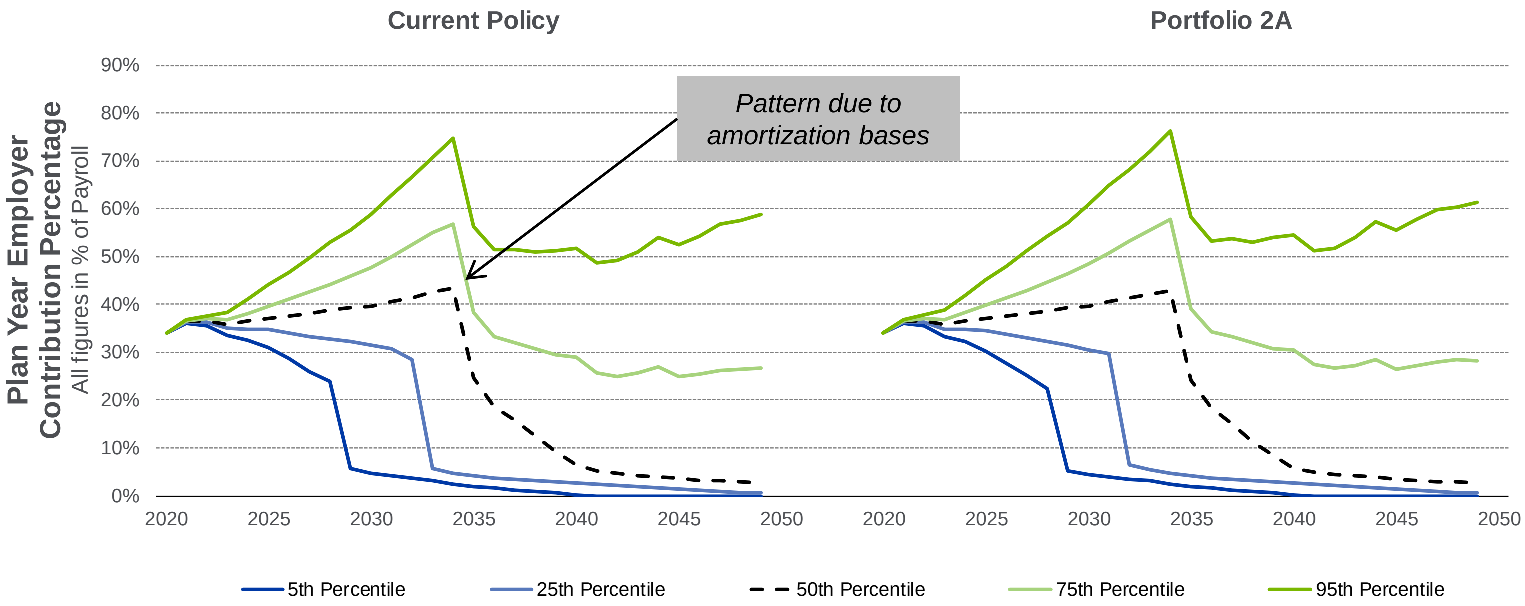
Asset-Liability Projection Results (Stochastic Results)

Employer Contribution Percentage of Payroll



Strategy	Current Policy			Portfolio 2A		
Year	2029	2039	2049	2029	2039	2049
5th Percentile	6%	1%	0%	5%	1%	0%
25th Percentile	32%	3%	1%	32%	3%	1%
50th Percentile	39%	9%	3%	39%	8%	3%
75th Percentile	46%	29%	27%	47%	31%	28%
95th Percentile	55%	51%	59%	57%	54%	61%

Key Takeaway:

- Both portfolios have a similar central expectation (50^{th} percentile outcome) that is projected to increase until the expiration of individual amortization bases or when the plan reaches a funded status of at least 100% on an actuarial value of assets basis

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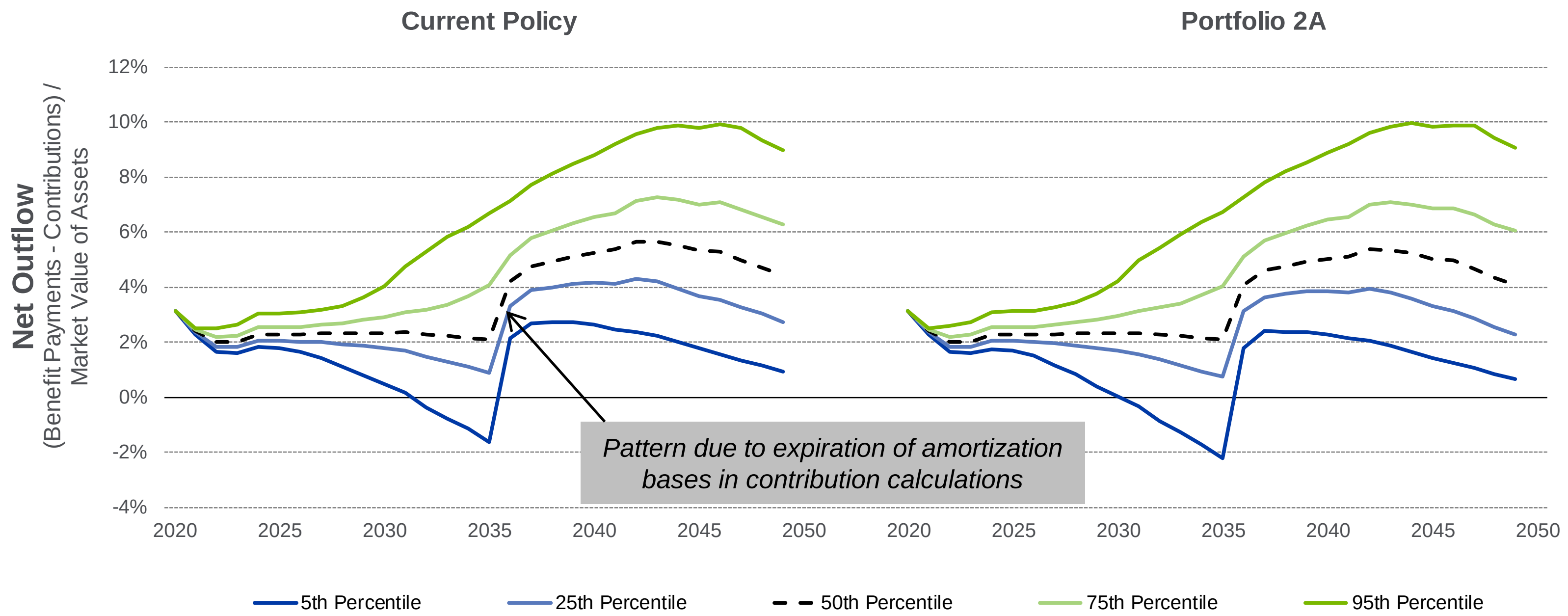
Asset-Liability Projection Results (Stochastic Results)

Net Outflow Analysis: (Benefit Payments less Contributions) / Market Value of Assets



Strategy	Current Policy			Portfolio 2A		
Year	**2029**	**2039**	**2049**	**2029**	**2039**	**2049**
5th Percentile	0.8%	2.7%	0.9%	0.4%	2.4%	0.7%
25th Percentile	1.9%	4.1%	2.7%	1.8%	3.8%	2.3%
50th Percentile	2.3%	5.1%	4.4%	2.3%	4.9%	4.1%
75th Percentile	2.8%	6.3%	6.3%	2.8%	6.2%	6.1%
95th Percentile	3.6%	8.5%	9.0%	3.8%	8.5%	9.1%
Probability > 10%	<1%	1%	3%	<1%	2%	3%

Key Takeaway:

- Net outflow is consistent across the portfolios modeled, sharply increasing once amortization bases fall out of the contribution calculations

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Analysis

- Summary and Conclusions

Summary and Conclusions

Portfolio Analysis

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All Scenarios (in $ billions)	30-year Present Value of Gross Contributions (Employee + Employer)		30-year Ending Funded Ratio (MVA / AL)		Expected Attainment of Full Funding
	Expected[1]	Downside[2]	Expected[1]	Downside[3]	
Current Policy	$73.1	$97.9	119%	38%	FYE 2041
Portfolio 2A	$72.9	$100.3	126%	35%	FYE 2040
- Delta from Current	*($0.2)*	*$2.4*	*7%*	*(3%)*	*1 Year*

Key Takeaways:

- Current Policy is expected to reach full funding in the median outcome by FYE 2041; Portfolio 2A is expected to reach full funding by FYE 2040
- Optimistic (or pessimistic) asset performance could lead to better (or worse) outcomes than the central expectation

Green = Savings/Funded Ratio Improvement from Current
Red = Increased Cost/Reduction in Funded Ratio from Current
[1] Expected = 50th percentile outcome or central expectation across all 5,000 simulations
[2] Downside = 95th percentile outcome across all 5,000 simulations
[3] Downside = 5th percentile outcome across all 5,000 simulations
Differences based on unrounded values so may not match the difference of rounded value

