Verus

PERSPECTIVES THAT DRIVE ENTERPRISE SUCCESS

MAY 2, 2018

Asset Liability Study: Phase 4

Fresno County Employees’ Retirement Association

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Executive summary

Over the first three phases of the 2018 Asset-Liability Study we have reviewed the following:

— FCERA's ability and willingness to accept investment risk.

— Background on the importance of diversification and the impact of the current return environment.

— Verus' 2018 Capital Market Assumptions.

— Several "goal post" asset allocation mixes, comparing and contrasting these portfolios through both asset-only and asset-liability frameworks to better understand their sources of risk and how each behaves in different market scenarios.

Using this information the Board narrowed down which mixes displayed risk and return characteristics appropriate for FCERA.

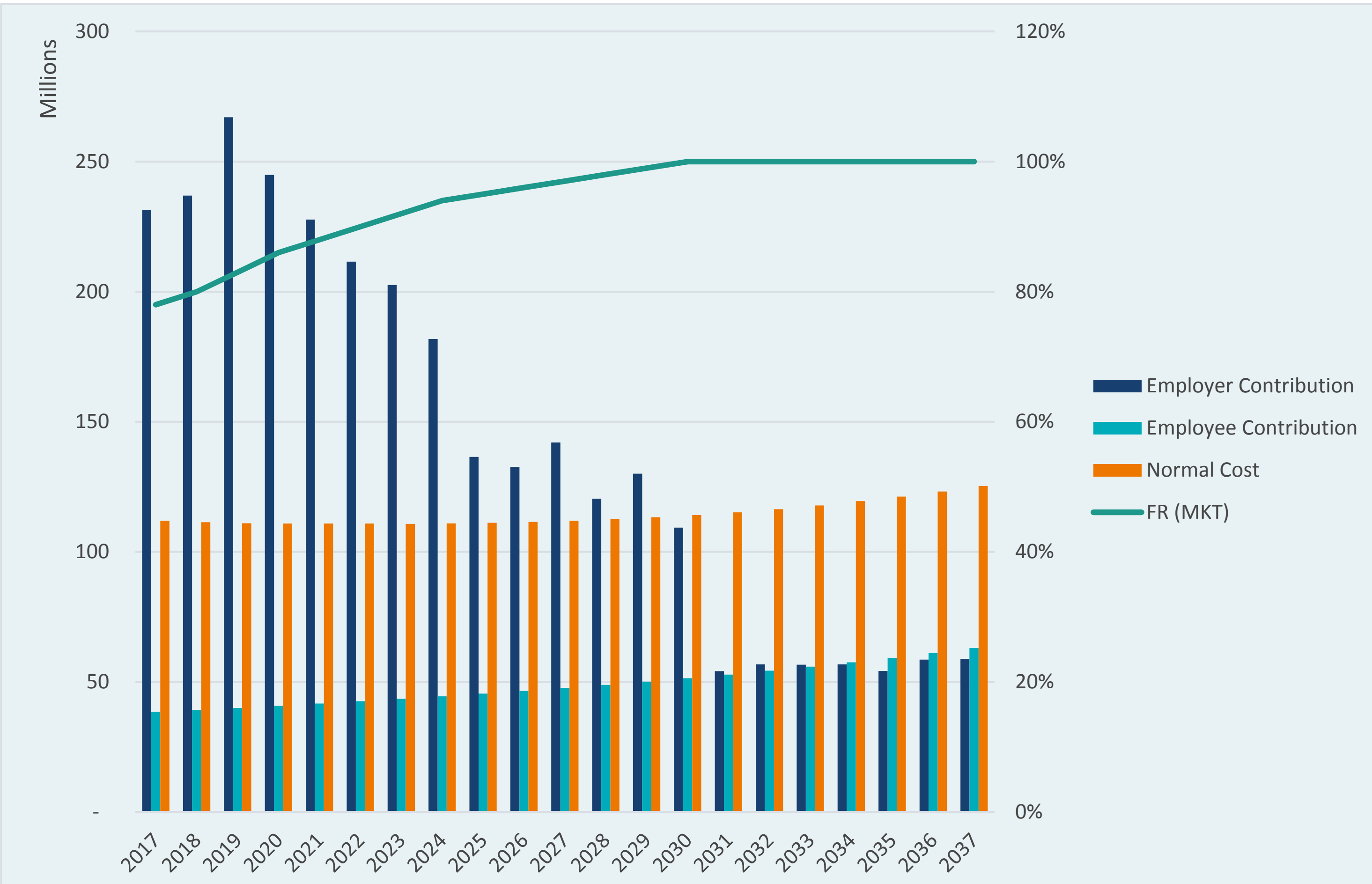
Today's discussion will focus on more granular differences between asset allocation alternatives.

This presentation introduces several allocations in between the goal post portfolios (current and peer); the objective today is to adopt the go-forward asset allocation mix.

Deterministic projections

Baseline deterministic projection

BASELINE DETERMINISTIC FORECAST (7% RETURN)



If all our assumptions hold true, the Plan would be fully funded in 15 years.

Once the UAAL is paid, employer contributions revert to roughly 50% of normal cost.

The impact of drawdowns

Drawdowns can have a significant impact on funded status and required contributions for FCERA

	Time Horizon (yrs)	Drawdown (%)	Drawdown Year	Total Contributions	Max Contribution (as % of Payroll)	Max Contribution ($ Amount)	Lowest Funded Ratio	Ending Funded Ratio	Unfunded Actuarial Liability ($ Amount)
Baseline	20	None	--	$2,970,252,563	60.7% (2019)	$267,034,428 (2019)	78% (2017)	100%	-$15,569,947
7.5% Return Scenario	20	None	--	$2,159,722,843	60.4% (2019)	$265,794,252 (2019)	78% (2017)	102%	-$154,951,840
Drawdown Scenario 1	20	-25	6	$6,067,367,675	60.7% (2019)	$354,949,778 (2030)	64% (2023)	94%	$603,544,981
Drawdown Scenario 2	20	-35	6	$7,041,543,058	70.6% (2027)	$420,789,451 (2030)	56% (2023)	92%	$716,420,843
Drawdown Scenario 3	20	-35	6	$7,794,658,010	77.2% (2027)	$488,703,465 (2037)	52% (2025)	90%	$952,883,354

— The Baseline and Drawdown scenarios assume the Plan follows the current contribution policy and grows each year at the 7.0% actuarial assumed rate (other than the drawdown event).

- Scenario 3 assumes the Plan experiences two years of 0% returns after the drawdown year before returning to the 7.0% growth rate.

— Under Scenarios 1, a -25% drawdown would require roughly $3 billion more in contributions and bring the Plan down to a funded ratio of 64% in 2023 before finishing at 94%.

— Under Scenarios 2, a -35% drawdown would require roughly $4 billion more in contributions and bring the Plan down to a funded ratio of 56% in 2023 before finishing at 92%.

— Relative to Scenario 2, Scenarios 3 would increase required contributions by an additional ~$800 million, bring contributions as a percentage of payroll up to 77% in 2027, and leave the Plan with a funded ratio of 90%.

Asset allocation alternatives

Asset allocation

	Mix 1 (Current Policy)	Mix 2	Mix 3	Mix 4	Mix 5 (SACRS Peer)	Mix 6
Domestic Large Cap Equity	14%	17%	18%	19%	21%	21%
Domestic Small Cap Equity	3%	4%	5%	5%	5%	5%
International Developed Equity	9%	11%	12%	14%	17%	15%
International Small Cap Equity	3%	3%	3%	3%		3%
Emerging Markets Equity	7%	6%	6%	6%	4%	6%
Global Equity					2%	
Total Public Equity	***36%***	***41%***	***44%***	***47%***	***49%***	***50%***
US Core Plus Fixed Income					20%	
US Credit Fixed Income	5%	4%	4%	4%		4%
High Yield Fixed Income	5%	5%	5%	3%		3%
Bank Loans	5%	5%	5%	5%		5%
Global Sovereign	7%	7%	7%	7%	1%	7%
Emgerging Markets Debt	5%	3%	3%	3%	2%	3%
TIPS	4%	3%	3%	3%		4%
Total Fixed Income	***31%***	***27%***	***27%***	***25%***	***23%***	***26%***
Private Equity	6%	6%	6%	6%	7%	6%
Private Credit	8%	8%	8%	8%	5%	8%
Commodities	3%	3%			3%	
Real Estate	5%	5%	5%	5%	8%	5%
Infrastructure	3%	3%	3%	3%		3%
Hedge Funds	8%	7%	7%	6%	5%	6%
Total Alternatives/Real Assets	***33%***	***32%***	***29%***	***28%***	***28%***	***28%***
Total Portfolio	**100%**	**100%**	**100%**	**100%**	**100%**	**104%**
Mean Variance Analysis						
Forecast 10 Year Return	**6.0**	**6.0**	**6.0**	**6.1**	**6.0**	**6.2**
Risk (StdDev Rtn), %	11.8	12.2	12.4	12.7	12.4	13.2
Sharpe Ratio	0.36	0.36	0.36	0.36	0.36	0.36
Equity Tail Risk	-34%	-35%	-36%	-37%	-38%	-38%

Mix 6 adds 4% leverage to the portfolio.

