

Asset Allocation Analysis
February 2018

Sioux Falls Employees' and Firefighters' Pension





ASSET ALLOCATION ANALYSIS



Introduction

This report provides a brief summary of the Asset Allocation modeling process.

Asset allocation is an effective tool to manage portfolio risk. However, the modeling process is an imperfect science that depends on forecasts and assumptions.

This report illustrates the Fund's current investment policies and a proposed portfolio mix. Our objective is to balance the Trustees' collective performance targets and risk tolerances.

Additional modeling may be performed to evaluate other asset allocation polices.

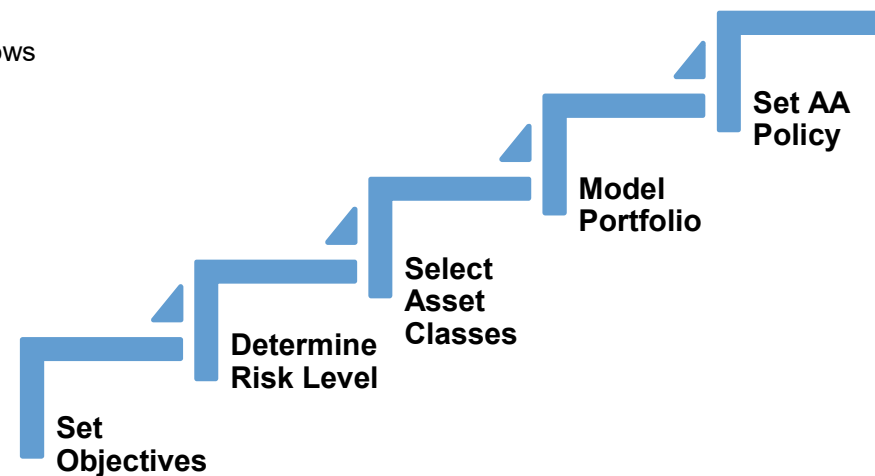


Introduction

- Asset allocation is a tool employed to manage a portfolio's risk. Risk may be defined as the standard deviation of returns, the probability of achieving a target return, or other measures of variability. In theory there is a positive relationship between risk and returns – the greater the risk, the greater the returns. However, the capital markets do not always behave in this manner.
- The modeling process is imperfect, relying on forecasts for the asset classes. Accurately predicting the performance of the capital markets is nearly impossible. Therefore, we utilize several models to help assist with the evaluation process. Additional modeling may be performed to evaluate other asset allocation policies.

- Key Steps In Conducting An Asset Allocation Study:

1. Identify and define the objectives.
 - a) Assess liquidity needs – current and future cash flows
 - b) Assess investment time horizon
 - c) Assess return target
2. Assess risk tolerance
3. Determine appropriate asset classes
4. Model investment portfolio alternatives
 - a) Historical model
 - b) Forecasting model
 - c) Monte Carlo simulations
 - d) Allocation to alternatives
 - e) Human overlay
5. Select an appropriate target asset allocation policy



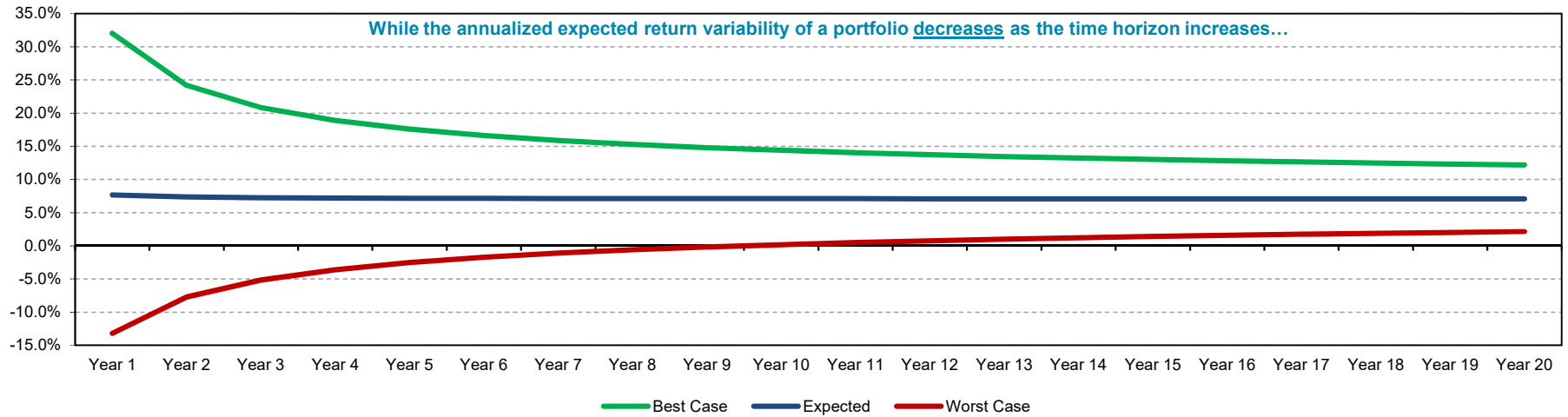
Limitation of Asset Allocation Models

- **Limitations of Asset Allocation Models:**
 - The model output is based on the capital market assumptions; accurately predicting the expected return, standard deviation, and correlation coefficients for each asset class is very difficult.
 - Many asset classes have historically exhibited non-normal return distributions (fat-tails and/or skewness); models generally assume normal distributions.
 - Correlation coefficients change over time and may potentially overestimate the diversification benefits of combining asset classes (particularly during periods of market stress).
 - Alternative asset classes introduce risk factors that are not captured in their standard deviation.
- **The return, risk, and correlation forecasts utilized in this report were developed by JP Morgan Asset Management. These projections are based on its expectations over the next 10 to 15 years.**

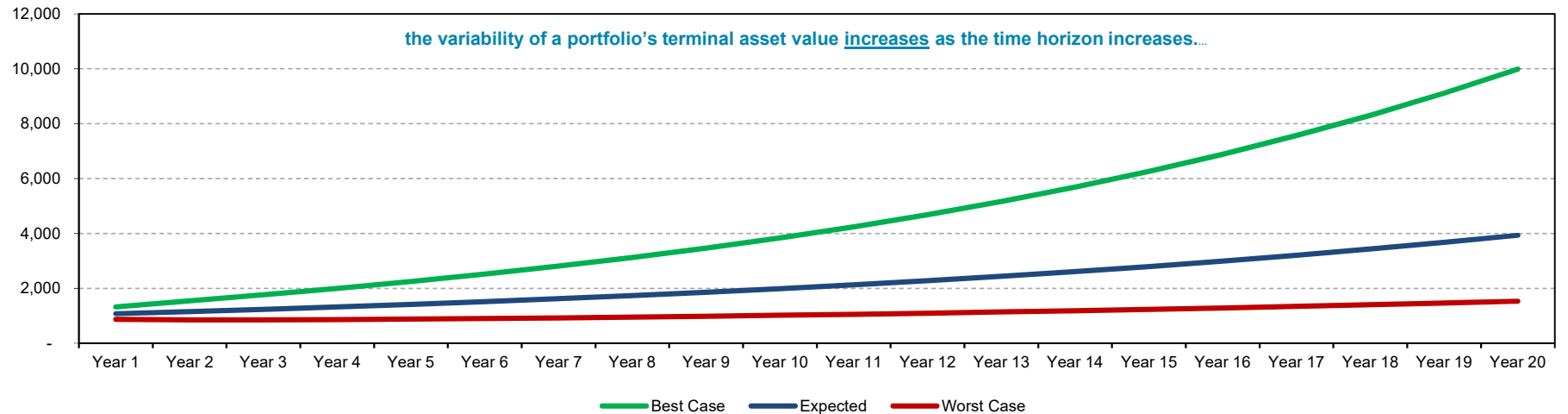


Asset Allocation and Investment Policy

Projected Annualized Return Expectations (%)



Projected Growth of \$1 million (,000)