Appendix

- Peer Comparisons

Public Pension Peer Comparison

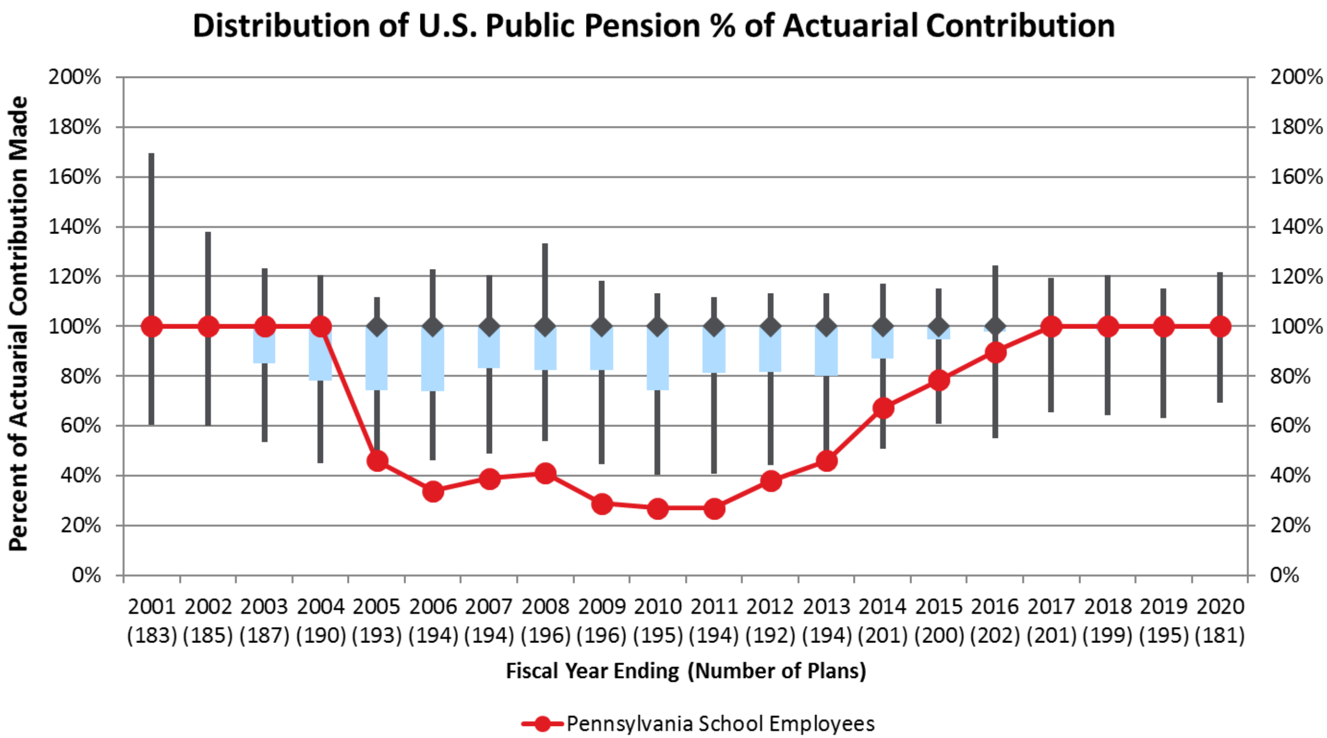
PSERS' Asset Allocation versus Public Peers

Asset Allocation	PSERS	Public Pension Plans (<$500M)*	Public Pension Plans ($501M-1B)*	Public Pension Plans ($1-5B)*	Public Pension Plans (>$5B)*	Total Public Pension Universe*
Equity Exposure						
Global Equity	0.0%	0.0%	1.3%	5.7%	2.3%	2.8%
Total U.S. Equity	11.0%	34.6%	35.5%	25.6%	21.4%	22.6%
Total Int'l Equity	16.0%	17.1%	19.1%	16.1%	15.3%	15.6%
Private Markets	12.0%	7.8%	3.2%	5.1%	9.3%	8.5%
Total Equity	***39.0%***	***59.4%***	***59.1%***	***52.5%***	***48.3%***	***49.5%***
Fixed Income Exposure						
U.S. Fixed Income	8.0%	23.1%	21.9%	21.7%	24.1%	23.7%
High Yield Bonds / Bank Loans	2.0%					
Private Debt	8.0%	0.1%	0.5%	1.9%	2.2%	2.1%
International / Global Fixed Income	0.0%	0.4%	4.6%	3.2%	2.0%	2.2%
Emerging Market Debt	2.0%	0.9%	0.5%	1.7%	0.8%	1.0%
Inflation Protected	15.0%					
Total Fixed Income	***35.0%***	***24.5%***	***27.5%***	***28.5%***	***29.1%***	***29.0%***
Real Asset Exposure						
Infrastructure	8.0%	1.3%	1.1%	0.9%	2.0%	1.8%
Commodities	10.0%	1.0%	0.9%	0.7%	2.2%	1.9%
Real Estate	10.0%	7.2%	7.7%	7.7%	7.4%	7.4%
Total Real Assets	***28.0%***	***9.5%***	***9.7%***	***9.3%***	***11.6%***	***11.1%***
Hedge Funds	8.0%	3.4%	1.0%	4.6%	4.4%	4.3%
Multi-Asset / Risk Parity	0.0%	1.5%	0.5%	2.1%	0.2%	0.5%
Money Market / Cash	0.0%	1.7%	1.1%	1.8%	2.3%	2.2%
Leverage	-10.0%					
Other	0.0%	0.1%	1.1%	1.5%	3.8%	3.3%
Net Other	***-2.0%***	***6.7%***	***3.7%***	***10.0%***	***10.7%***	***10.3%***
Total	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***

* Source: "*2020 U.S. Institutional Market Trends*", Greenwich Associates

Public Pension Peer Comparison

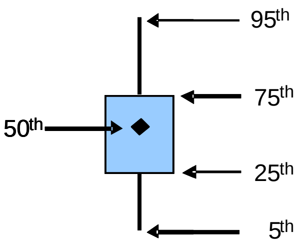
Percentage of Actuarial Contribution Made versus Peers[1]



Key Takeaway:

- Contributions for PSERS, as a percentage of the actuarially-determined amount, had been below 100% for FYE 2005-2016 and have been 100% since that time

Percentile



Sources: Public Plans Data (publicplansdata.org) as of October 2021

[1] Peers defined as public funds published within publicplansdata.org as of October 2021; Number of plans per year are shown in parentheses

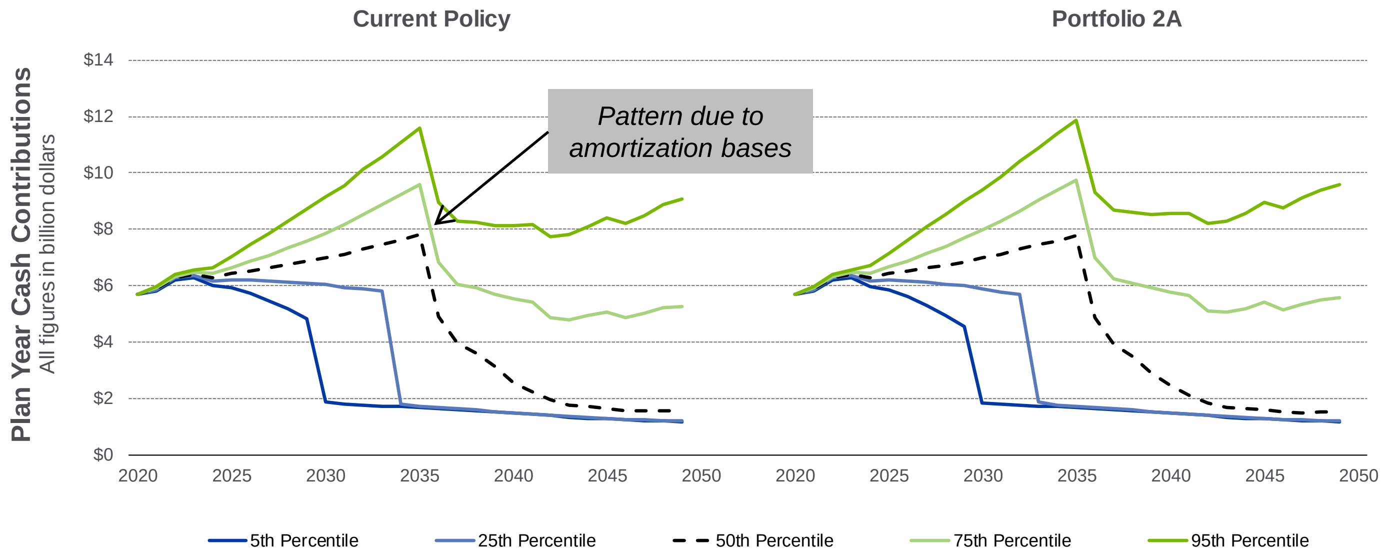
Empower Results®

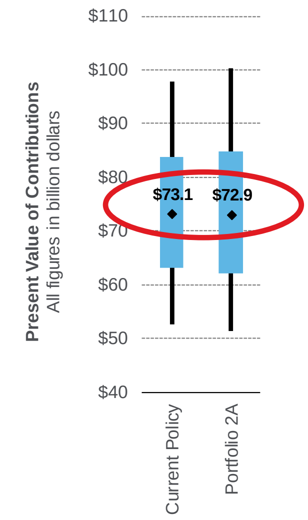
Appendix

- Asset-Liability Projection Results (Additional Stochastic Results)