Asset allocation changes explained

Changes relative to the current policy

Mix 2:

— Adds 5% to global public equity, funded 1% from hedge funds and 4% from fixed income.

Mix 3:

— Adds 8% to global public equity, funded 1% from hedge funds, 4% from fixed income, and removing the 3% commodities allocation.

Mix 4:

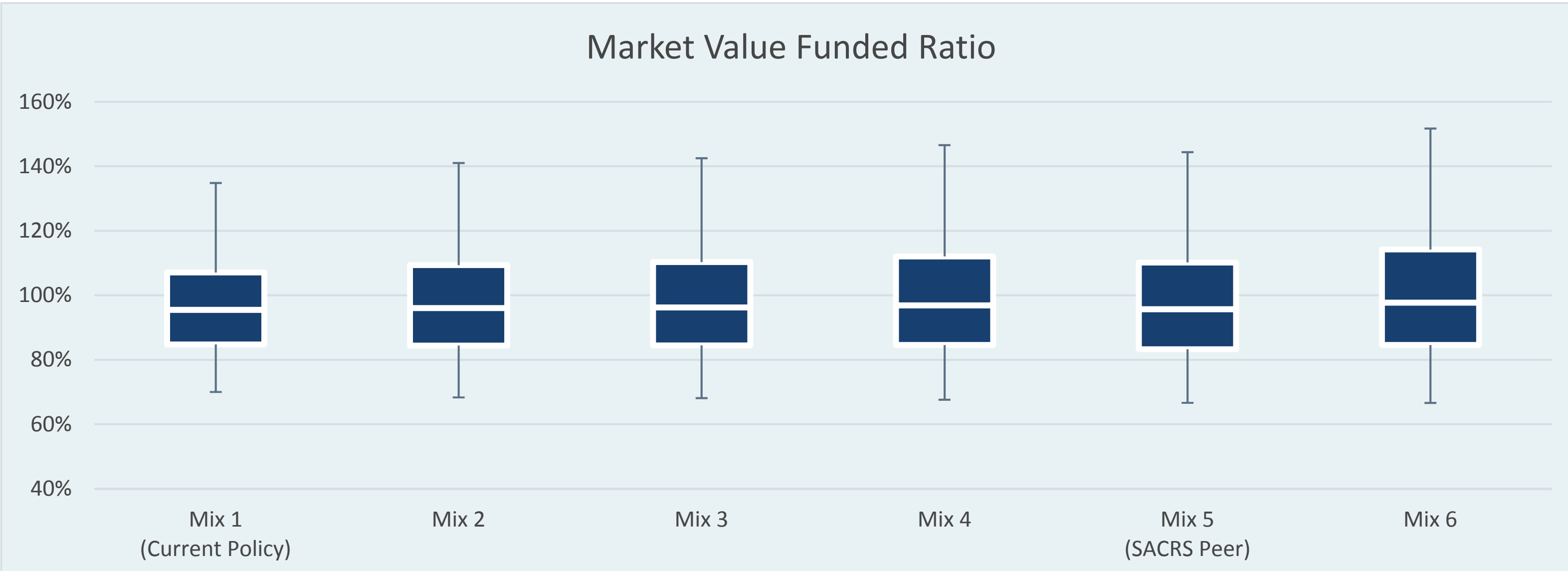
— Adds 11% to global public equity, funded 2% from hedge funds, 6% from fixed income, and removing the 3% commodities allocation.

Mix 5: The peer mix

Mix 6:

— Identical to Mix 4, except that the equity allocation is increased 3% and TIPS is increased 1% (accomplished through leverage).

Stochastic projections – funded status



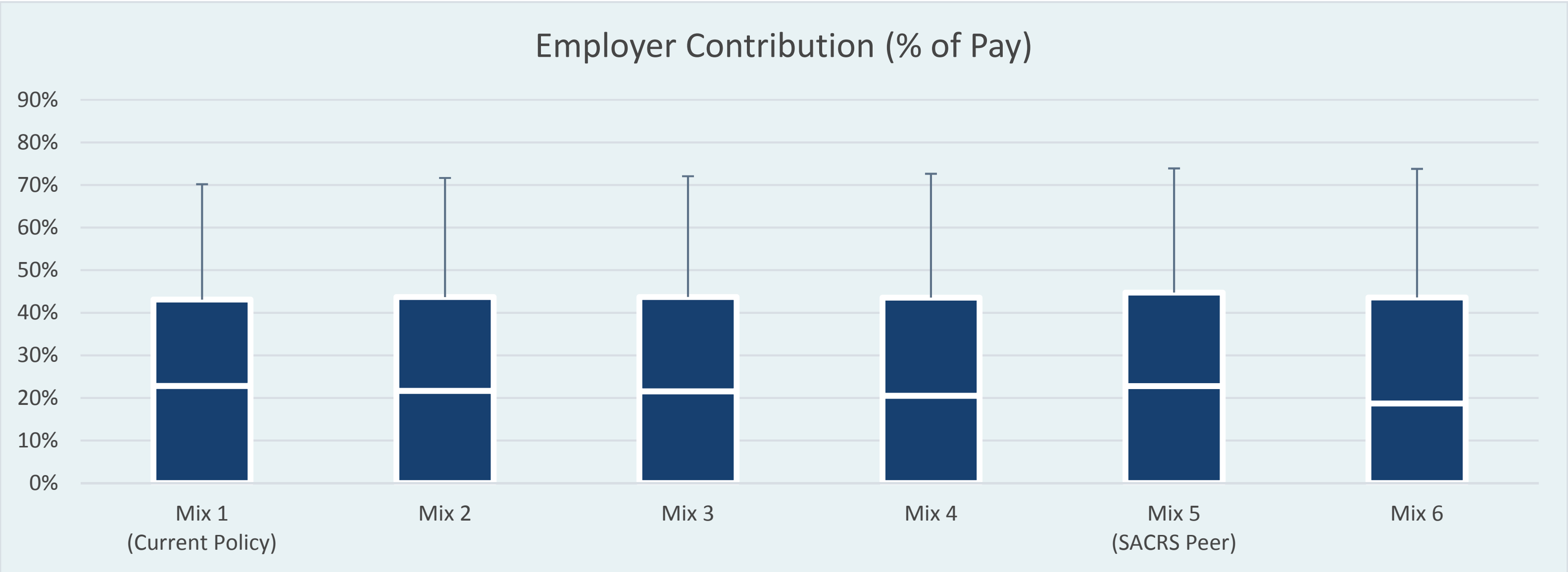
More aggressive portfolios increase the range of possible outcomes.

FUNDED STATUS – STOCHASTIC OUTCOMES IN 10 YEARS

	Mix 1 (Current Policy)	Mix 2	Mix 3	Mix 4	Mix 5 (SACRS Peer)	Mix 6
Best Case (95%)	134.8%	141.0%	142.5%	146.5%	144.4%	151.7%
Median Outcome (50%)	95.5%	96.0%	96.2%	96.9%	95.7%	97.7%
Worst Case (5%)	70.0%	68.3%	68.1%	67.6%	64.4%	66.6%
CVAR (5%)	51.2%	49.8%	49.6%	49.2%	47.9%	48.1%
Range (Best-Worst Case)	64.8%	72.7%	74.4%	78.9%	80.0%	85.1%

Source: ProVal, Verus

Stochastic projections – employer contributions



More aggressive portfolios increase the magnitude of worst case scenarios.