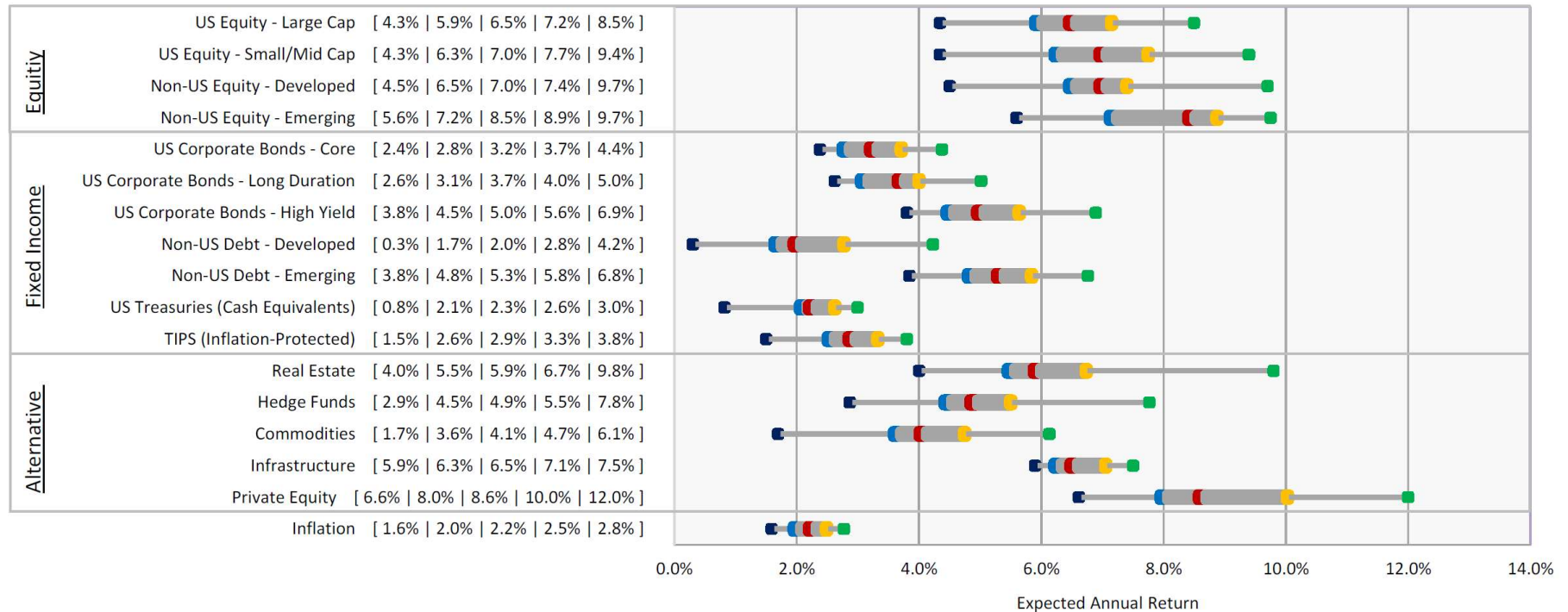
As a result, it is important to understand that you cannot “time diversify” away a portfolio’s risk.



Asset Allocation and Educated Guesses

10-Year Expected Return Ranges (Geometric Assumptions) Long-Term Survey Respondents - 35 Assumption Sets

Asset Class [Min | 25th | 50th | 75th | Max]

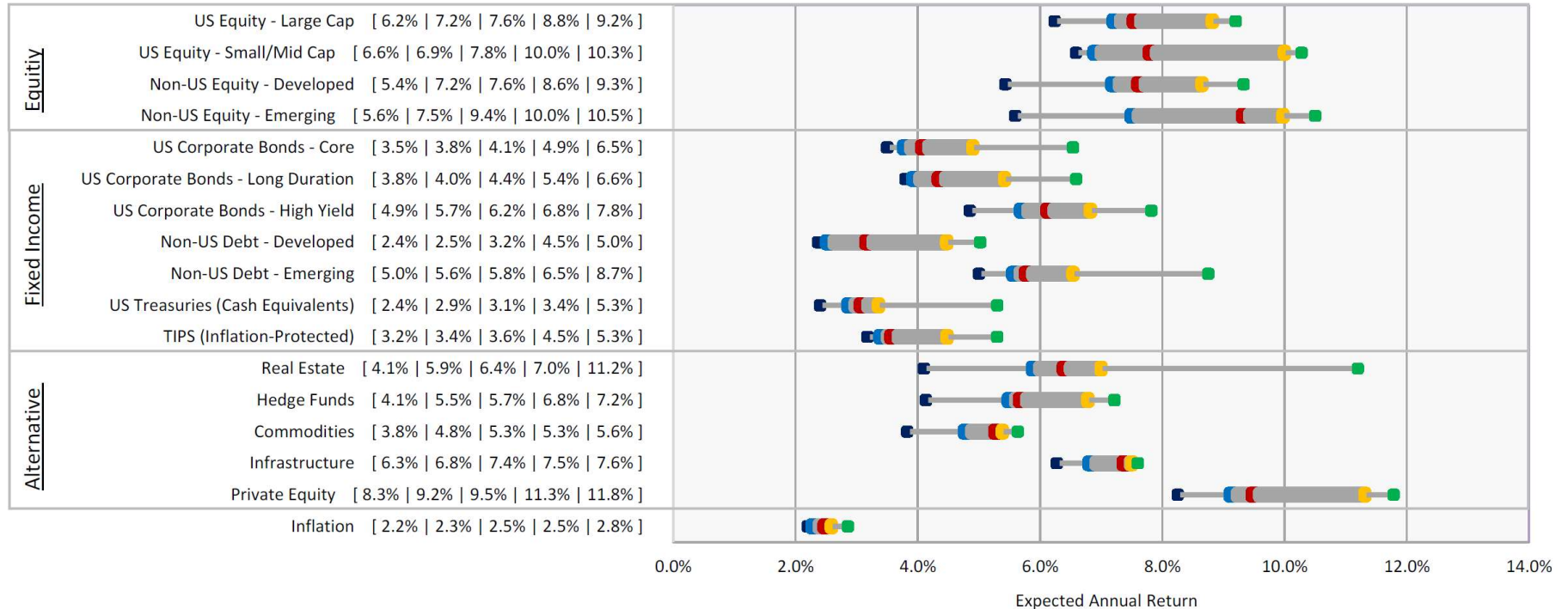


- **While there is no shortage of forward-looking educated guesses for return, standard deviation, and correlation assumptions, practitioners do not:**
 - Forecast the same asset classes.
 - Forecast the same time horizons.
 - Use the same tools and/or methodologies to develop their assumptions.

Asset Allocation and Educated Guesses

Long-Term (20-Years or More) Expected Return Ranges (Geometric Assumptions) Long-Term Survey Respondents - 12 Assumption Sets

Asset Class [Min | 25th | 50th | 75th | Max]



- **While there is no shortage of forward-looking educated guesses for return, standard deviation, and correlation assumptions, practitioners do not:**
 - Forecast the same asset classes.
 - Forecast the same time horizons.
 - Use the same tools and/or methodologies to develop their assumptions.

Source: Horizon Actuarial 2017 Survey of Capital Market Assumptions.



Asset Allocation and Investment Policy

- **Developing an investment strategy is based on four decisions:**
 - What asset classes should be considered for potential investment?
 - What strategic (long-term) weights should be assigned to each asset class?
 - What are the appropriate allocation ranges (+/-) around the strategic weight of each asset class?
 - What are the most appropriate managers/vehicles to implement and retain for each asset class?
- **While manager and investment vehicle selection is an important part of implementing and maintaining an investment strategy, approximately 90% of a portfolio's variability over time is determined by the first two investment strategy decisions.**