Asset-Liability Projection Results (Additional Stochastic Results)

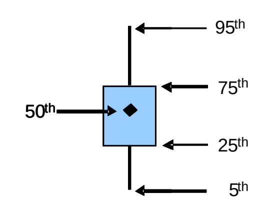
Gross Contribution Amount (Includes Employee and Employer Contributions)





Strategy	Current Policy			Portfolio 2A		
Year	2029	2039	2049	2029	2039	2049
5th Percentile	$4.84	$1.50	$1.17	$4.56	$1.50	$1.17
25th Percentile	$6.08	$1.53	$1.20	$5.99	$1.53	$1.19
50th Percentile	$6.86	$3.13	$1.55	$6.85	$2.91	$1.50
75th Percentile	$7.59	$5.69	$5.24	$7.69	$5.91	$5.56
95th Percentile	$8.72	$8.14	$9.06	$8.98	$8.54	$9.59

Percentile



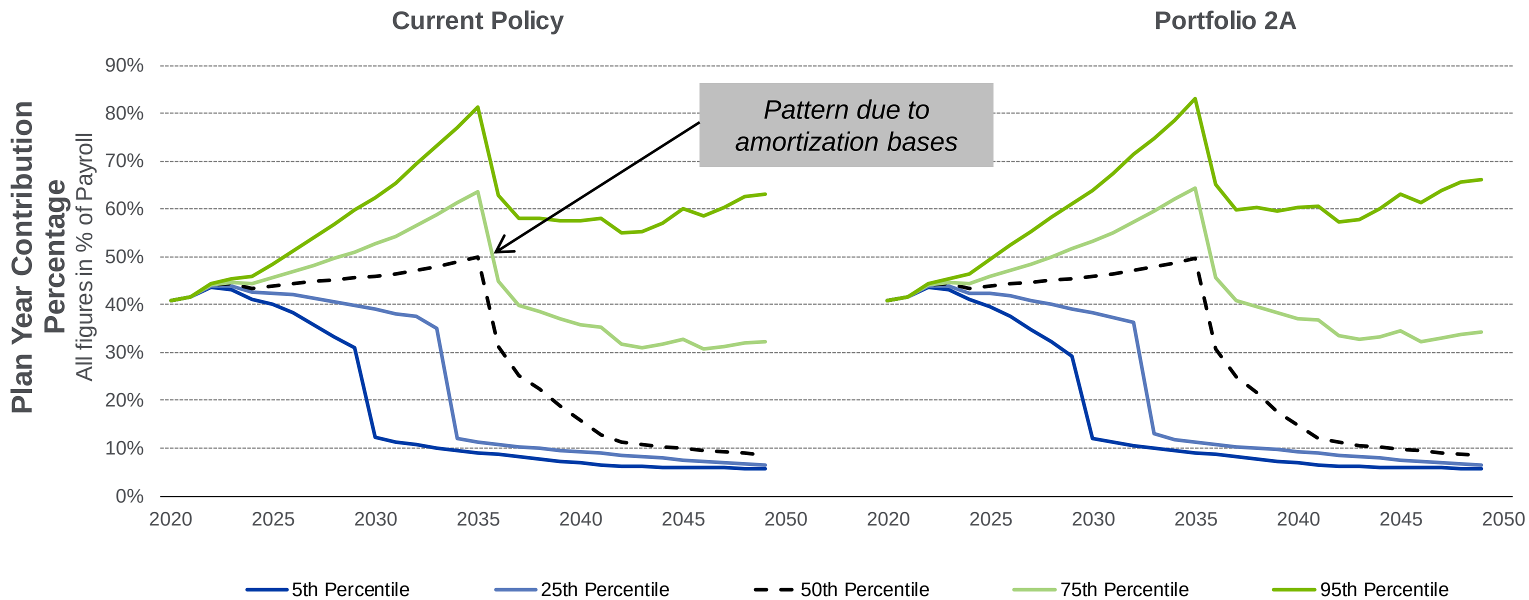
Key Takeaways:

- Contributions in the central expectation (50th percentile outcomes) are projected to increase from their current levels until the expiration of individual amortization bases or when the plan reaches a funded status of at least 100% on an actuarial value of assets basis
- Portfolio 2A is expected to have a slight reduction in expected costs with more volatility (both on the upside and downside) compared to the Current Policy

* Liability projections assume discount rates of 7.25% (FYE 2020) and 7.00% (FYE 2021+) for all investment policies studied

Asset-Liability Projection Results (Additional Stochastic Results)

Gross Contribution Percentage of Payroll (Includes Employee and Employer Contributions)



Strategy	Current Policy			Portfolio 2A		
Year	2029	2039	2049	2029	2039	2049
5th Percentile	31%	7%	6%	29%	7%	6%
25th Percentile	40%	10%	6%	39%	10%	6%
50th Percentile	46%	19%	9%	46%	18%	9%
75th Percentile	51%	37%	32%	52%	38%	34%
95th Percentile	60%	57%	63%	61%	60%	66%

Key Takeaway:

- Both portfolios have a similar central expectation (50th percentile outcome) that is projected to increase until the expiration of individual amortization bases or when the plan reaches a funded status of at least 100% on an actuarial value of assets basis

* Liability projections assume discount rates of 7.25% (FYE 2020) and 7.00% (FYE 2021+) for all investment policies studied

Appendix

- Actuarial Assumptions and Methods

Actuarial Assumptions and Methods

- Actuarial projections were provided by the plan actuary as of the most recent valuation date (June 30, 2020) inclusive of projected 2021 assumption changes as noted below:
  - Assumed Investment Return 7.00% for 2021 (was 7.25% in 2020)
  - Average Salary Increase: 4.50% for 2021 (was 5.00% in 2020)
  - Payroll Growth: 3.25% in 2021 (was 3.50% in 2020)
  - Inflation: 2.50% for 2021 (was 2.75% in 2020)

- Additional actuarial assumptions:
  - Actuarial Value of Assets: smooth gains/losses relative to expected valuation rate of interest over 10 years and shall be no less than 70% and no greater than 130% of the market value of assets
  - Projection assumptions from the plan actuary
    - The active workforce size is assumed to remain constant over the projection period;
    - Future new employees have similar characteristics (age/gender/salary) to new employees for the period July 1, 2017 through June 30, 2020
      - Among new school employees hired on or after July 1, 2020, 98% will become Class T-G members, 1% will elect Class T-H membership, and 1% will elect Class DC participation.
    - Class T-G and T-H members who terminate employment with less than 25 years of service and who commence their benefits prior to age 62 will have their benefits reduced from age 67 to age 62 based on the System’s current actuarial-equivalent early retirement factors, which are based on the statutory interest rate of 4%. The benefit will be further reduced from age 62 to the member’s age at benefit commencement based on new actuarial-equivalent early retirement factors based on an interest rate of 7.00%.

Actuarial Assumptions and Methods (continued)

- Additional actuarial assumptions (continued):
  - Projection assumptions from the plan actuary (continued)
    - The projection reflects the ACT 5 risk-sharing provisions for TE/TF/TG/TH members. We caution that while the System assets and projected unfunded accrued liability amortization schedules reflect the under/over contribution from the basic member rate resulting from the assumed asset returns, the corresponding System accrued liabilities do not reflect the increase in the affected members contribution rates. Changes in the member rate influence the System's total liabilities due to incidence of return of contributions for non-vested members, Option 4 lump sum withdrawals, etc.
  - All other assumptions as documented in the Actuarial Valuation Report as of June 30, 2020

- Actuarially-Determined Contribution Calculation = Normal Cost plus a level percent amortization of the unfunded liability with layered 24 year, closed periods, and a 3.25.% salary scale
  - Amortization bases developed are projected to continue until either their individual expiry or the plan reaches 100% funded on an actuarial value of assets basis at which point any remaining balance is fully recognized

- Other assumptions
  - Asset figures reflect performance for the period July 1, 2020 – June 30, 2021, resulting in a market asset value of $69.585 billion as of June 30, 2021
  - Employee contributions are limited to the actuarially-determined contribution
  - The health care premium assistance assets and liabilities have been excluded from this analysis
  - The rate collar provision of Act 120 was not considered in this analysis as it has been deemed to no longer be effective
  - "Shared Risk" provisions of Act 120 have not been considered in this analysis

Appendix

- Capital Market Assumptions

Capital Market Assumption Methodology

- The Aon Asset Model and Economic Scenario Generator (ESG) creates 5,000 simulations of key economic variables and total returns.
- We believe the model is complete and consistent. All the major markets and asset classes are modeled within a consistent framework allowing for the interactions between them to be properly taken into account.
- It is arbitrage free and captures the fact that extreme market events do occur more frequently than would be predicted by simpler statistical models.
- The ESG models the full yield curve as this allows for accurate treatment of liabilities and realistic modeling of the future distribution of interest rates and inflation. This allows us to assess the sensitivities of assets and liabilities to changes in interest and inflation rates.
- The model is calibrated to Aon's globally-consistent Capital Market assumptions every quarter.
- Nominal and real government interest rates are projected using an extended two factor Black-Karasinki model and a 2 factor Vasicek model respectively. The models are mean reverting starting with current yield curves and reverting towards our long-term fair values over the very long-term.
- Credit spreads are modeled stochastically using a Markov based model to determine the probabilities of transition between various credit rating and default, and a stochastic parameter reflecting the level of risk aversion in the market.
- Return seeking assets (including equities) are modeled using an individual asset class model with its own returns and volatilities but no correlations to other asset classes, and exposure to 6 other economic models to gain the correct correlation structures between returns for each asset class.