EMPLOYER CONTRIBUTIONS – STOCHASTIC OUTCOMES IN 10 YEARS

	Mix 1 (Current Policy)	Mix 2	Mix 3	Mix 4	Mix 5 (SACRS Peer)	Mix 6
Best Case (95%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Median Outcome (50%)	22.8%	21.7%	21.5%	20.5%	22.8%	18.7%
Worst Case (5%)	70.2%	71.7%	72.1%	72.6%	73.9%	73.8%
CVAR (5%)	80.8%	82.8%	83.1%	83.6%	85.5%	85.4%

Source: ProVal, Verus

Adding leverage

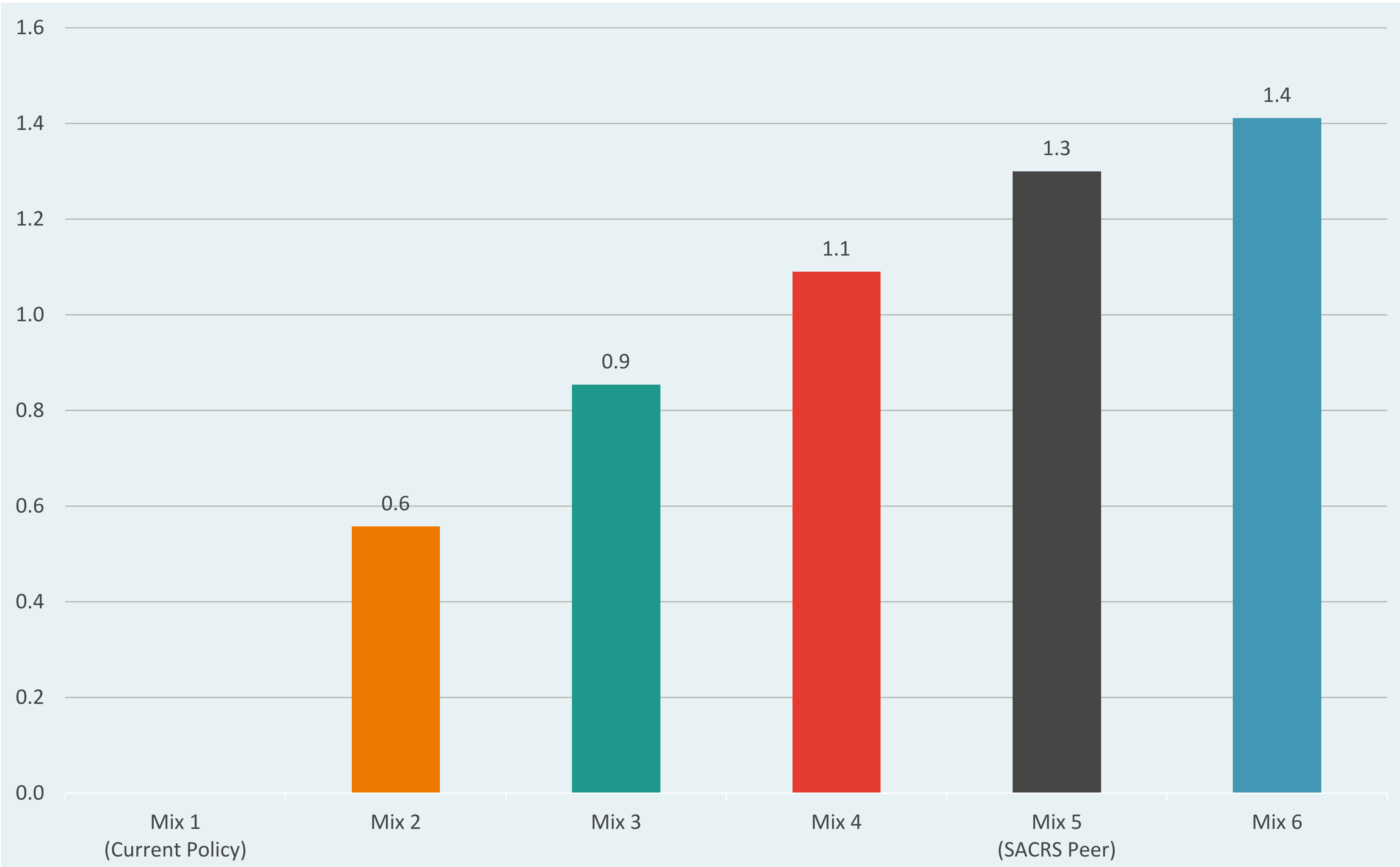
— Mix 6 has 104% total exposure to the market. This is achieved by using TIPS to back the futures exposure within the PIMCO StocksPLUS Small mandate.

— In order to obtain a 4% TIPS allocation, strategies that use futures to gain exposure (like PIMCO's Small Cap StocksPLUS) would have to be expanded to 5% of the total portfolio. This would be addressed in implementation (June meeting).

- Today, the account invests in small cap equity futures and manages the collateral pool as an absolute return bond mandate seeking to outperform LIBOR.
- The guidelines would be modified such that the collateral pool benchmark would be U.S. TIPS. We estimate 80% of the collateral can be re-invested.
- This provides greater market exposure (i.e. leverage) in a capital-efficient manner.
- The additional benefit to this approach is TIPS generally have a negative correlation with U.S. equities.

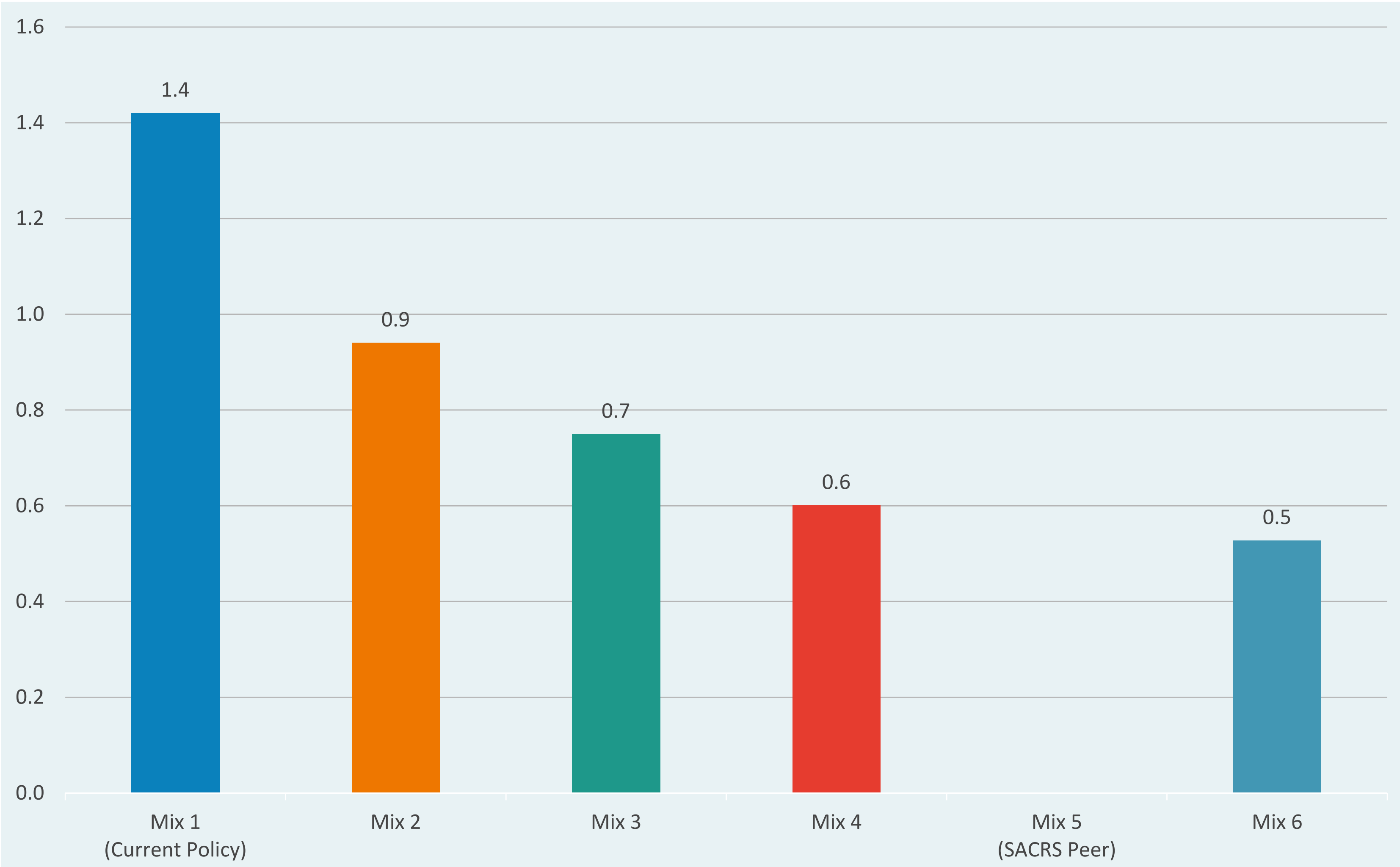
— While we have modeled this leverage alternative for Mix 6, Verus can model the other mixes with leverage if desired by the Board of Trustees.