Long Term Asset Allocation Model Inputs

	Expected Return	Std Dev	Correlation Matrix																				
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
1. US Cash	2.00%	0.50%	1.00																				
2. US Aggregate	3.32%	3.75%	0.10	1.00																			
3. US High Yield	5.59%	8.50%	(0.10)	0.19	1.00																		
4. US Leveraged Loan	5.28%	7.75%	(0.14)	(0.07)	0.80	1.00																	
5. WGBI ex US	2.56%	8.00%	0.11	0.62	0.24	(0.07)	1.00																
6. Emg Mkt Sov Debt	5.70%	9.75%	(0.02)	0.60	0.72	0.40	0.57	1.00															
7. US Large Cap	6.41%	14.00%	(0.06)	0.00	0.69	0.55	0.21	0.52	1.00														
8. US Mid Cap	6.93%	16.00%	(0.08)	(0.01)	0.74	0.59	0.17	0.52	0.96	1.00													
9. US Small Cap	7.35%	18.75%	(0.08)	(0.10)	0.65	0.51	0.10	0.42	0.90	0.95	1.00												
10. EAFE Equity	7.61%	17.25%	0.00	0.10	0.74	0.56	0.39	0.65	0.88	0.86	0.76	1.00											
11. Emerging Markets	10.04%	21.50%	0.08	0.14	0.73	0.55	0.39	0.68	0.76	0.77	0.68	0.87	1.00										
12. Private Equity	9.21%	21.00%	(0.03)	0.04	0.65	0.51	0.25	0.51	0.82	0.82	76.00	0.82	0.72	1.00									
13. US Core Direct RE	5.79%	10.75%	(0.02)	0.05	0.23	0.14	0.10	0.19	0.30	0.31	0.31	0.26	0.21	0.25	1.00								
14. US Val Add RE	7.37%	13.75%	(0.03)	0.05	0.25	0.15	0.10	0.20	0.33	0.33	0.33	0.28	0.23	0.27	0.95	1.00							
15. US REITS	7.42%	16.00%	(0.07)	0.27	0.62	0.36	0.32	0.56	0.74	0.76	0.74	0.66	0.56	0.63	0.40	0.43	1.00						
16. Infrastructure	6.89%	11.75%	(0.01)	0.00	0.22	0.19	0.07	0.16	0.30	0.30	0.28	0.26	0.23	0.25	0.30	0.29	0.25	1.00					
17. HF Diversified	4.52%	7.50%	0.08	(0.10)	0.60	0.65	0.02	0.36	0.66	0.69	0.58	0.71	0.68	0.61	0.13	0.14	0.34	0.20	1.00				
18. Direct Lending	7.46%	10.00%	(0.07)	0.74	0.68	0.47	0.48	0.77	0.32	0.35	0.24	0.45	0.49	0.34	0.12	0.12	0.45	0.10	0.30	1.00			
19. Commodities	5.06%	16.75%	0.08	0.05	0.48	0.37	0.41	0.39	0.44	0.46	0.38	0.54	0.61	0.44	0.10	0.10	0.26	0.15	0.52	0.27	1.00		

Note that not all asset classes are appropriate for every client portfolio.



Long Term Asset Allocation Model Inputs

- The first two columns in the table on the preceding slide shows the long-term (10-15 year) expected return and risk (standard deviation) for each of the 13 asset classes that will be modeled in this analysis as well as a more general description for each asset class that will be modeled.
- The expected return of a blended asset mix can be determined by simply multiplying each asset class allocation by its expected return using the following formula:

$$E(R_p) = \sum_{i=1}^n w_i E(R_i)$$

- The same basic multiplication methodology cannot be used to calculate an asset mix's standard deviation (risk). In order to model a portfolio's risk, we have to take correlation into account.
- The remainder of the table shows the model's correlation matrix. This matrix represents the degree of co-movement between each pair of asset classes when they are combined together to construct portfolios. The correlation coefficient ranges from +1.00 to -1.00. As the table illustrates, the correlation between an asset class and itself is +1.00 or perfect co-movement. Taken one step further, combining different asset classes together, with less than perfect or even negative correlation, will increase a portfolio's level of diversification.
- The variance of a blended asset mix is determined by the following formula where ρ_{ij} is the correlation coefficient between the returns on assets i and j . The standard deviation is then calculated by taking the square root of this variance calculation.

$$\sigma_p^2 = \sum_{i=1}^n w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j \rho_{ij}$$



Asset Class Historical Performance vs. Assumptions

Annualized as of 12/31/2017

-----Historical-----Forecast-----

	5 Year	10 Year	15 Year	20 Year	LT Std. Dev.*	Return	Std. Dev.
US Cash	0.2%	0.3%	1.2%	2.0%	0.6%	2.00%	0.50%
US Aggregate	2.1%	4.0%	4.1%	5.0%	3.4%	3.32%	3.75%
US High Yield	5.8%	8.0%	9.0%	6.8%	9.2%	5.59%	8.50%
US Leveraged Loans	4.0%	4.9%	5.2%	4.9%	5.9%	5.28%	7.75%
WGB ex US (unhedged)	-0.3%	2.4%	4.1%	4.4%	8.2%	2.56%	8.00%
EM Bonds (unhedged)	3.8%	6.4%	8.7%	7.8%	11.5%	5.70%	9.75%
US Large Cap	15.7%	8.6%	10.2%	7.4%	15.1%	6.41%	14.00%
US Mid Cap	15.0%	9.1%	12.1%	9.5%	16.8%	6.93%	16.00%
US Small Cap	14.1%	8.7%	11.2%	7.9%	19.8%	7.35%	18.75%
EAFE Equity (unhedged)	7.9%	1.9%	8.1%	5.2%	16.6%	7.61%	17.25%
Emerging Market Equity	4.3%	1.7%	12.3%	NA	21.4%	10.04%	21.50%
Private Equity	14.4%	10.7%	11.3%	12.5%	21.0%	9.21%	21.00%
US Core RE (UL)	10.9%	6.9%	9.0%	9.8%	11.5%	5.79%	10.75%
US Val Add RE (UL)	13.9%	3.8%	NA	12.2%	15.0%	7.37%	13.75%
US REITs	9.8%	7.8%	11.1%	9.1%	21.0%	7.42%	16.00%
Infrastructure	9.2%	3.4%	11.4%	NA	14.6%	6.89%	11.75%
Hedge Funds – Diversified	4.3%	3.8%	5.7%	7.1%	6.6%	4.52%	7.50%
Commodities	-8.5%	-6.8%	-0.3%	0.8%	16.3%	5.06%	16.75%

*20 years or longest period available

	5 Year	10 Year	15 Year	20 Year
Current Mix	10.20%	6.06%	8.53%	6.48%

Return	Std. Dev.
6.04%	10.83%

Asset class allocations proxied for the current mix where historical data was not available.



Model Asset Allocation

Core Asset Class Allocation (%)	Current	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Domestic Equity	50.00	46.00	46.00	41.00	40.50	45.00
International Equity	20.00	22.00	22.00	22.00	22.00	22.00
Core Fixed Income	25.00	25.00	25.00	30.00	25.00	23.00
Real Estate	5.00	7.00	7.00	7.00	12.50	10.00

- **Current Target:** The current investment policy targets for the portfolio.
- **Mix 1:** Started with Mix 4 and reduced Real Estate to 7% and added 5.5% to US Large Cap.
- **Mix 2:** Same as Mix 1 but changed Real Estate to 5% Core and 2% Value-Add.
- **Mix 3:** Same as Mix 2 but increased US Aggregate to 30% and reduced US Large Cap to 25%.
- **Mix 4:** Original Mix 4 from November 2017 which increased Real Estate, increasing US Mid Cap, reducing US Small Cap and eliminating Long Duration FI.
- **Mix 5:** Maximized exposure to Real Estate to 10% by reducing US Aggregate to 23% and US Small Cap to 5%.



Model Asset Allocation

Broad Asset Class Allocation (%)	Current	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5	Constraints
US Aggregate	25.00	25.00	25.00	30.00	25.00	23.00	15-50
US Large Cap	35.00	30.00	30.00	25.00	24.30	30.00	20-45
US Mid Cap	5.00	10.00	10.00	10.00	10.10	10.00	0-10
US Small Cap	10.00	6.00	6.00	6.00	6.10	5.00	0-10
EAFE Equity	17.00	16.50	16.50	16.50	16.50	16.50	10-30
Emerging Markets Equity	3.00	5.50	5.50	5.50	5.50	5.50	0-7.5
US Core RE	5.00	3.50	5.00	3.50	7.50	5.00	0-15
US Val Add RE	0.00	3.50	2.00	3.50	5.00	5.00	0-5

Single Year Expectations	Current	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Return	6.04	6.16	6.13	6.00	6.15	6.21
Standard Deviation	10.83	10.75	10.73	10.10	10.27	10.72
Sharpe Ratio	0.56	0.57	0.57	0.59	0.60	0.58
Best Case Return	24.92	25.18	24.96	23.68	24.23	25.09
Worst Case Return	-10.71	-10.25	-10.31	-9.48	-9.69	-10.25
Negative Return Probability	31.10	30.67	30.80	30.27	29.97	30.53
Time Horizon Expectations	Current	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Return	5.50	5.61	5.59	5.51	5.64	5.67
Best Case Return	9.53	9.62	9.59	9.32	9.50	9.67
Worst Case Return	1.72	1.88	1.86	2.02	2.07	1.93
Negative Return Probability	0.87	0.70	0.77	0.57	0.53	0.60