Aon Investments' Capital Market Assumptions

As of June 30, 2021 (30 Years)

		Expected Real Return[1]	Expected Nominal Return[1]	Expected Nominal Volatility
	Equity			
1	Large Cap U.S. Equity	4.1%	6.3%	17.5%
2	Small Cap U.S. Equity	4.6%	6.8%	23.5%
3	International Equity (Developed) - Hedged	5.3%	7.5%	18.5%
4	International Equity (Developed) - Unhedged	4.8%	7.0%	20.5%
5	Emerging Markets Equity	5.3%	7.5%	27.5%
	Fixed Income			
6	Cash (Gov't)	-0.2%	1.9%	1.5%
7	TIPS	-0.3%	1.8%	3.5%
8	Core Fixed Income	0.4%	2.5%	4.5%
9	Long Duration Bonds – Gov't	0.0%	2.1%	7.5%
10	Non-US Inflation Linked	-0.3%	1.8%	3.0%
11	High Yield Bonds	2.4%	4.5%	13.0%
12	Emerging Market Bonds, Hard	2.2%	4.3%	14.5%
	Alternatives			
13	Hedge Funds[2]	2.8%	5.0%	9.5%
14	Non Core Real Estate	5.1%	7.3%	25.5%
15	REITs	2.9%	5.1%	19.0%
16	Commodities	2.3%	4.4%	17.0%
17	Private Equity[3]	7.2%	9.5%	27.0%
18	Infrastructure - Private	4.9%	7.1%	15.0%
19	Infrastructure - Public	4.4%	6.6%	17.5%
20	Gold	0.8%	2.9%	19.5%
21	Private Debt	3.9%	6.1%	17.5%
	Inflation			
22	Inflation	0.0%	2.1%	1.5%

Notes:

[1] All expected returns are geometric (long-term compounded; rounded to the nearest decimal) and net of investment fees.

[2] Hedge Fund assumptions developed as follows: 14% Event Driven, 38% Global Macro, 20% Distressed Debt, 16% Fixed Income Arbitrage, 12% Cat. Bonds

[3] Private Equity assumptions developed as follows: 72% Buyouts, 13% Venture Capital, 15% Distressed Debt

Aon Investments’ Capital Market Assumptions

As of June 30, 2021 (30 Years)

	Nominal Correlations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Large Cap U.S. Equity	**1.00**	0.92	0.89	0.79	0.73	0.08	-0.03	0.02	-0.14	-0.03	0.60	0.43	0.56	0.48	0.66	0.35	0.92	0.38	0.89	0.01	0.37	0.08
2	Small Cap U.S. Equity	0.92	**1.00**	0.82	0.72	0.67	0.07	-0.03	0.02	-0.13	-0.03	0.55	0.40	0.51	0.45	0.61	0.31	0.87	0.36	0.83	0.01	0.35	0.07
3	International Equity (Developed) - Hedged	0.89	0.82	**1.00**	0.89	0.74	0.09	-0.02	0.03	-0.13	-0.02	0.56	0.41	0.51	0.48	0.60	0.31	0.82	0.35	0.84	0.01	0.35	0.08
4	International Equity (Developed) - Unhedged	0.79	0.72	0.89	**1.00**	0.75	0.03	-0.04	0.00	-0.13	-0.05	0.57	0.43	0.50	0.44	0.53	0.47	0.73	0.31	0.84	0.01	0.35	0.09
5	Emerging Markets Equity	0.73	0.67	0.74	0.75	**1.00**	0.06	-0.03	0.02	-0.12	-0.03	0.64	0.48	0.41	0.41	0.50	0.35	0.68	0.29	0.78	0.01	0.37	0.08
6	Cash (Gov't)	0.08	0.07	0.09	0.03	0.06	**1.00**	0.52	0.46	0.27	0.65	0.12	0.18	0.08	0.12	0.08	0.18	0.04	0.11	0.09	0.04	-0.17	0.42
7	TIPS	-0.03	-0.03	-0.02	-0.04	-0.03	0.52	**1.00**	0.56	0.50	0.86	0.06	0.16	-0.02	0.03	-0.01	0.11	-0.05	0.04	-0.01	0.02	-0.15	0.23
8	Core Fixed Income	0.02	0.02	0.03	0.00	0.02	0.46	0.56	**1.00**	0.79	0.44	0.30	0.48	0.12	0.04	0.02	0.04	0.01	0.05	0.03	0.00	0.06	0.02
9	Long Duration Bonds – Gov’t	-0.14	-0.13	-0.13	-0.13	-0.12	0.27	0.50	0.79	**1.00**	0.33	-0.11	0.14	-0.13	-0.06	-0.09	-0.04	-0.14	-0.04	-0.13	-0.01	-0.27	-0.14
10	Non-US Inflation Linked	-0.03	-0.03	-0.02	-0.05	-0.03	0.65	0.86	0.44	0.33	**1.00**	0.05	0.12	0.01	0.03	-0.01	0.14	-0.05	0.05	-0.01	0.03	-0.15	0.31
11	High Yield Bonds	0.60	0.55	0.56	0.57	0.64	0.12	0.06	0.30	-0.11	0.05	**1.00**	0.76	0.59	0.32	0.40	0.37	0.57	0.26	0.61	0.02	0.70	0.15
12	Emerging Market Bonds, Hard	0.43	0.40	0.41	0.43	0.48	0.18	0.16	0.48	0.14	0.12	0.76	**1.00**	0.55	0.23	0.29	0.25	0.41	0.18	0.44	0.00	0.42	0.06
13	Hedge Funds	0.56	0.51	0.51	0.50	0.41	0.08	-0.02	0.12	-0.13	0.01	0.59	0.55	**1.00**	0.27	0.37	0.39	0.52	0.21	0.54	0.01	0.48	0.12
14	Non Core Real Estate	0.48	0.45	0.48	0.44	0.41	0.12	0.03	0.04	-0.06	0.03	0.32	0.23	0.27	**1.00**	0.49	0.16	0.44	0.22	0.48	0.01	0.18	0.09
15	REITs	0.66	0.61	0.60	0.53	0.50	0.08	-0.01	0.02	-0.09	-0.01	0.40	0.29	0.37	0.49	**1.00**	0.22	0.61	0.26	0.68	0.01	0.24	0.07
16	Commodities	0.35	0.31	0.31	0.47	0.35	0.18	0.11	0.04	-0.04	0.14	0.37	0.25	0.39	0.16	0.22	**1.00**	0.32	0.10	0.50	0.03	0.16	0.39
17	Private Equity	0.92	0.87	0.82	0.73	0.68	0.04	-0.05	0.01	-0.14	-0.05	0.57	0.41	0.52	0.44	0.61	0.32	**1.00**	0.35	0.83	0.01	0.37	0.07
18	Infrastructure - Private	0.38	0.36	0.35	0.31	0.29	0.11	0.04	0.05	-0.04	0.05	0.26	0.18	0.21	0.22	0.26	0.10	0.35	**1.00**	0.34	0.01	0.15	0.08
19	Infrastructure - Public	0.89	0.83	0.84	0.84	0.78	0.09	-0.01	0.03	-0.13	-0.01	0.61	0.44	0.54	0.48	0.68	0.50	0.83	0.34	**1.00**	0.02	0.36	0.14
20	Gold	0.01	0.01	0.01	0.01	0.01	0.04	0.02	0.00	-0.01	0.03	0.02	0.00	0.01	0.01	0.01	0.03	0.01	0.01	0.02	**1.00**	0.00	0.09
21	Private Debt	0.37	0.35	0.35	0.35	0.37	-0.17	-0.15	0.06	-0.27	-0.15	0.70	0.42	0.48	0.18	0.24	0.16	0.37	0.15	0.36	0.00	**1.00**	0.02
22	Inflation	0.08	0.07	0.08	0.09	0.08	0.42	0.23	0.02	-0.14	0.31	0.15	0.06	0.12	0.09	0.07	0.39	0.07	0.08	0.14	0.09	0.02	**1.00**

Aon Investments' Capital Market Assumptions

Explanation of Capital Market Assumptions—Q3 2021

The following capital market assumptions were developed by Aon's Global Asset Allocation Team and represent the long-term capital market outlook (i.e., 30 years) based on data at the end of the second quarter of 2021. The assumptions were developed using a building block approach, reflecting observable inflation and interest rate information available in the fixed income markets as well as Consensus Economics forecasts. Our long-term assumptions for other asset classes are based on historical results, current market characteristics, and our professional judgment.