Active risk to current policy



Each mix adds incremental tracking error relative to the current policy.

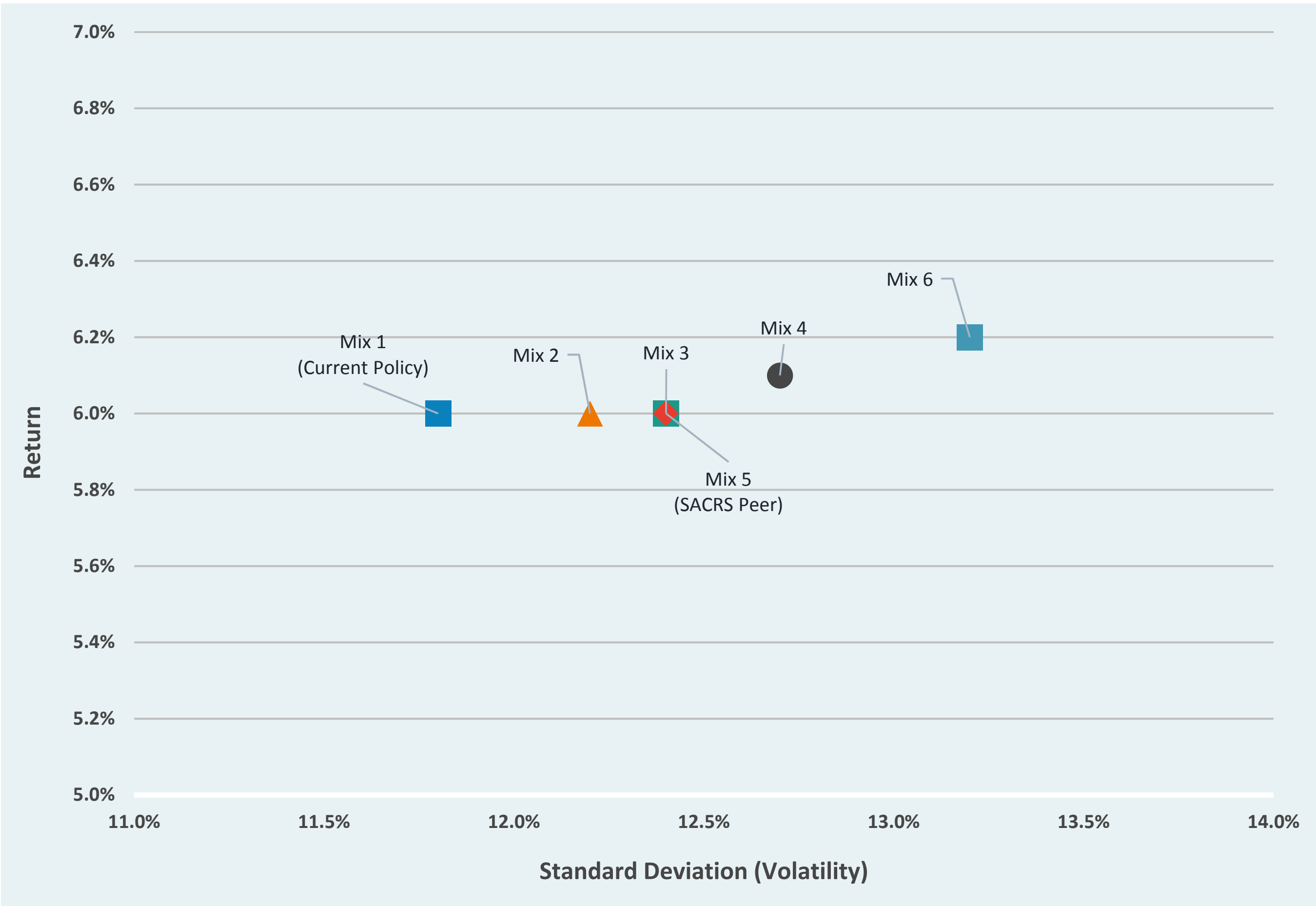
Active risk to peers



Each mix reduces incremental tracking error relative to peers.