Efficient Frontier

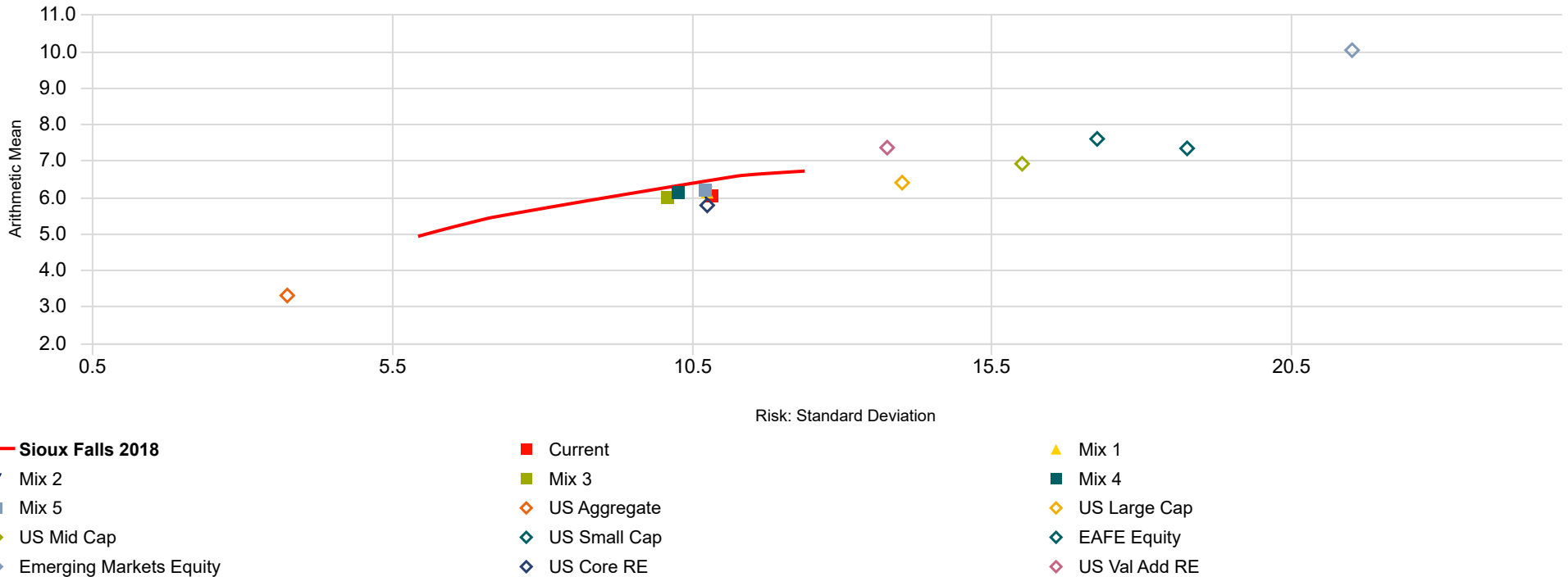
- **Restricted Efficient Frontier**

- The efficient frontier (EF) is a visual display of the mathematical optimization of mean/variance opportunities for a given set of asset class inputs.
- This red line represents the maximum level of return available for each level of standard deviation (risk). Stated another way, if a portfolio is being designed to target a specific, desired rate of return, the EF illustrates the risk that must be taken to achieve this objective.
- The restricted EF is limited by the constraints set on the individual asset classes and the various groups. Using the return, risk and correlation expectations for each asset classes in the model, the optimization software creates a set of portfolios that combine the various asset classes to create mathematically efficient portfolios (mean/variance optimized). As a result of this optimization, a portfolio cannot be created that plots above the EF.
- The restricted EF only includes the asset classes input into the model for this study.

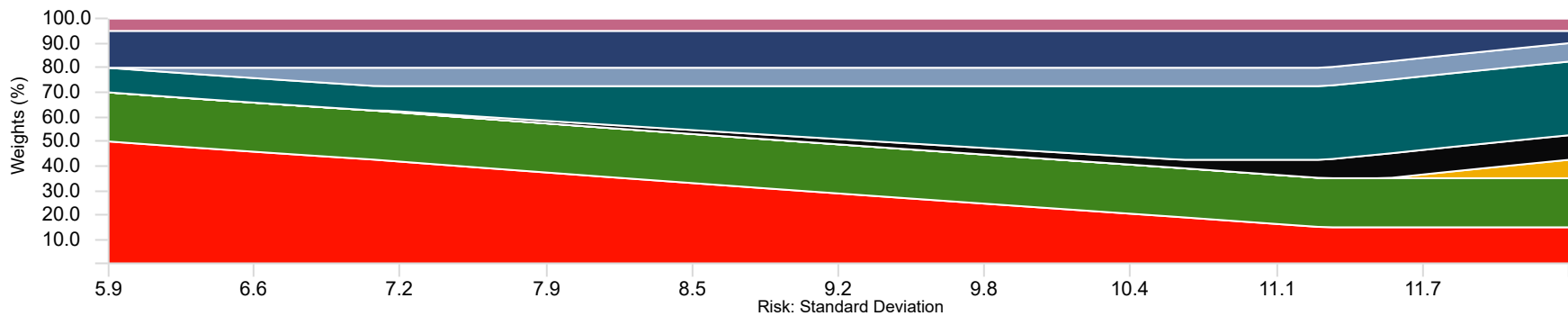


Efficient Frontier, Asset Class Allocation & Asset Mixes

Efficient Frontier & Asset Mixes

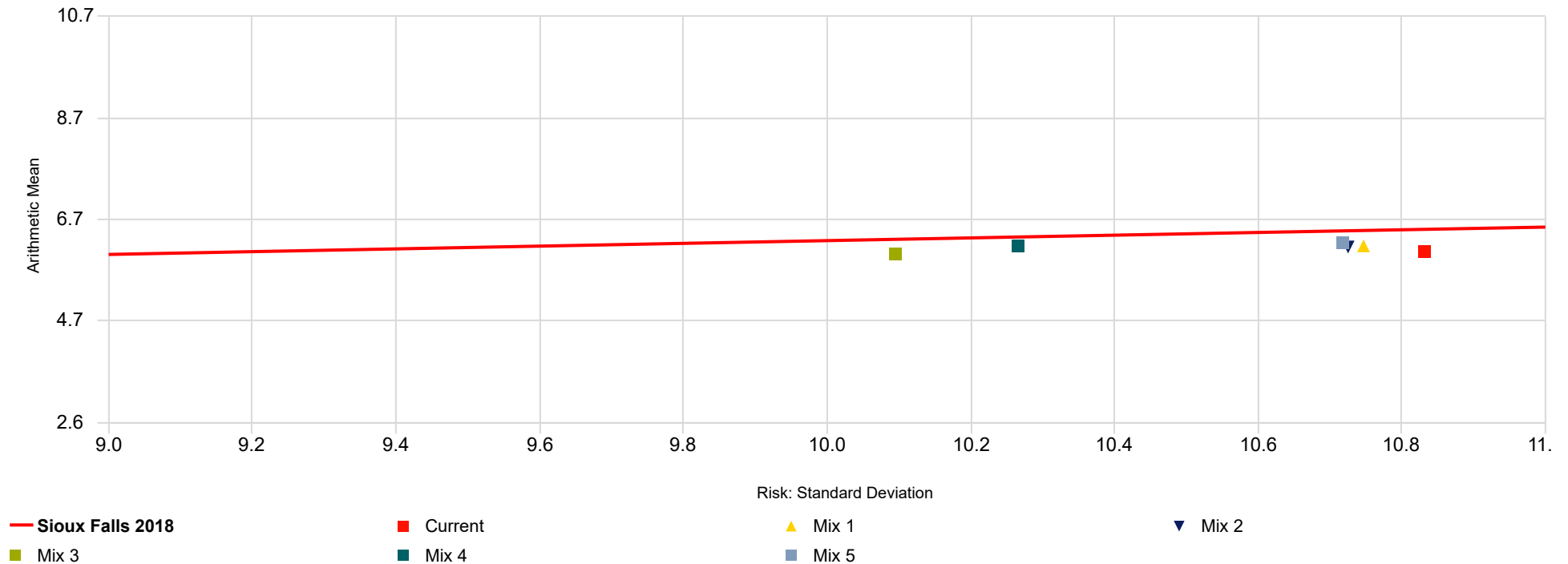


Efficient Frontier Asset Class Allocation



Efficient Frontier, Asset Class Allocation & Asset Mixes

Efficient Frontier & Asset Mixes



Asset Mix Statistics

	Current	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
Mean Return	6.04	6.16	6.13	6.00	6.15	6.21
Standard Deviation	10.83	10.75	10.73	10.10	10.27	10.72
Sharpe Ratio	0.56	0.57	0.57	0.59	0.60	0.58