Inflation – Expected Level (2.1%)

Based on Consensus Economics long-term estimates and our near-term economic outlook, we expect U.S. consumer price inflation to be approximately 2.1% during the next 30 years.

Real Returns for Asset Classes

Fixed Income

- **Cash (-0.2%)** – Over the long run, we expect the real yield on cash and money market instruments to produce a real return of -0.2% in a moderate to low-inflationary environment.
- **TIPS (-0.03)** – We expect intermediate duration Treasury Inflation-Protected Securities to produce a real return of about -0.3%.
- **Core Fixed Income (i.e., Market Duration) (0.4%)** – We expect intermediate duration Treasuries to produce a real return of about -0.2%. We estimate the fair value credit spread (credit risk premium - expected losses from defaults and downgrades) to be 0.6%, resulting in a long-term real return of 0.4%.
- **Long Duration Bonds – Government and Credit (0.5%)** – We expect Treasuries with a duration comparable to the Long Government Credit Index to produce a real return of 0.0%. We estimate the fair value credit spread (credit risk premium - expected losses from defaults and downgrades) to be 0.5%, resulting in an expected real return of 0.5%.

Aon Investments' Capital Market Assumptions

Explanation of Capital Market Assumptions—Q3 2021

- **Long Duration Bonds – Credit (0.8%)** – We expect Treasuries with a duration comparable to the Long Credit Index to produce a real return of 0.0%. We estimate the fair value credit spread (credit risk premium - expected losses from defaults and downgrades) to be 0.8, resulting in an expected real return of 0.8%.
- **Long Duration Bonds – Government (0.0%)** – We expect Treasuries with a duration of ~12 years to produce a real return of 0.0% during the next 30 years.
- **High Yield Bonds (2.4%)** – We expect intermediate duration Treasuries to produce a real return of about -0.2%. We estimate the fair value credit spread (credit risk premium - expected losses from defaults and downgrades) to be 2.6%, resulting in an expected real return of 2.4%.
- **Bank Loans (2.8%)** – We expect LIBOR to produce a real return of about 0.1%. We estimate the fair value credit spread (credit risk premium - expected losses from defaults) to be 2.7%, resulting in an expected real return of 2.8%.
- **Non-US Developed Bonds: 50% Hedged (-0.1%) –** We forecast real returns for non-US developed market bonds to be -0.1% over a 30-year period after adjusting for a 50% currency hedge. We assume a blend of one-third investment grade corporate bonds and two-thirds government bonds. We also produce assumptions for 0% hedged and 100% hedged non-US developed bonds.
- **Emerging Market Bonds (Sovereign; USD) (2.2%) –** We forecast real returns for emerging market sovereign bonds denominated in US dollars to be 2.2% over a 30-year period.
- **Emerging Market Bonds (Corporate; USD) (2.1%) –** We forecast real returns for emerging market corporate bonds denominated in US dollars to be 2.1% over a 30-year period.
- **Emerging Market Bonds (Sovereign; Local) (2.1%)** – We forecast real returns for emerging market sovereign bonds denominated in local currency to be 2.1% over a 30-year period.
- **Multi Asset Credit (MAC) (3.4%) –** We assume real returns from beta exposure to high yield, bank loans and emerging market debt to add 2.6% plus 0.8% from alpha (net of fees) over a 30-year period.
- **Private Debt-Direct Lending (3.9%) –** The base building block is bank loans 2.8% + spread 3.0% (net of management fees and performance incentives). There is 100% leverage included in the assumption with the nominal cost of financing at LIBOR + 2.5%.

Aon Investments' Capital Market Assumptions

Explanation of Capital Market Assumptions—Q3 2021

Equities

- **Large Cap U.S. Equity (4.1%)** – This assumption is based on our 30-year outlook for large cap U.S. company dividends and real earnings growth. Adjustments are made for valuations as needed.
- **Small Cap U.S. Equity (4.6%)** – Adding a 0.5% return premium for small cap U.S. equity over large cap U.S. equity results in an expected real return of 4.6%. This return premium is theoretically justified by the higher risk inherent in small cap U.S. equity versus large cap U.S. equity, and is also justified by historical data. In recent years, higher small cap valuations relative large cap equity has reduced the small cap premium.
- **Global Equity (Developed & Emerging Markets) (4.8%)** – We employ a building block process similar to the U.S. equity model using the developed and emerging markets that comprise the MSCI All-Country World Index. Our roll-up model produces an expected real return of 4.8% for global equity.
- **International (Non-U.S.) Equity, Developed Markets (4.8%)** – We employ a building block process similar to the U.S. equity model using the non-U.S. developed equity markets that comprise the MSCI EAFE Index.
- **Emerging Market Stocks (5.3%)** - We employ a building block process similar to the U.S. equity model using the non-U.S. emerging equity markets that comprise the MSCI Emerging Markets Index.
- **Equity Risk Insurance Premium Strategies-High Beta (3.3%) –** We expect real returns from 50% equity + 50% cash beta of 2.3% plus 1.0% insurance risk premium over the next 30 years.

Alternative Asset Classes

- **Hedge Fund-of-Funds Universe (1.5%)** – The generic category "hedge funds" encompasses a wide range of strategies accessed through "fund-of-funds" vehicles. We also assume the ***median*** manager is selected and also allow for the additional costs associated with Fund-of-Funds management. A top-tier portfolio of funds (hedge fund-of-funds buy-list) could add an additional 1.2% in return at similar volatility based on alpha, lower fees and better risk management.

Aon Investments' Capital Market Assumptions

Explanation of Capital Market Assumptions—Q3 2021

- **Hedge Fund-of-Funds Buy List (2.6%)** – The generic category of top-tier "hedge funds" encompasses a wide range of strategies accessed through "fund-of-funds" vehicles. We assume additional costs associated with Funds-of-Funds management. To use this category the funds must be buy rated or we advise on manager selection.
- **Broad Hedge Funds Universe (2.8%)** – Represents a diversified portfolio of direct hedge fund investments. This investment will tend to be less diversified than a typical "fund-of-funds" strategy as there will be fewer underlying managers and will not include the extra layer of fees found in a Fund-of-Funds structure.
- **Broad Hedge Funds Buy List (4.1%)** – Represents a diversified portfolio of top-tier direct hedge fund investments. This investment will tend to be less diversified than a typical "fund-of-funds" strategy as there will be fewer underlying managers and will not include the extra layer of fees found in a Fund-of-Funds structure. To use this category the funds must be buy rated or we advise on manager selection.
- **Core Real Estate (3.3%)** -- Our real return assumption for core real estate is based a gross income of about 3.5%, management fees of roughly 1%, 25% leverage and future capital appreciation near the rate of inflation during the next 30 years. We assume a portfolio of equity real estate holdings that is diversified by property and by geographic region.
- **Non-Core Real Estate (5.1%)** -- Core real estate is levered approximately 100% as the base building block for this assumption. We subtract financing costs for the leverage and 2% management costs. We also assume nominal alpha of 3%. We assume a 50/50 mix of value-add and opportunistic investments.
- **U.S. REITs (2.9%)** – Our real return assumption for U.S. REITs is based on income of about 3.5% and future capital appreciation near the rate of inflation during the next 30 years. REITs are a sub-set of U.S. small/mid cap equity universe.
- **Commodities (2.3%)** – Our commodity assumption is for a diversified portfolio of commodity futures contracts. Commodity futures returns are composed of three parts: spot price appreciation, collateral return, and roll return (positive or negative change implied by the shape of the future curve). We believe that spot prices will converge with CPI over the long run (i.e., 2.1%). Collateral is assumed to be LIBOR cash (0.1%). Also, we believe the roll effect will be near zero, resulting in a real return of about 2.3% for commodities.

Aon Investments' Capital Market Assumptions

Explanation of Capital Market Assumptions—Q3 2021

- **Private Equity (6.5%)** – Our private equity assumption reflects a diversified fund of funds with exposure to buyouts, venture capital, distressed debt, and mezzanine debt.
- **Infrastructure (4.9%)** – Our infrastructure assumption is formulated using a cash flow based approach that projects cash flows (on a diversified portfolio of assets) over a 30-year period. Income and capital growth as well as gearing levels, debt costs and terms, relevant tax and management expenses are all taken into consideration. Our approach produces an expected real return of 4.9% for infrastructure.
- **Equity Risk Insurance Premium Strategies-Low Beta (2.3%) –** We assume real returns from cash of -0.2% + 2.5% from alpha.
- **Alternative Risk Premia (ARP) (4.0%) –** Real return target LIBOR 0.1% plus 3.9% alpha (net of fees)
- **eLDI (1.6%) –** Combination of various long credit strategies (1/6 real estate debt, 1/3 securitized debt, 1/6 CMOs, 1/3 private placements)

Volatility / Correlation Assumptions

Assumed volatilities are formulated with reference to implied volatilities priced into option contracts of various terms, as well as with regard to historical volatility levels. For asset classes which are not marked to market (for example real estate), we "de-smooth" historical returns before calculating volatilities. Importantly, we consider expected volatility trends in the future – in recent years we assumed the re-emergence of an economic cycle and a loss of confidence in central bankers would lead to an increase in volatility. Correlation assumptions are generally similar to actual historical results; however, we do make adjustments to reflect our forward-looking views as well as current market fundamentals.