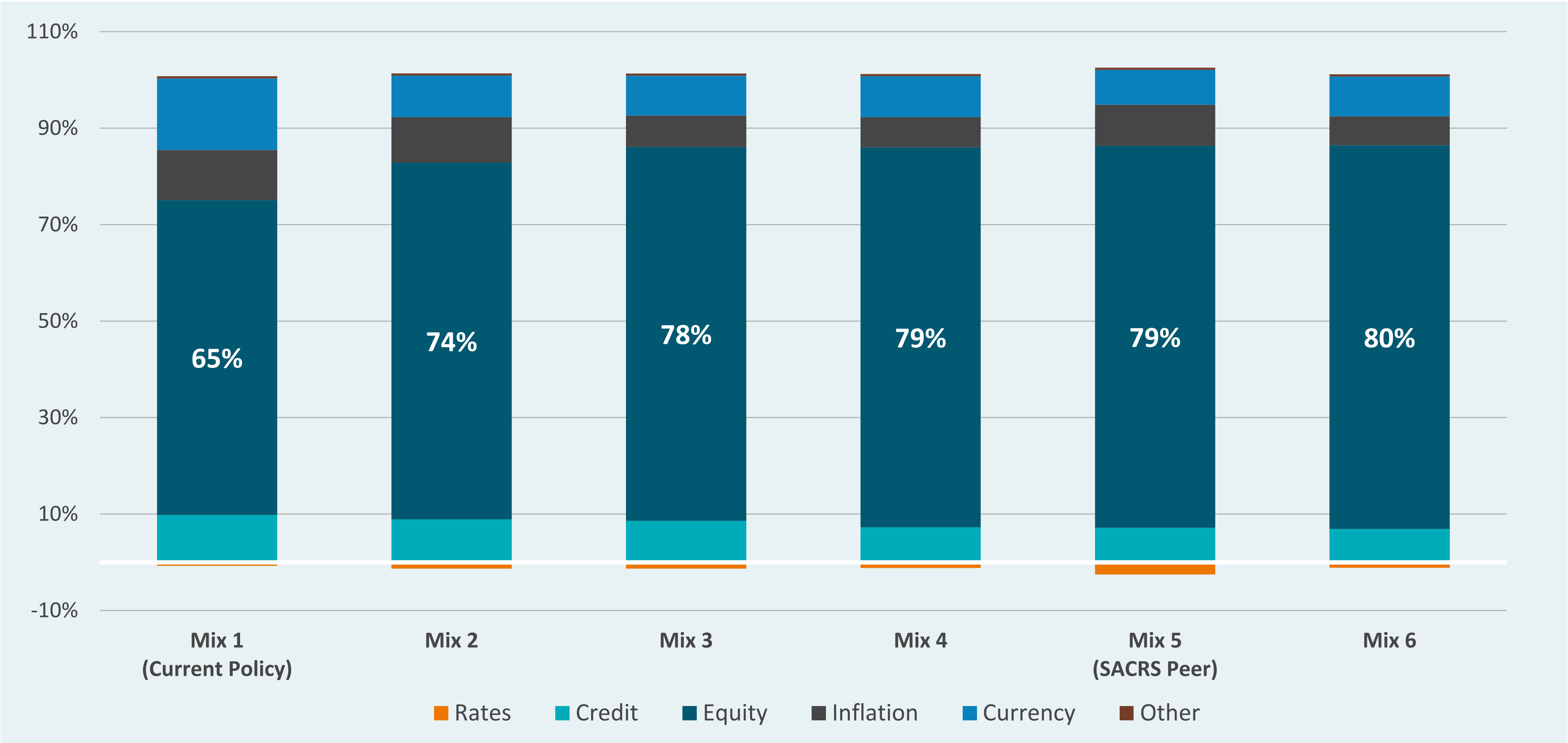
Risk and return

EXPECTED RETURN VS EXPECTED STANDARD DEVIATION

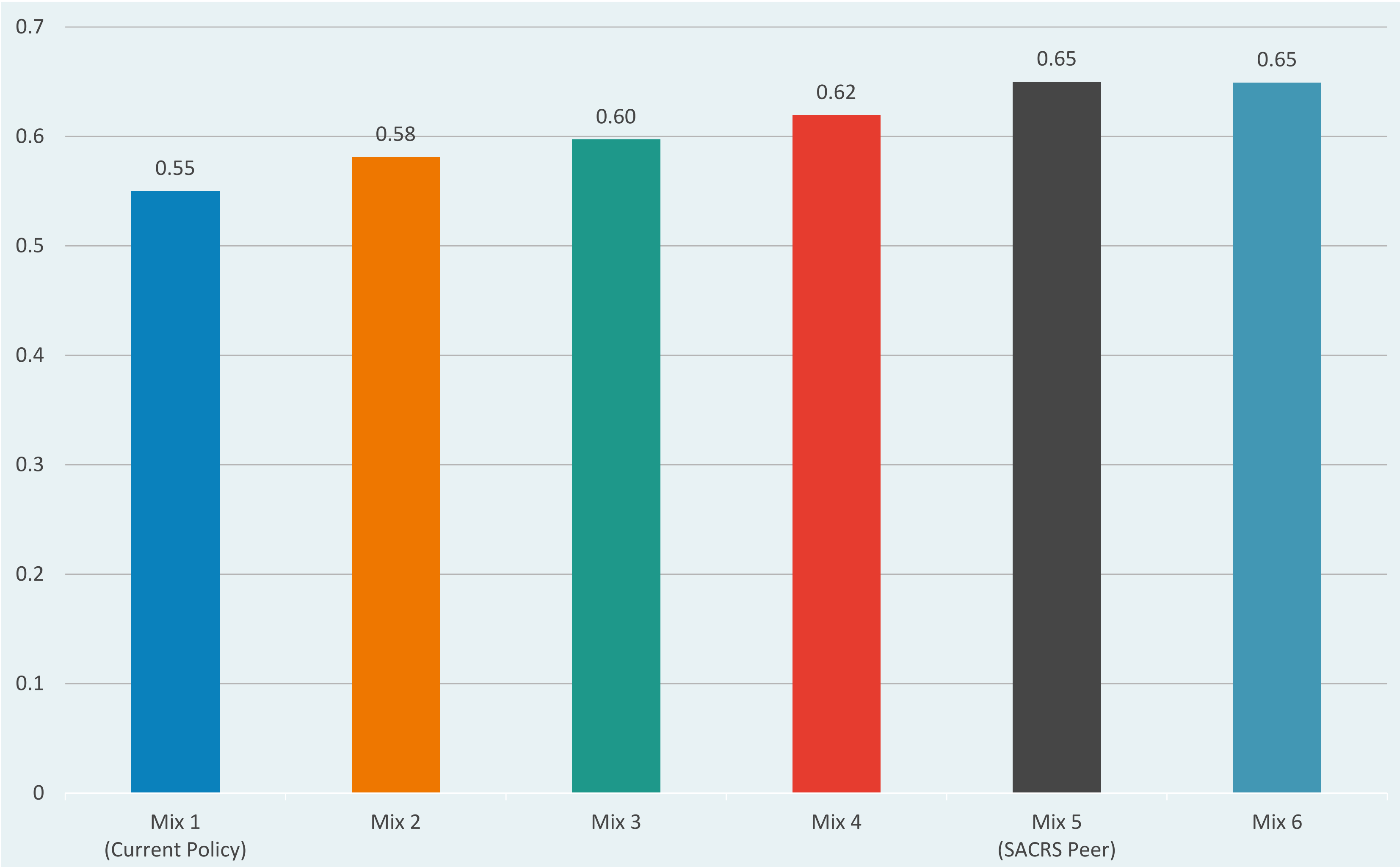


Increasing equity exposure incrementally increases both expected return and expected volatility.

Risk decomposition

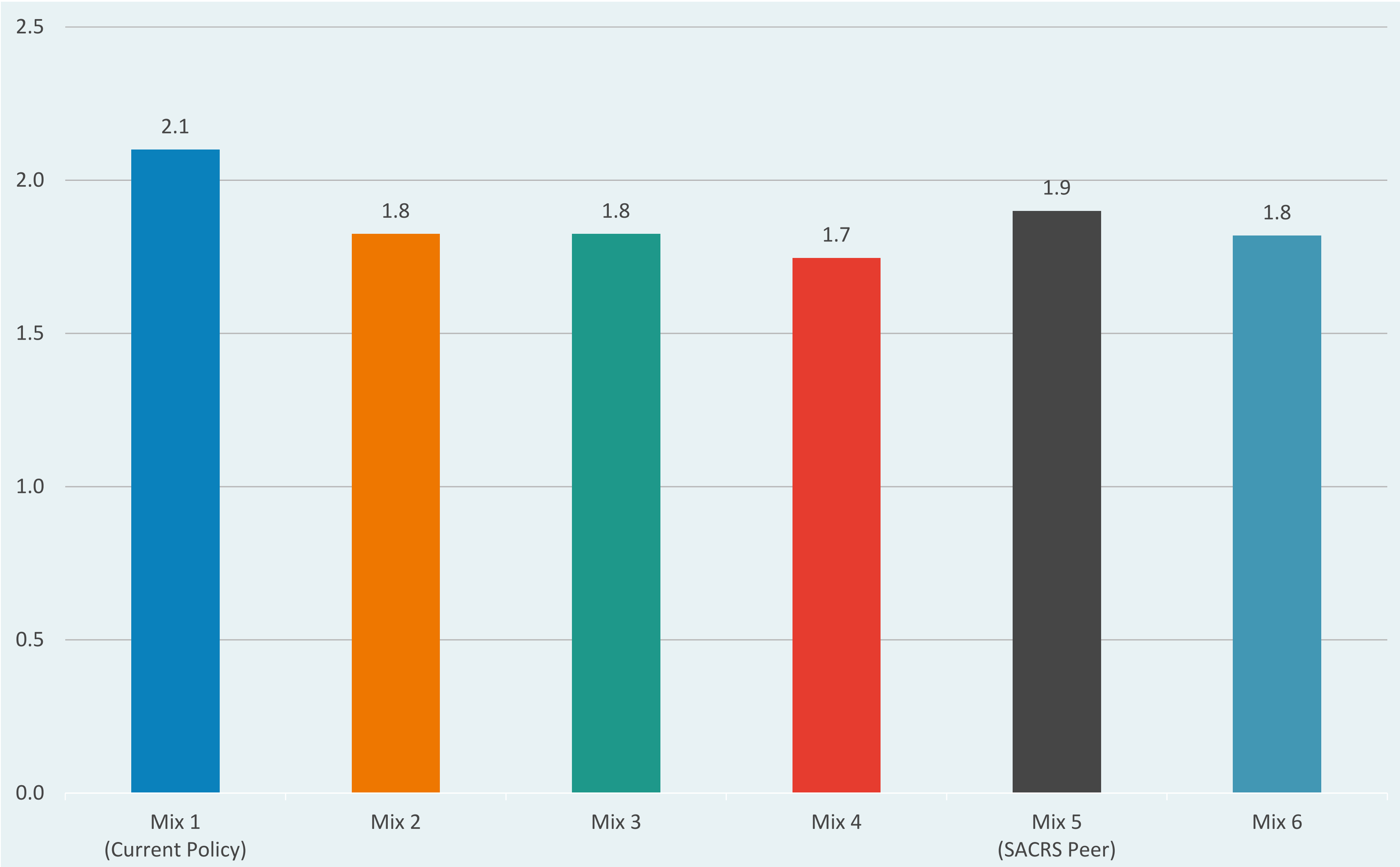


Equity beta



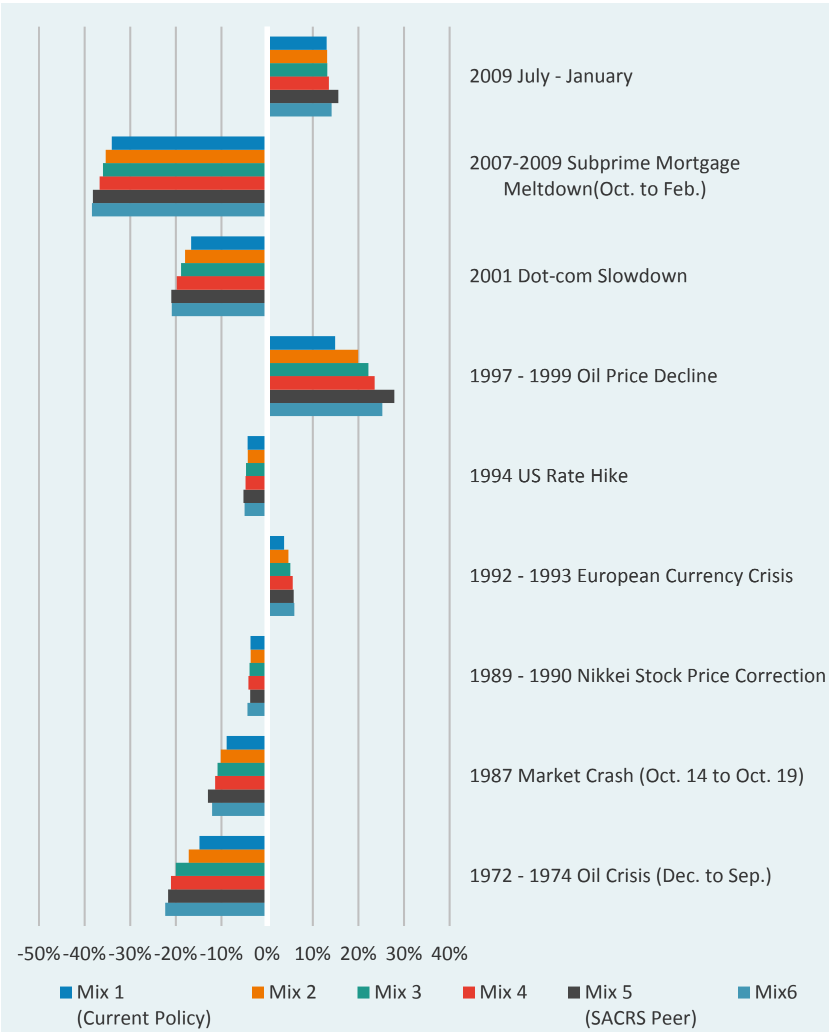
The greater the equity allocation the higher the equity beta.