Current Mix - Return, Risk, Probability Forecast

Asset Class Allocation

	Current
US Aggregate	25.00
US Large Cap	35.00
US Mid Cap	5.00
US Small Cap	10.00
EAFE Equity	17.00
Emerging Markets Equity	3.00
US Core RE	5.00
US Val Add RE	0.00

Single Year Expectations

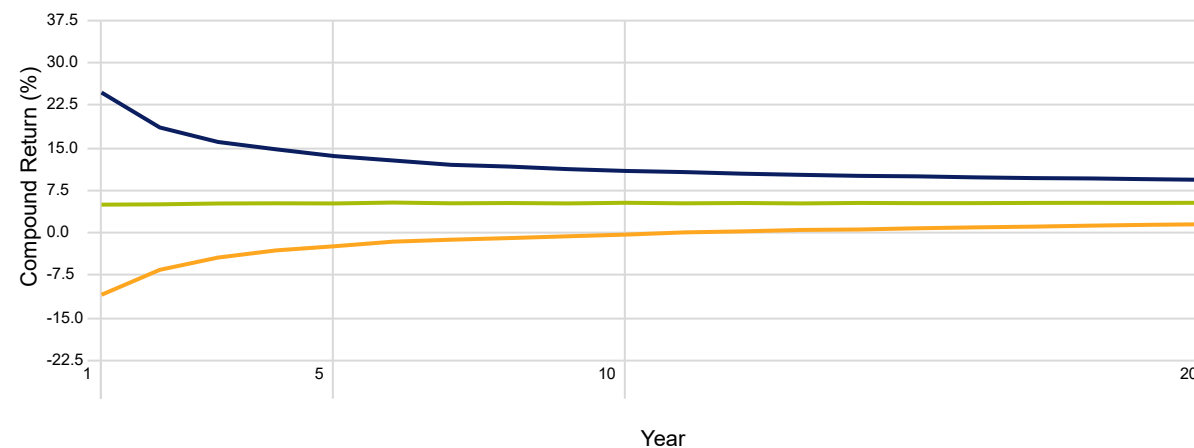
%	Current
Return	6.04
Standard Deviation	10.83
Sharpe Ratio	0.56
Best Case Return	24.92
Worst Case Return	-10.71
Negative Return Probability	31.10

Time Horizon Expectations

Return	5.50
Best Case Return	9.53
Worst Case Return	1.72
Negative Return Probability	0.87

Return Percentiles

Current



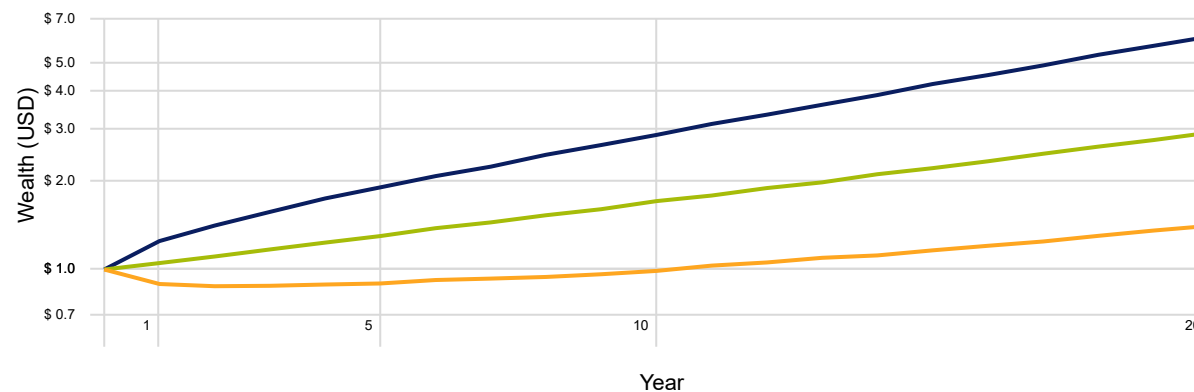
— 95th

— 50th

— 5th

Forecasted Growth of \$1

Current



— 95th

— 50th

— 5th



Mix 1 - Return, Risk, Probability Forecast

Asset Class Allocation

	Mix 1
US Aggregate	25.00
US Large Cap	30.00
US Mid Cap	10.00
US Small Cap	6.00
EAFE Equity	16.50
Emerging Markets Equity	5.50
US Core RE	3.50
US Val Add RE	3.50

Single Year Expectations

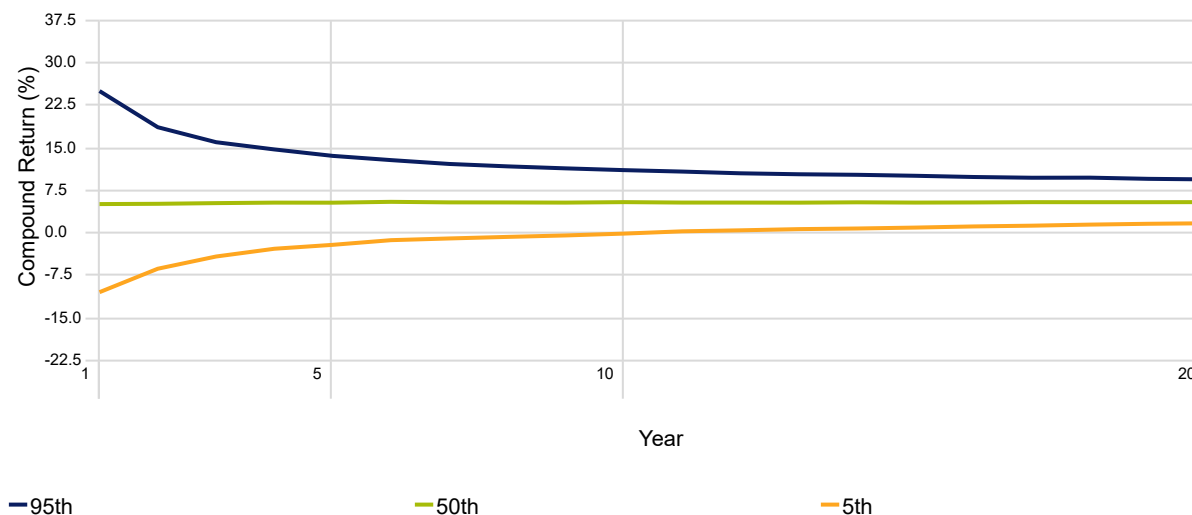
%	Mix 1
Return	6.16
Standard Deviation	10.75
Sharpe Ratio	0.57
Best Case Return	25.18
Worst Case Return	-10.25
Negative Return Probability	30.67

Time Horizon Expectations

Return	5.61
Best Case Return	9.62
Worst Case Return	1.88
Negative Return Probability	0.70