Appendix

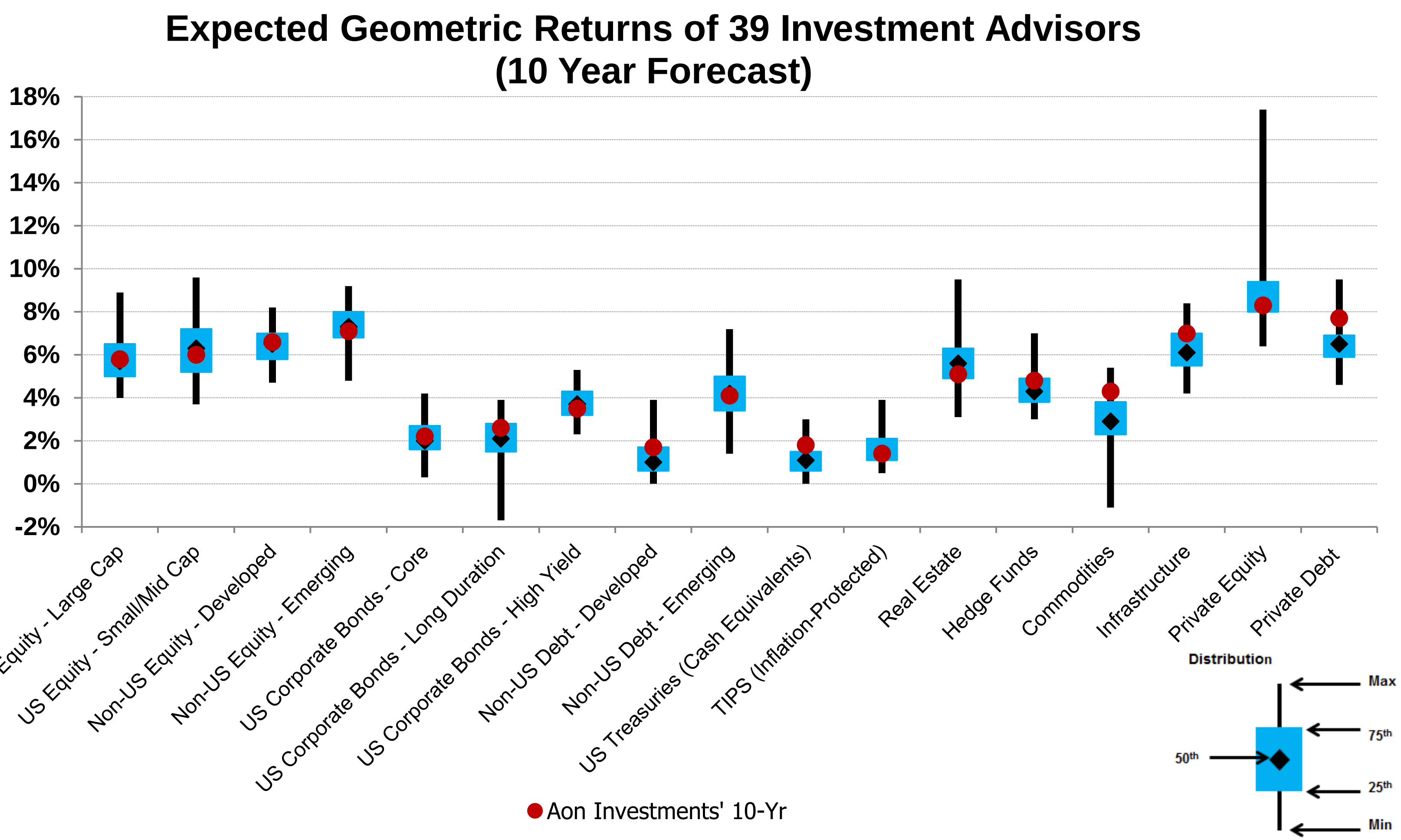
- Horizon Survey of Capital Market Assumptions

2021 Horizon Survey Results

- **What is the Horizon Survey?**
  - Since 2010, Horizon Actuarial Services, LLC has conducted a capital market assumption survey of investment firms to aid in determining reasonable assumptions for a pension plan's expected return on assets
    - While Aon does not seek to change our approach based on how we stack up to peers, it is a helpful double-check to make sure we are not too far off from others in the industry

- **How does Aon compare to the 2021 survey results?**
  - Aon Investments' 2021 10-year forecast assumptions (as of March 31, 2021)
    - ***Equities:*** approximately middle of the pack for U.S. and Non-U.S. equities
    - ***Fixed Income:*** approximately middle of the pack relative to the survey's median level; higher for U.S. Treasuries
    - ***Alternatives:*** approximately middle of the pack relative to the survey's median level; higher for Commodities and Private Debt

Aon Investments’ Capital Market Assumptions vs. Horizon Survey



SOURCE: Horizon Actuarial Solutions, LLC survey of 2021 capital market assumptions from 39 independent investment advisors
Expected returns of the survey are annualized over 10-years (geometric).
Aon Investments’ expected returns are annualized over 10-years as of 2Q 2021 (3/31/2021).

Aon Investments vs. Peers (2021 Horizon Survey)—10-Year Forecast

Asset Class	Horizon Survey 10 Year Horizon Expected Return	Horizon Survey 10 Year Horizon Expected Risk	Aon Investments 10 Year Forecasts Expected Return	Aon Investments 10 Year Forecasts Expected Risk	Difference (Aon Investments - Horizon Survey) Expected Return	Difference (Aon Investments - Horizon Survey) Expected Risk
US Equity - Large Cap	5.7%	16.4%	5.8%	17.0%	0.1%	0.6%
US Equity - Small/Mid Cap	6.3%	20.2%	6.0%	23.0%	-0.3%	2.8%
Non-US Equity - Developed	6.5%	18.3%	6.6%	20.0%	0.1%	1.7%
Non-US Equity - Emerging	7.3%	24.3%	7.1%	27.0%	-0.2%	2.7%
US Fixed Income - Core	2.0%	5.5%	2.2%	4.0%	0.2%	-1.5%
US Fixed Income - Long Duration Corp	2.1%	10.4%	2.6%	9.0%	0.5%	-1.4%
US Fixed Income - High Yield	3.7%	9.9%	3.5%	12.0%	-0.2%	2.1%
Non-US Fixed Income - Developed	1.0%	7.2%	1.7%	5.5%	0.7%	-1.7%
Non-US Fixed Income - Emerging	4.2%	11.3%	4.1%	13.0%	-0.1%	1.7%
Treasuries (Cash Equivalents)	1.1%	1.3%	1.8%	1.5%	0.7%	0.2%
TIPS (Inflation-Protected)	1.4%	5.6%	1.4%	3.5%	0.0%	-2.1%
Real Estate	5.6%	17.6%	5.1%	15.0%	-0.5%	-2.6%
Hedge Funds	4.3%	8.1%	4.8%	9.0%	0.5%	0.9%
Commodities	2.9%	17.3%	4.3%	17.0%	1.4%	-0.3%
Infrastructure	6.1%	17.0%	7.0%	14.5%	0.9%	-2.5%
Private Equity	8.3%	22.3%	8.3%	25.0%	0.0%	2.8%
Private Debt	6.5%	11.4%	7.7%	16.5%	1.2%	5.1%
Inflation	2.0%	2.1%	2.1%	1.0%	0.1%	-1.1%

Notes (Horizon Survey):
Source: Horizon Actuarial survey of 2021 capital market assumptions from 39 independent investment advisors
Expected returns are median annualized (geometric).

Notes (Aon Investments' Forecasts):
Aon Investments' Forecasts are for Q2 2021
- US Equity - Small/Mid Cap forecasts represents Aon Investments' forecasts for US Small Cap
- US Fixed Income - Long Duration forecasts represents Aon Investments' forecasts for Long Duration Credit
- Non-US Fixed Income - Developed forecasts represents Aon Investments' forecasts for Non-US Fixed Income - Developed (50% Hedged)
- Non-US Fixed Income - Emerging forecasts represents Aon Investments' forecasts for Emerging Market Bonds - Sovereign USD
- Real Estate forecasts represents Aon Investments' forecasts for Core Real Estate
- Hedge Fund forecasts represents Aon Investments' forecasts for Direct Hedge Funds (Universe)

Leading Methodologies & Reasons for Differences

Leading Methodologies

- Building Block
- Global Capital Asset Pricing Model (Global CAPM)
- Surveys
- Historical data (as a guide to future)
- Black-Litterman (combination of building block and CAPM)

Reasons for Differences

- Methodology
- Time Horizon
- Arithmetic vs. Geometric forecasts*
- Alpha (active management)*
- Inflation
- Investment Fees*
- Asset class definition

* While some firms in the Horizon survey responded with arithmetic forecasts, the results have been converted to geometric forecasts for comparison purposes. Additionally, the return expectations included in the Horizon survey are generally market returns that do not reflect active management. Returns for asset classes where passive investments are not available (e.g., hedge funds and private equity) are net of fees.