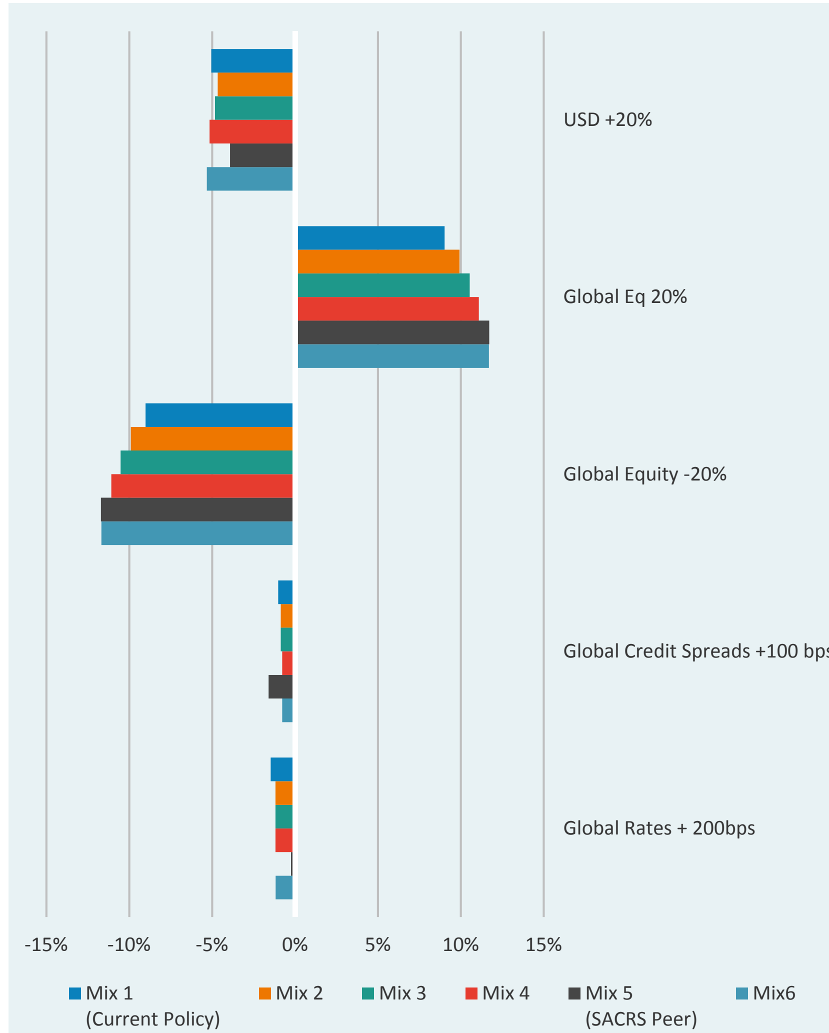
Effective duration



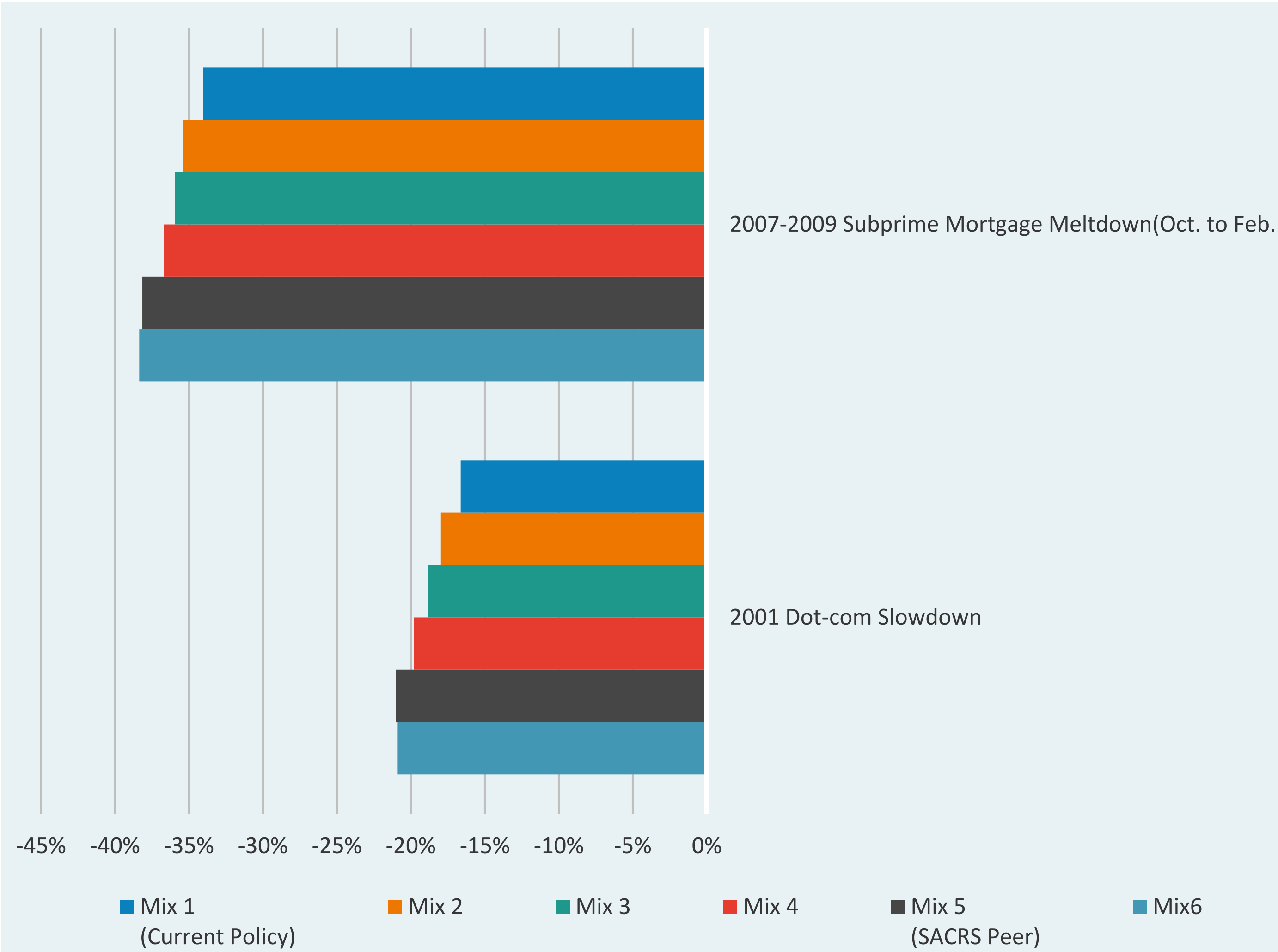
Lowering the allocation to fixed income in favor of equities decreases the duration of each portfolio relative to the current policy.

Scenario analysis





Equity tail risk



Higher equity allocations increase portfolio exposure to equity market shocks.