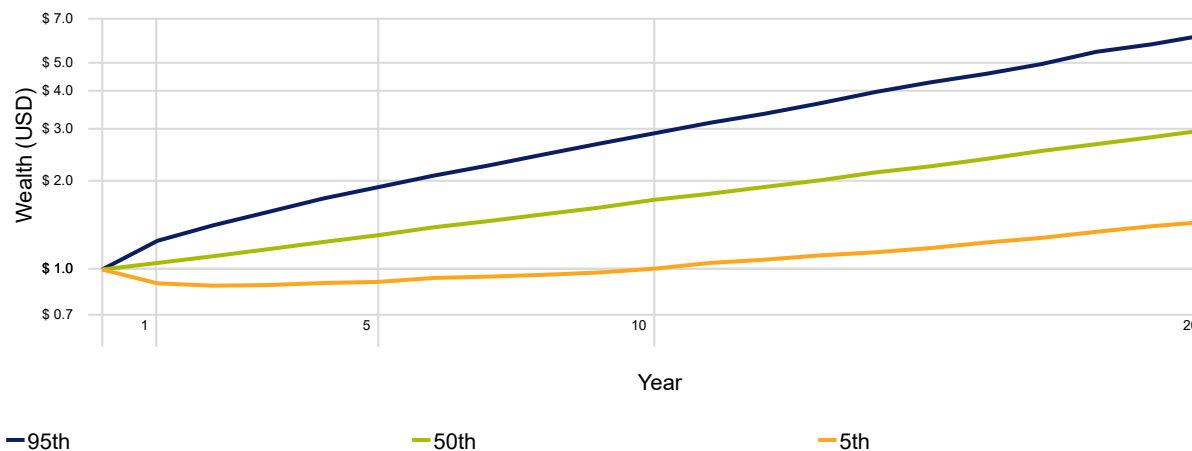
Return Percentiles

Mix 1



Forecasted Growth of \$1

Mix 1



Mix 2 - Return, Risk, Probability Forecast

Asset Class Allocation

	Mix 2
US Aggregate	25.00
US Large Cap	30.00
US Mid Cap	10.00
US Small Cap	6.00
EAFE Equity	16.50
Emerging Markets Equity	5.50
US Core RE	5.00
US Val Add RE	2.00

Single Year Expectations

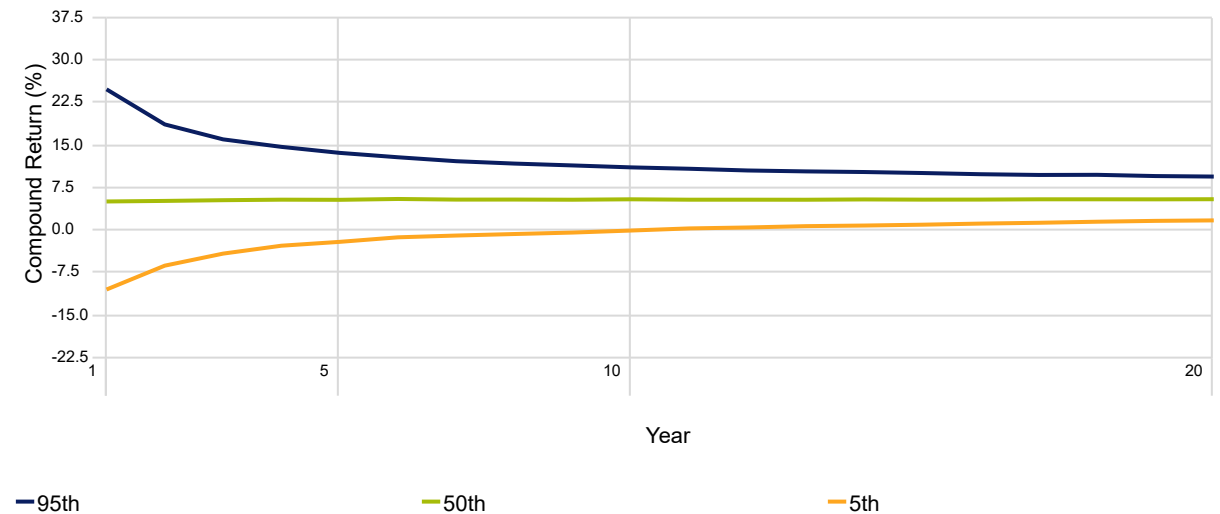
%	Mix 2
Return	6.13
Standard Deviation	10.73
Sharpe Ratio	0.57
Best Case Return	24.96
Worst Case Return	-10.31
Negative Return Probability	30.80

Time Horizon Expectations

Return	5.59
Best Case Return	9.59
Worst Case Return	1.86
Negative Return Probability	0.77

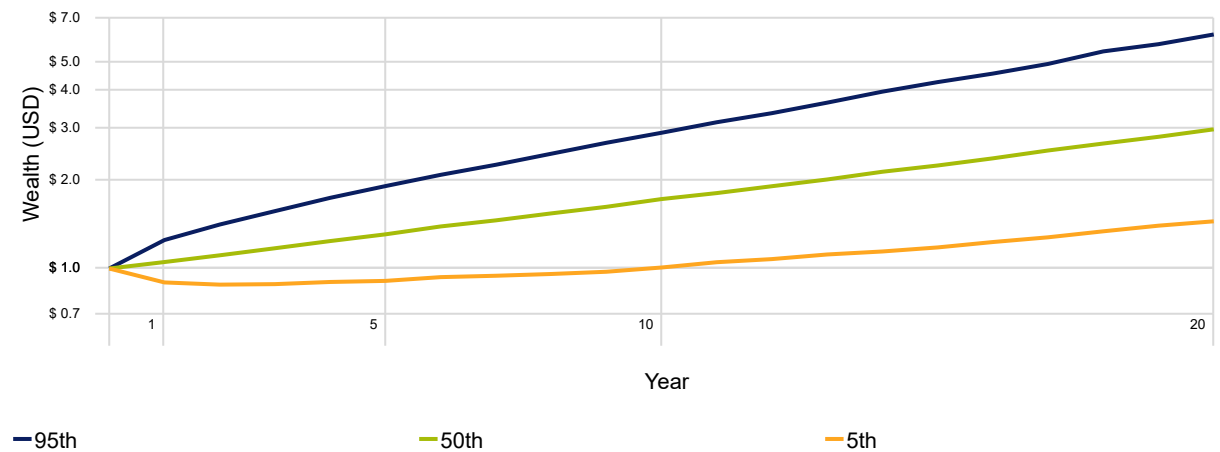
Return Percentiles

Mix 2



Forecasted Growth of \$1

Mix 2



Mix 3 - Return, Risk, Probability Forecast

Asset Class Allocation

	Mix 3
US Aggregate	30.00
US Large Cap	25.00
US Mid Cap	10.00
US Small Cap	6.00
EAFE Equity	16.50
Emerging Markets Equity	5.50
US Core RE	3.50
US Val Add RE	3.50

Single Year Expectations

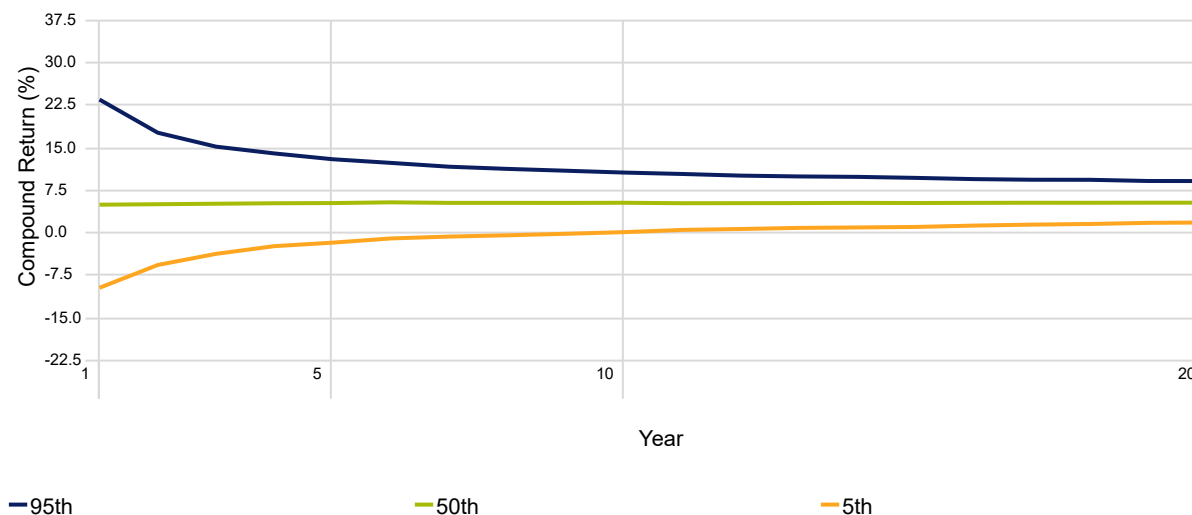
%	Mix 3
Return	6.00
Standard Deviation	10.10
Sharpe Ratio	0.59
Best Case Return	23.68
Worst Case Return	-9.48
Negative Return Probability	30.27

Time Horizon Expectations

Return	5.51
Best Case Return	9.32
Worst Case Return	2.02
Negative Return Probability	0.57