Appendix

- How Do Public Pensions Impact Credit Ratings?

How Do Public Pensions Impact Credit Ratings?

Summary and Conclusions

Pension Impact on Credit Ratings

- Pension plans have a direct impact on the ultimate state or local credit rating
- Rating agencies are not just looking at where public pension plans stand today; they are looking at the expected future trajectory of the plan based on how it is managed

Credit Ratings and Borrowing Costs

- Taxpayers in lower credit rated jurisdictions are paying higher borrowing costs and could save money through healthier pension plan management

Call to Action

- The Big Three value selecting appropriate actuarial assumptions, avoiding excessive risk taking, and developing an adequate funding policy
- While debt priorities and revenue framework to service such debt will vary on a case-by-case basis, every jurisdiction has the ability to thoughtfully develop a funding policy and set appropriate assumptions
- These initial steps will help pension stakeholders better understand the true economic costs, improve the funding outlook for public pensions, and potentially reduce borrowing costs and further taxpayer burden

How Do Public Pensions Impact Credit Ratings?

Call to Action: Plan Sponsors Have Ability to Impact Credit Rating

Below are three specific actions plan sponsors can take today to directly improve the impact a pension plan will have on the credit rating of its locality:

Action	Considerations
1. Conduct an actuarial assumption audit ▪ Review reasonability of key assumptions: – Salary scale, Mortality, Retirement rates, Turnover rates	▪ Assumptions set to plan-specific expectations will lead to lower contribution volatility ▪ Aggressive assumptions may provide short-term relief but may have long-term consequences
2. Consider adjustments to expected return assumption ▪ Adjustments should be in line with forward-looking expectations for asset returns	▪ Contributing an actuarial amount? – **Yes:** Failing to achieve target returns will necessitate increases in future contributions and make what was intended to be a smooth, budget-friendly progression of contribution increases far more volatile – **No:** The funding gap will widen and become highly volatile as contribution policy will not add enough dollars to replenish losses
3. Review the plan's funding policy ▪ Look far enough into the future to identify potential pain points	▪ Conduct "tread water"/hurdle rate analysis to ensure short-term contributions are sufficient to keep pace with growth of plan liabilities ▪ Consider asset-liability study to understand range of potential future outcomes rather than a single deterministic scenario

Appendix

- Asset-Liability Management Background

Asset-Liability Management Background
Overview

What?

- A comprehensive toolkit for making decisions on a fund's **asset allocation and investment risk that align with the liabilities** those funds support

Why?

- Aon believes optimal decisions regarding pension plan management are made when they are based on a **clear understanding of the assets and liabilities** of the plan(s) and how they interact

When?

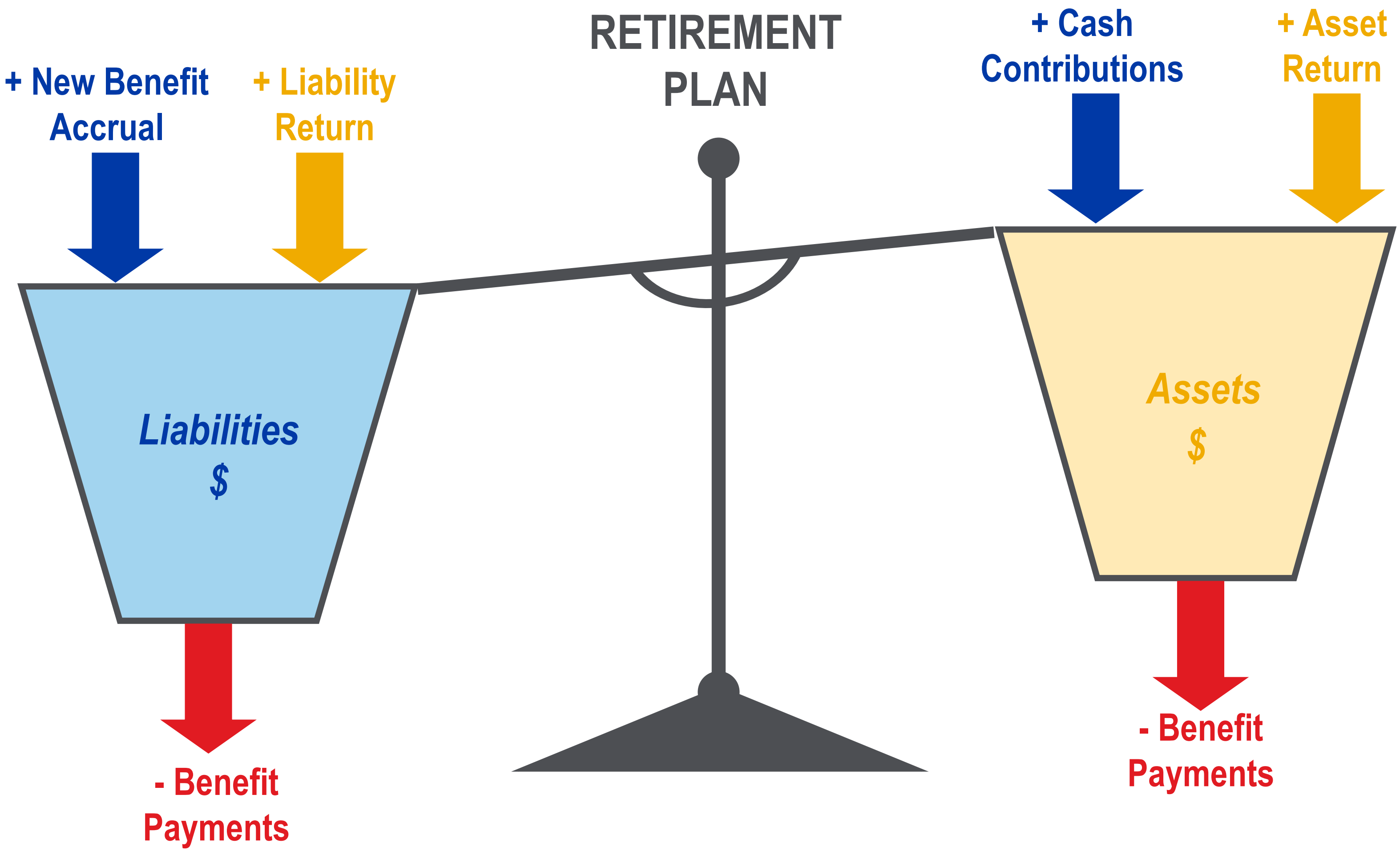
- For a formal review of the asset-liability modeling, Aon suggests conducting asset-liability studies every **3 to 5 years** depending on client specifics, or more frequently should circumstances dictate (e.g., material changes to the liability profile, etc.)

How?

- **Identify future trends** in the financial health of the fund (e.g., funded ratio, contributions, etc.) based on economic uncertainties that may not be evident from an actuarial valuation, which provides only a snapshot at a point in time

Asset-Liability Management Background

Balance of Liabilities and Assets



Asset-Liability Management Background

Key Risks for Public Pension Plans

Types of Risk	Time Horizon	Risk Management Tools and Controls
Return Shortfall ▪ Assets do not grow with liabilities ▪ Investment Return & Contribution less than Liability Growth	**Long Term** (10+ years)	▪ Funding Policy ▪ Plan Design ▪ Investment Policy ▪ Assumptions & Methods
Liquidity ▪ Cannot liquidate assets efficiently to meet needs ▪ Lost control of asset allocation	**Short to Medium Term** (<5 years)	▪ Funding Policy ▪ Benefit Accruals ▪ Use of Illiquid Investments ▪ Scenario Analysis ▪ Monitoring
Investment ▪ Asset Allocation (Policy) ▪ Investment Structure ▪ Manager Selection ▪ Rebalancing ▪ Scenario (or Path Risk) ▪ Factor	**Short to Medium Term** (<5 years)	▪ Investment Policy Statement – Static/Dynamic – Asset Allocation – Rebalancing – Manager Guidelines – Monitoring/Roles & Responsibilities ▪ Risk Budgeting Tools ▪ Monitoring / Dashboards ▪ Medium Term Views ▪ Regression and Scenario Analysis
Other (e.g., Operational)	**Ongoing**	▪ Operational and Specialty Due Diligence

Asset-Liability Management Background

Overview of the Asset-Liability Study Process

Planning Discussions

Planning
- Objectives of the Study
- Modeling and Liability Assumptions

\+

Risk Tolerance
- Risk Preference
- Demographics
- Funded Status
- Business/Financial
- Industry Practices