Next steps

2018 Asset-liability study timeline

Timeframe	Action	Description
March 7, 2018 Board Meeting	Phase 2 of ALS	Verus to review the current portfolio relative to the comparison portfolios and generate asset-only modeling for each portfolio, focused on risk, return, scenario analysis, shock analyses, and risk decomposition
+ 3 weeks	Asset-Liability Integration	Verus to load comparison portfolios into liability model framework, prepare deterministic and stochastic modeling.
April 4, 2018 Board Meeting	Phase 3 of ALS	Verus to review results of asset-liability modeling using the comparison portfolios. **Milestone #1: Narrow down which comparison portfolio offers the most attractive set of trade-offs relative to liabilities.*
+ 3 weeks	Further refinement of selected comparison portfolio	Once the Board gains comfort with the broad set of risk/return characteristics of a comparison portfolio, Verus to conduct further asset-only modeling to determine several similar alternatives
May 2, 2018 Board Meeting	Phase 4 of ALS	Verus will review the similar alternatives relative to the comparison portfolio that was selected for further consideration at April meeting. **Milestone #2: Identify the new asset allocation mix to be implemented.*
June 6, 2018 Board Meeting	Phase 5 of ALS	Verus will review next steps for implementing the new asset allocation. Revise IPS, manager searches, transitions, etc.

Appendix

10-year return & risk assumptions

Asset Class	Index Proxy	Ten Year Return Forecast Geometric	Arithmetic	Standard Deviation Forecast	Sharpe Ratio Forecast (g)	Sharpe Ratio Forecast (a)	10-Year Historical Sharpe Ratio (g)	10-Year Historical Sharpe Ratio (a)
Equities								
U.S. Large	S&P 500	4.5%	5.6%	15.7%	0.15	0.22	0.50	0.56
U.S. Small	Russell 2000	4.4%	6.5%	21.5%	0.10	0.20	0.36	0.44
International Developed	MSCI EAFE	8.6%	10.1%	18.1%	0.35	0.44	0.11	0.2
International Developed Hedged	MSCI EAFE Hedged	8.6%	9.8%	16.2%	0.40	0.47	0.21	0.28
International Small	MSCI EAFE Small Cap	7.9%	10.2%	22.7%	0.25	0.35	0.24	0.33
International Small Hedged	MSCI EAFE Small Cap Hedged	7.9%	9.7%	20.1%	0.28	0.37	0.36	0.43
Emerging Markets	MSCI EM	7.3%	10.4%	26.6%	0.19	0.31	0.17	0.28
Global Equity	MSCI ACWI	6.3%	7.7%	17.5%	0.23	0.31	0.27	0.35
Private Equity	Cambridge Private Equity	6.4%	9.3%	25.8%	0.16	0.28	0.93	0.92
Fixed Income								
Cash	30 Day T-Bills	2.2%	2.2%	1.2%	-	-	-	-
U.S. TIPS	BBgBarc U.S. TIPS 5 - 10	2.6%	2.7%	5.5%	0.07	0.09	0.57	0.59
U.S. Treasury	BBgBarc Treasury 7-10 Year	2.4%	2.6%	6.8%	0.03	0.06	0.68	0.70
Global Sovereign ex U.S.	BBgBarc Global Treasury ex U.S.	2.7%	3.2%	9.9%	0.05	0.10	0.30	0.33
Global Sovereign ex U.S. Hedged	BBgBarc Global Treasury ex U.S. Hedged	2.7%	2.8%	3.3%	0.15	0.18	1.23	1.22
Core Fixed Income	BBgBarc U.S. Aggregate Bond	2.9%	3.1%	6.4%	0.11	0.14	1.09	1.08
Core Plus Fixed Income	BBgBarc U.S. Corporate IG	3.3%	3.6%	8.4%	0.13	0.17	0.81	0.81
Short-Term Gov't/Credit	BBgBarc U.S. Gov't/Credit 1 - 3 year	2.5%	2.6%	3.7%	0.08	0.11	1.36	1.34
Short-Term Credit	BBgBarc Credit 1-3 Year	2.4%	2.5%	3.7%	0.05	0.08	1.05	1.05
Long-Term Credit	BBgBarc Long U.S. Corporate	3.5%	3.9%	9.4%	0.14	0.18	0.64	0.67
High Yield Corp. Credit	BBgBarc U.S. Corporate High Yield	3.7%	4.3%	11.6%	0.13	0.18	0.64	0.67
Bank Loans	S&P/LSTA	4.9%	5.4%	10.5%	0.26	0.30	0.48	0.51
Global Credit	BBgBarc Global Credit	1.7%	2.0%	7.6%	-0.07	-0.03	0.59	0.61
Global Credit Hedged	BBgBarc Global Credit Hedged	1.7%	1.8%	5.0%	-0.10	-0.08	1.01	1.00
Emerging Markets Debt (Hard)	JPM EMBI Global Diversified	5.1%	5.9%	12.8%	0.23	0.29	0.74	0.76
Emerging Markets Debt (Local)	JPM GBI EM Global Diversified	5.8%	6.5%	12.1%	0.30	0.36	0.31	0.37
Private Credit	Bank Loans + 200 bps	6.9%	7.5%	10.5%	0.45	0.50	-	-
Other								
Commodities	Bloomberg Commodity	4.3%	5.5%	15.9%	0.13	0.21	-0.33	-0.25
Hedge Funds	HFRI Fund of Funds	4.0%	4.8%	7.9%	0.23	0.33	0.21	0.23
Hedge Fund of Funds	HFRI Fund of Funds	3.0%	3.8%	7.9%	0.10	0.20	0.21	0.23
Hedge Funds - Equity Hedge	HFRI Equity Hedge	4.2%	5.5%	11.1%	0.18	0.30	0.36	0.39
Hedge Funds - Event Driven	HFRI Event Driven	4.5%	5.6%	9.9%	0.22	0.34	0.55	0.57
Hedge Funds - Relative Value	HFRI Relative Value	3.9%	4.5%	6.8%	0.25	0.34	0.89	0.89
Hedge Funds - Macro	HFRI Macro	3.3%	4.7%	8.5%	0.12	0.29	0.43	0.44
Core Real Estate	NCREIF Property	6.0%	6.7%	12.7%	0.30	0.35	0.77	0.75
Value-Add Real Estate	NCREIF Property + 200bps	8.0%	9.7%	19.5%	0.30	0.38	-	-
Opportunistic Real Estate	NCREIF Property + 400bps	10.0%	12.9%	26.0%	0.30	0.41	-	-
REITs	Wilshire REIT	6.0%	7.7%	19.5%	0.19	0.28	0.16	0.28
Infrastructure	S&P Global Infrastructure	7.1%	8.7%	18.9%	0.26	0.34	0.27	0.34
Risk Parity	Risk Parity	7.2%	7.7%	10.0%	0.50	0.55	-	-
Currency Beta	Russell Conscious Currency	2.2%	2.3%	4.4%	0.00	0.02	0.23	0.24
Inflation		2.1%	-	-	-	-	-	-

Investors wishing to produce expected geometric return forecasts for their portfolios should use the arithmetic return forecasts provided here as inputs into that calculation, rather than the single-asset-class geometric return forecasts. This is the industry standard approach, but requires a complex explanation only a heavy quant could love, so we have chosen not to provide further details in this document – we will happily provide those details to any readers of this who are interested.