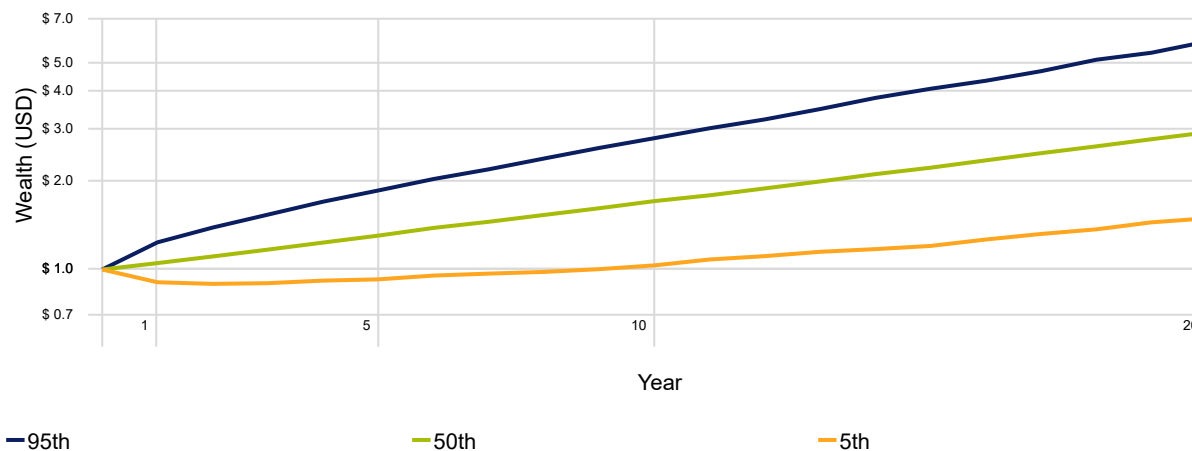
Return Percentiles

Mix 3



Forecasted Growth of \$1

Mix 3



Mix 4 - Return, Risk, Probability Forecast

Asset Class Allocation

	Mix 4
US Aggregate	25.00
US Large Cap	24.30
US Mid Cap	10.10
US Small Cap	6.10
EAFE Equity	16.50
Emerging Markets Equity	5.50
US Core RE	7.50
US Val Add RE	5.00

Single Year Expectations

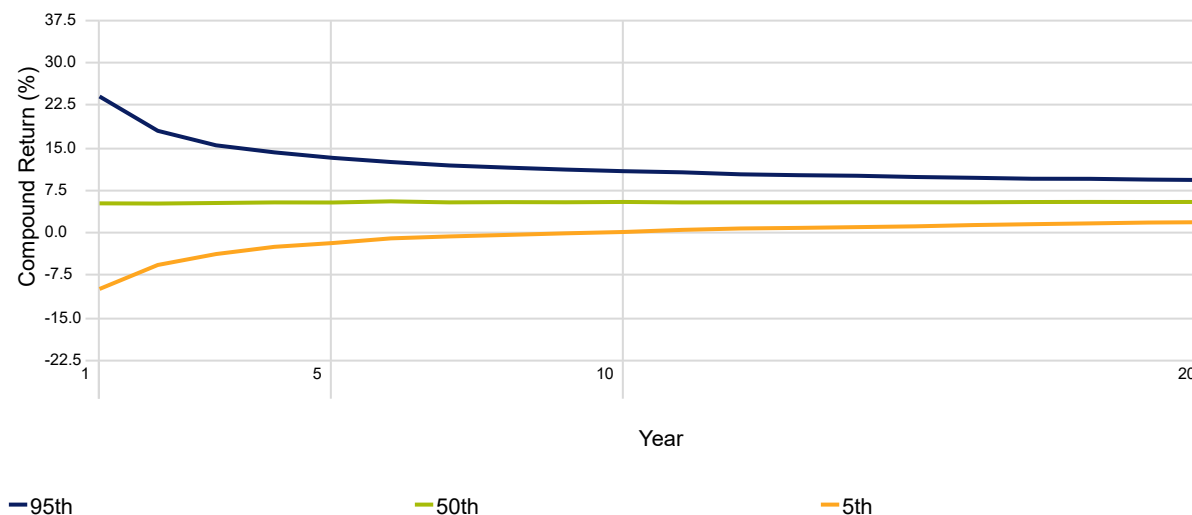
	Mix 4
%	
Return	6.15
Standard Deviation	10.27
Sharpe Ratio	0.60
Best Case Return	24.23
Worst Case Return	-9.69
Negative Return Probability	29.97

Time Horizon Expectations

Return	5.64
Best Case Return	9.50
Worst Case Return	2.07
Negative Return Probability	0.53

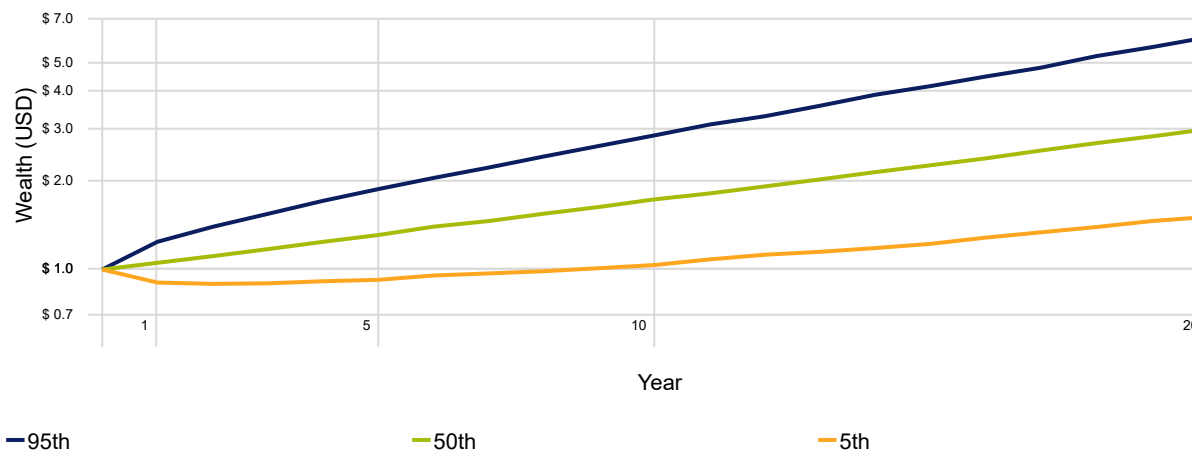
Return Percentiles

Mix 4



Forecasted Growth of \$1

Mix 4



Mix 5 - Return, Risk, Probability Forecast

Asset Class Allocation

	Mix 5
US Aggregate	23.00
US Large Cap	30.00
US Mid Cap	10.00
US Small Cap	5.00
EAFE Equity	16.50
Emerging Markets Equity	5.50
US Core RE	5.00
US Val Add RE	5.00

Single Year Expectations

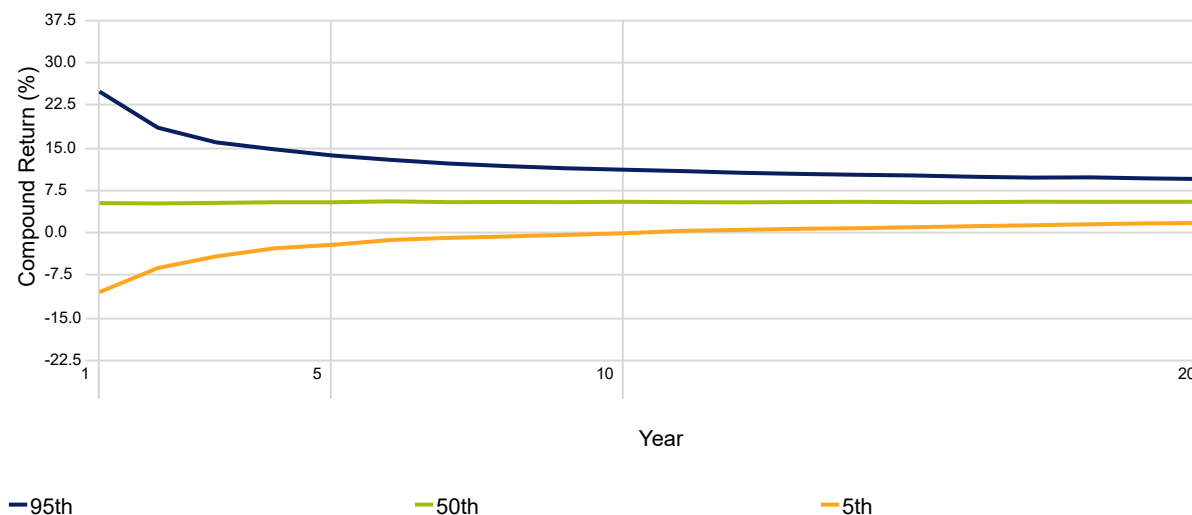
%	Mix 5
Return	6.21
Standard Deviation	10.72
Sharpe Ratio	0.58
Best Case Return	25.09
Worst Case Return	-10.25
Negative Return Probability	30.53