\+

Asset-Liability Projections

Asset Modeling
- Capital Market Analysis
- Efficient Frontier Analysis
- Portfolios for Study

\+

Liability Analysis
- Cost Projections
- Funded Status
- Sensitivity Analysis

Desired Outcomes:
- **Understand the pension risk**
- **Identify optimal investment strategy**

↓

Implementation

↓

Monitoring & Execution

Asset-Liability Management Background

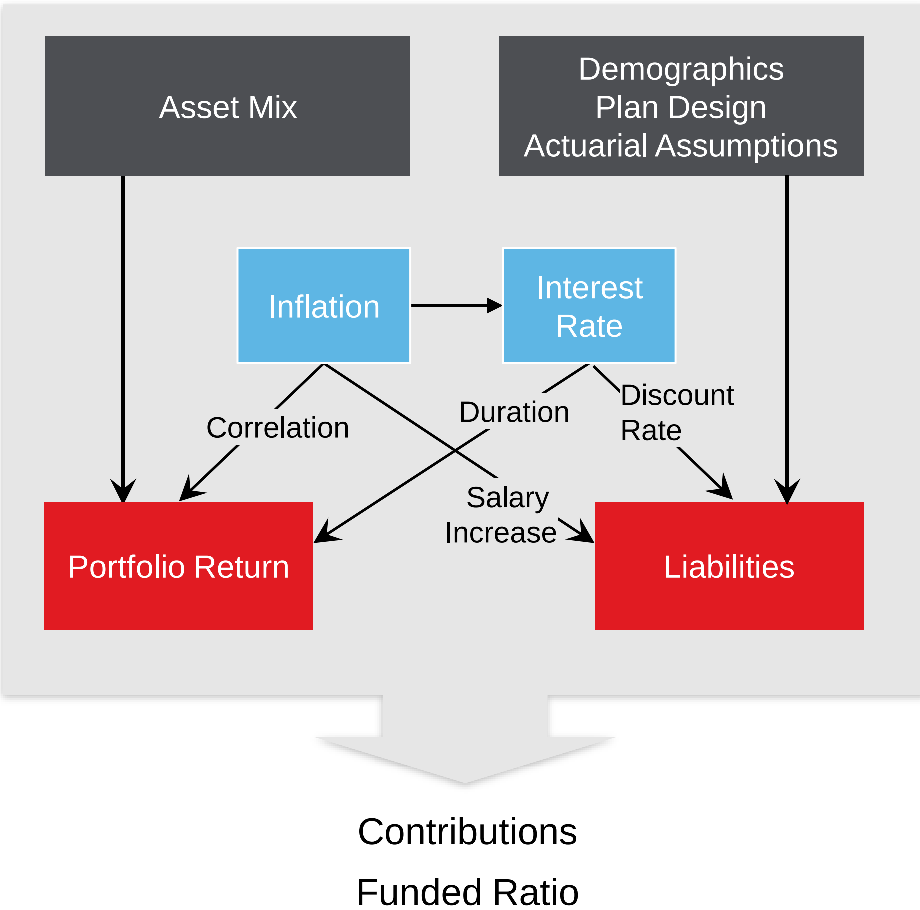
Modeling Process

- Goals of an asset-liability study:
  - Understand the pension plan's asset-liability risk, and
  - Identify the optimal investment strategies

- Stochastic, Monte Carlo simulation analysis used
  - 5,000 independent economic trials
  - Building block approach
    - Starts with inflation and interest rates
    - Using a multi-factor regression analysis, other asset classes are then modeled
  - Assets and liabilities are modeled over the projection period
    - Projections include contribution requirements and funded ratios

- Asset-liability studies are best-suited to determine the optimal mix of return-seeking (e.g., equity) and fixed income assets for the pension fund
  - Asset mix is the single most important investment decision for the plan sponsor
    - Is it worthwhile to have a more aggressive allocation in order to reduce long term cost in exchange for risk of higher costs in a bad outcome?
    - Is it worthwhile to have a more conservative allocation in order to have a more predictable cost in exchange for potentially higher average costs?

Asset-Liability Management Background
Mechanics of Asset-Liability Modeling Process



Asset and liability modeling integrated in single platform

- Integrates impact of key economic variables

Flexibility in modeling parameters and output to client preferences

Stochastic and deterministic modeling performed

Asset-Liability Management Background

Risk and Return in an Asset-Liability Context

- **Traditional:**
  - Return = Investment performance
  - Risk = Annual volatility of investment gains and losses (e.g., weak/negative capital market returns)

- **Asset-Liability:**
  - Return = Potential cost reduction or funded status improvement under average economic conditions
  - Risk = During the worst economic conditions, contributions need to increase or funded status declines (e.g., stocks decline, inflation/deflation shocks and/or interest rates decline)

Asset-Liability Management Background
Key Factors Affecting the Risk/Reward Trade-off

- The key take-away from the A/L study is the allocation between equity (“return-seeking”) vs. fixed income (“risk-reducing”)

- Major factors affecting the ultimate mix are:
  - Time horizon (or amortization period of unfunded liability) to fund the liability: a longer time horizon supports more risk taking
  - Characteristics of plan participants: a growing population of active participants supports more risk taking; a mature population with significant retirees might need a more conservative policy
  - Funded status: a less funded plan can utilize additional returns from equity investments
  - Nature of plan benefits: a pension with sensitivity to wage inflation growth can benefit from equities in the long-term; an increased need for liquidity due to significant benefit payments in the near future can lead to a more conservative policy

Asset-Liability Management Background
Limitations of Asset-Liability Modeling

- Asset-liability studies are best-suited to determine the optimal mix of return-seeking (e.g., equity) and risk-reducing (e.g., fixed income) assets for the retirement fund
  - Asset mix is the single most important investment decision for the plan sponsor
  - Studies have found that more than 90% of the variability of a portfolio's return is determined by the asset allocation
  - Decisions regarding how to divide allocations among various sub-categories are less important in an asset-liability context and can be addressed in the implementation phase, following the asset-liability study

- Asset-liability modeling can capture the likelihood of a strategy meeting the objectives
  - It does not 'predict' the future, i.e., we cannot say which of the economic scenarios will actually occur
  - The results depend on the assumptions underlying the model and the structure of the model itself

- There are elements that cannot be modeled and must be thought of in addition to the results of any analysis:
  - E.g., idiosyncratic manager risk, liquidity requirements
  - Black swans

Appendix

- About This Material

Empower Results®

About This Material

This material includes a summary of calculations and consulting related to the finances of Pennsylvania Public School Employees' Retirement System (PSERS). The following variables have been addressed:

- Contributions, Funded Ratio, Hurdle Rate, Net Outflow

This analysis is intended to assist the Investment Committee with a review of the associated issues and options, and its use may not be appropriate for other purposes. This analysis has been prepared solely for the benefit of the Investment Committee. Any further dissemination of this report is not allowed without the written consent of Aon Investments USA Inc.

Our calculations were generally based on the methodologies identified in the actuary's valuation report for PSERS. We believe the methodology used in these calculations conforms to the applicable standards identified in the report.

Models are used to develop alternative scenarios based on the underlying valuation model and project financial results under those scenarios. The models were developed by experts outside and within Aon. Where outside models were used, the models were reviewed by experts within Aon. The models were selected as appropriate for these projections by the undersigned.

Experience different than anticipated could have a material impact on the ultimate costs of the benefits. In addition, changes in plan provisions or applicable laws could have a significant impact on cost. Actual experience may differ from our modeling assumptions.

Our calculations were based on data provided by the plan actuary. The actuarial assumptions and methods and plan provisions reflected in these projections are the same as those used for the 2020 actuarial valuation for PSERS as noted in the actuarial reports, except where noted in this report. Unless specifically noted, our calculations do not reflect any other changes or events after June 30, 2020. Reflecting events after June 30, 2020 would impact the results of the projection.

In conducting these projections, we have relied on plan design, demographic and financial information provided by other parties, including the plan's actuary and plan sponsor. While we cannot verify the accuracy of all of the information, the supplied information was reviewed for consistency and reasonableness. As a result of this review, we have no reason to doubt the substantial accuracy or completeness of the information and believe that it has produced appropriate results.

These projections have been conducted in accordance with generally accepted actuarial principles and practices, including applicable Actuarial Standards of Practice as issued by the Actuarial Standards Board. The undersigned actuary is familiar with the near-term and long-term aspects of pension valuations and meet the Qualification Standards of the American Academy of Actuaries necessary to render the actuarial opinions contained herein. All sections of this report are considered an integral part of the actuarial opinions.

To our knowledge, no colleague of Aon Investments USA Inc. providing services to PSERS has any direct financial interest or indirect material interest in PSERS. Thus, we believe there is no relationship existing that might affect our capacity to prepare and certify this report for PSERS.

Aon Investments USA Inc.

Phil Kivarkis FSA, CFA

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Aon Investments USA Inc.
200 E. Randolph Street
Suite 700
Chicago, IL 60601
ATTN: Aon Investments Compliance Officer

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