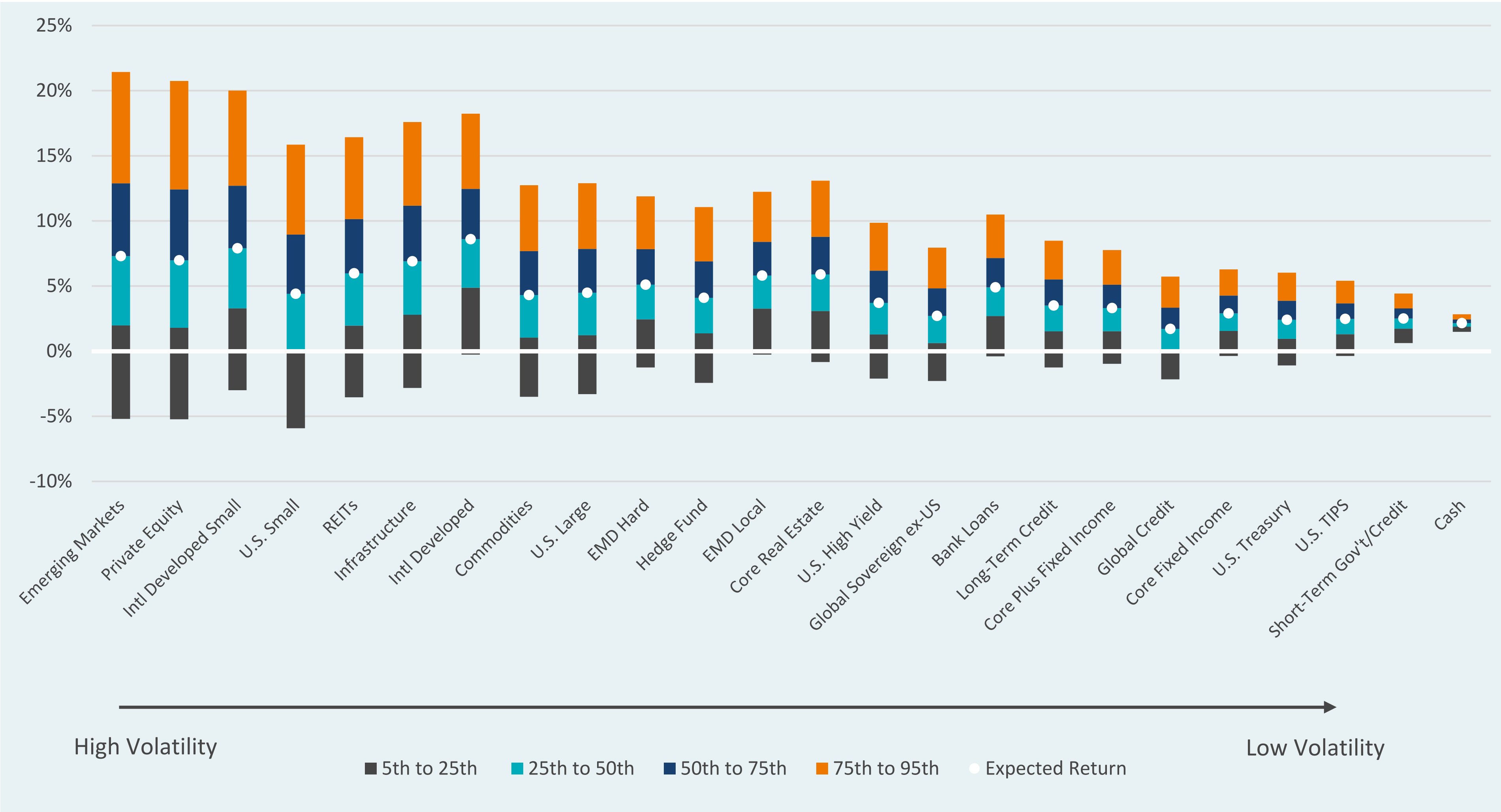
Correlation assumptions

	Cash	US Large	US Small	Intl Large	Intl Large Hdg	Intl Small	Intl Small Hdg	EM	Global Equity	PE	US TIPS	US Treasury	Global Sovereign ex US	Global Sovereign ex US Hdg	US Core	US Core Plus	ST Govt/Credit	Short-Term Credit	Long-Term Credit	US HY	Bank Loans	Global Credit	Global Credit Hdg	EMD USD	EMD Local	Commodities	Hedge Funds	Real Estate	REITs	Infras-tructure	Risk Parity	Currency Beta	Inflation
Cash	1.0																																
US Large	-0.3	1.0																															
US Small	-0.2	0.9	1.0																														
Intl Large	-0.3	0.9	0.8	1.0																													
Intl Large Hdg	-0.4	0.9	0.8	0.9	1.0																												
Intl Small	-0.3	0.9	0.8	1.0	0.9	1.0																											
Intl Small Hdg	-0.4	0.8	0.8	0.9	1.0	0.9	1.0																										
EM	-0.3	0.8	0.7	0.9	0.8	0.9	0.8	1.0																									
Global Equity	-0.3	1.0	0.9	1.0	0.9	0.9	0.9	0.9	1.0																								
PE	-0.2	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.7	1.0																							
US TIPS	0.0	0.2	0.1	0.3	0.1	0.3	0.2	0.4	0.3	0.1	1.0																						
US Treasury	0.1	-0.3	-0.3	-0.2	-0.3	-0.2	-0.3	-0.2	-0.2	-0.2	0.6	1.0																					
Global Sovereign ex US	0.1	0.3	0.1	0.4	0.1	0.4	0.1	0.4	0.4	0.0	0.6	0.5	1.0																				
Global Sovereign ex US Hdg	0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.2	-0.1	0.4	0.8	0.4	1.0																			
US Core	0.0	0.0	-0.1	0.2	0.0	0.2	0.0	0.2	0.1	-0.1	0.8	0.9	0.6	0.7	1.0																		
US Core Plus	-0.2	0.4	0.3	0.5	0.4	0.5	0.4	0.5	0.5	0.1	0.7	0.5	0.5	0.4	0.8	1.0																	
ST Govt/Credit	0.3	-0.1	-0.1	0.1	-0.1	0.1	-0.1	0.1	0.0	-0.1	0.6	0.6	0.6	0.5	0.7	0.6	1.0																
Short-Term Credit	-0.1	0.3	0.3	0.5	0.4	0.5	0.4	0.5	0.4	0.1	0.6	0.2	0.4	0.2	0.5	0.8	0.7	1.0															
Long-Term Credit	-0.2	0.3	0.2	0.4	0.3	0.4	0.4	0.4	0.4	0.0	0.6	0.5	0.5	0.5	0.8	1.0	0.5	0.6	1.0														
US HY	-0.3	0.7	0.7	0.8	0.7	0.8	0.8	0.8	0.8	0.4	0.5	-0.2	0.3	-0.2	0.2	0.6	0.2	0.6	0.5	1.0													
Bank Loans	-0.4	0.6	0.6	0.6	0.6	0.6	0.7	0.6	0.6	0.4	0.3	-0.4	0.0	-0.3	0.0	0.4	-0.1	0.5	0.3	0.9	1.0												
Global Credit	-0.2	0.6	0.5	0.8	0.6	0.8	0.6	0.8	0.7	0.2	0.7	0.2	0.7	0.2	0.6	0.8	0.5	0.7	0.8	0.8	0.5	1.0											
Global Credit Hdg	-0.2	0.5	0.4	0.6	0.6	0.6	0.6	0.7	0.6	0.2	0.7	0.3	0.5	0.4	0.7	1.0	0.5	0.8	0.9	0.8	0.6	0.9	1.0										
EMD USD	-0.2	0.6	0.5	0.7	0.6	0.7	0.6	0.7	0.7	0.3	0.7	0.3	0.5	0.2	0.6	0.8	0.4	0.7	0.7	0.8	0.6	0.9	0.9	1.0									
EMD Local	0.0	0.6	0.6	0.7	0.6	0.7	0.6	0.8	0.7	0.3	0.6	0.2	0.7	0.1	0.5	0.6	0.4	0.5	0.6	0.7	0.4	0.8	0.7	0.8	1.0								
Commodities	-0.1	0.5	0.4	0.6	0.4	0.6	0.4	0.7	0.6	0.3	0.4	-0.2	0.4	-0.3	0.1	0.3	0.2	0.4	0.2	0.5	0.5	0.6	0.4	0.5	0.6	1.0							
Hedge Funds	-0.4	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.3	-0.3	0.1	-0.2	0.0	0.4	-0.1	0.5	0.3	0.7	0.7	0.6	0.5	0.5	0.5	0.6	1.0						
Real Estate	-0.1	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.1	-0.1	0.1	0.0	0.0	0.2	0.0	0.1	0.1	0.3	0.3	0.3	0.2	0.3	0.3	0.2	0.4	1.0					
REITs	-0.1	0.7	0.7	0.7	0.6	0.7	0.6	0.6	0.7	0.4	0.3	0.0	0.4	0.1	0.3	0.5	0.1	0.3	0.4	0.7	0.5	0.6	0.6	0.6	0.6	0.3	0.4	0.6	1.0				
Infrastructure	-0.3	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.2	0.4	-0.1	0.5	-0.1	0.2	0.5	0.1	0.5	0.5	0.7	0.5	0.8	0.7	0.7	0.7	0.6	0.6	0.1	0.6	1.0			
Risk Parity	-0.1	0.5	0.4	0.6	0.4	0.6	0.5	0.6	0.6	0.3	0.7	0.3	0.6	0.3	0.6	0.7	0.5	0.6	0.6	0.6	0.3	0.8	0.7	0.7	0.7	0.6	0.5	-0.1	0.5	0.7	1.0		
Currency Beta	-0.1	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.2	-0.2	-0.2	-0.1	0.0	-0.1	-0.1	-0.1	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	0.0	0.1	0.0	1.0	
Inflation	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.2	0.1	-0.3	0.0	-0.3	-0.2	-0.1	-0.2	0.0	-0.2	0.3	0.4	0.1	0.0	0.1	0.1	0.3	0.2	0.1	0.1	0.1	0.1	-0.1	1.0

Note: Correlation assumptions are based on the last ten years. Private Equity and Real Estate correlations are especially difficult to model – we have therefore used BarraOne correlation data to strengthen these correlation estimates.

Range of likely 10 year outcomes

10 YEAR RETURN 90% CONFIDENCE INTERVAL



Verus