Time Horizon Expectations

Return	5.67
Best Case Return	9.67
Worst Case Return	1.93
Negative Return Probability	0.60

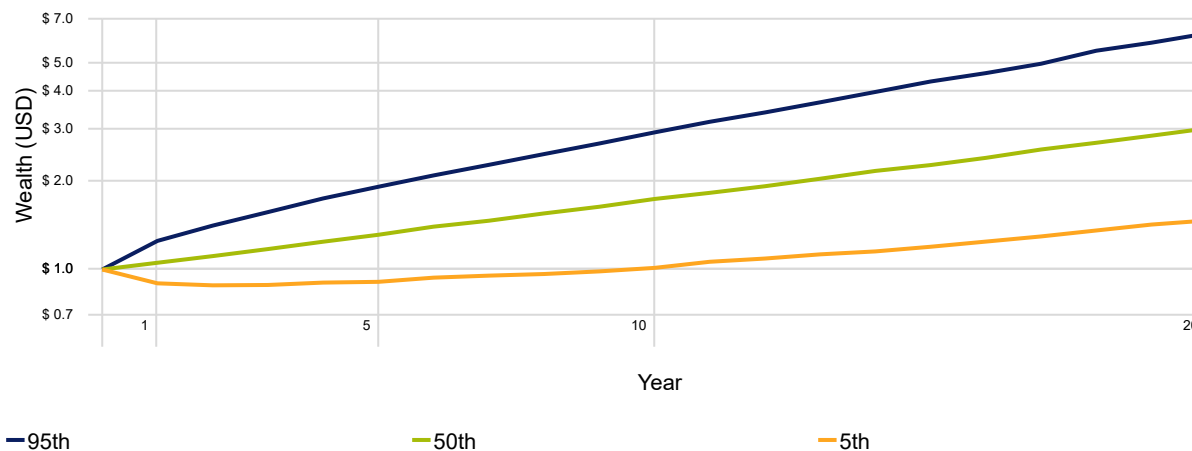
Return Percentiles

Mix 5



Forecasted Growth of \$1

Mix 5



Model Asset Allocation

■ Conclusions

- Opportunities exist in Emerging Markets where the plan is currently underweight relative to the market weights.
- Opportunities exist in domestic Mid-Cap equities where the plan is currently underweight relative to the market weights and overweight to domestic small-cap equities.
- Additional exposure to private Real Estate is recommended, especially in the non-core or value-added sector.

■ Action Items / Considerations

- Remove exposure to Long Duration Fixed Income (-5%) and increase US Aggregate (5%).
- Reduce US Large Cap (-5%) and increase US Mid-Cap (5%).
- Reduce US Small Cap (-4%) and increase Emerging Markets Equity (1.5%) and Real Estate (2%)



Introduction To Asset Allocation Modeling

Mean/variance optimization using forecast capital market assumptions

Model Input	Description
Expected Return	The arithmetic average expected return (mean) of each asset class.
Expected Risk	The variability of each asset class around its mean return. The statistical measure known as standard deviation.
Correlation	The degree of co-movement of each asset class relative to all other asset classes. The statistical measure known as a correlation coefficient.

- **Understanding asset allocation model limitations:**

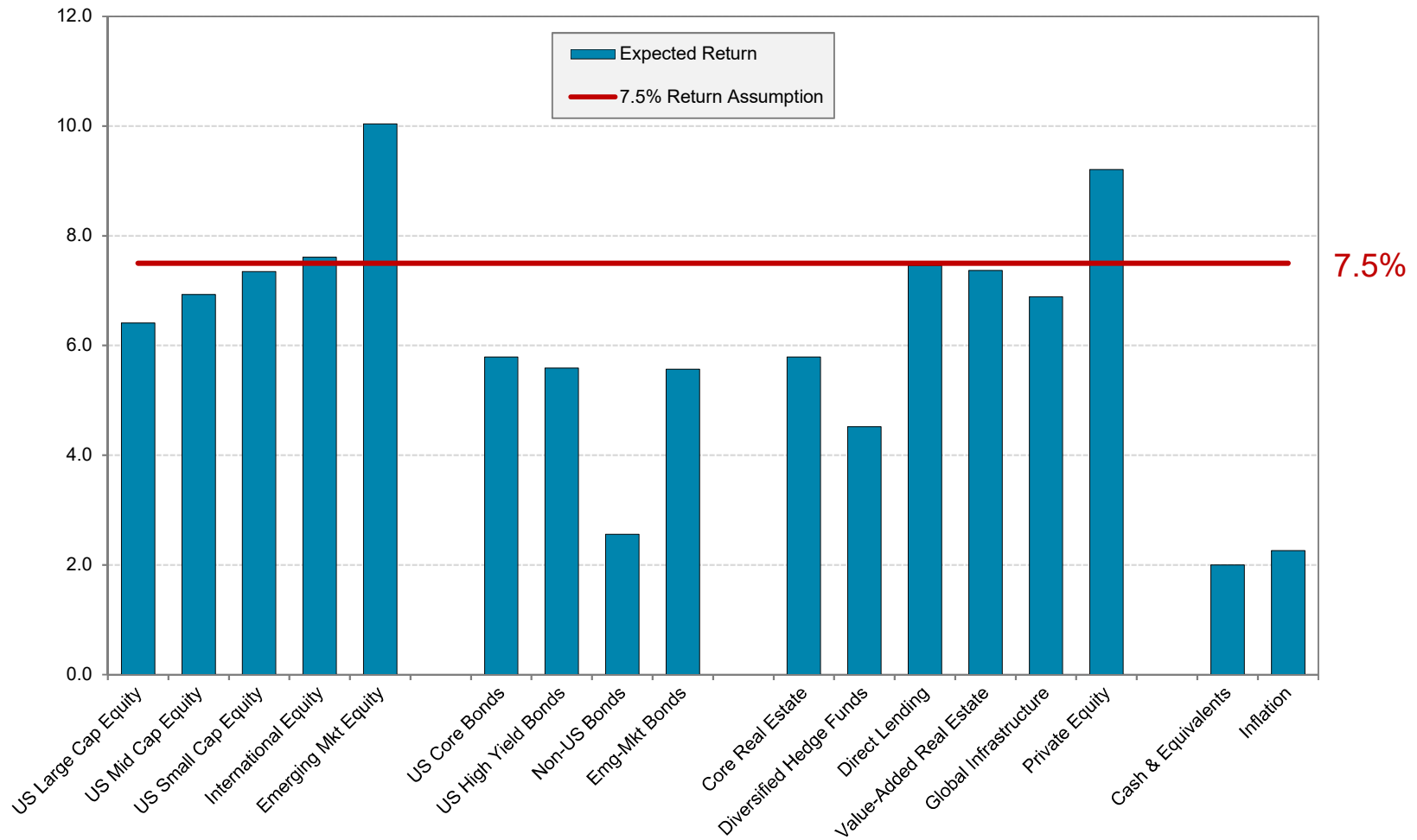
- Output is based on forecasts (guesses) of each capital market assumption. Accurately predicting the expected return, expected risk (standard deviation), and correlation coefficients for each asset class is not a science, it's an economic methodology that varies by organization and forecast timeframe.
- Assumes asset class returns are normally distributed (bell-shape curve). However, many asset classes exhibit non-normal (kurtosis - fat-tails and/or skewness) return distributions.
- Assumes correlations between asset class pairs are static. However, since correlation coefficients can and do change over time, diversification and/or stability benefits of combining different asset classes may be overstated. Even historically stable correlation relationships may break down during periods of market stress.
- Alternative asset classes introduce a variety of important risk factors that are not captured in their standard deviation measures.

- **Despite its shortcomings, asset allocation modeling provides a foundational framework for making sound portfolio decisions.**



A Closer Look at Expected Returns

10-15 Year Expected Returns Relative to a 7.5% Return Assumption

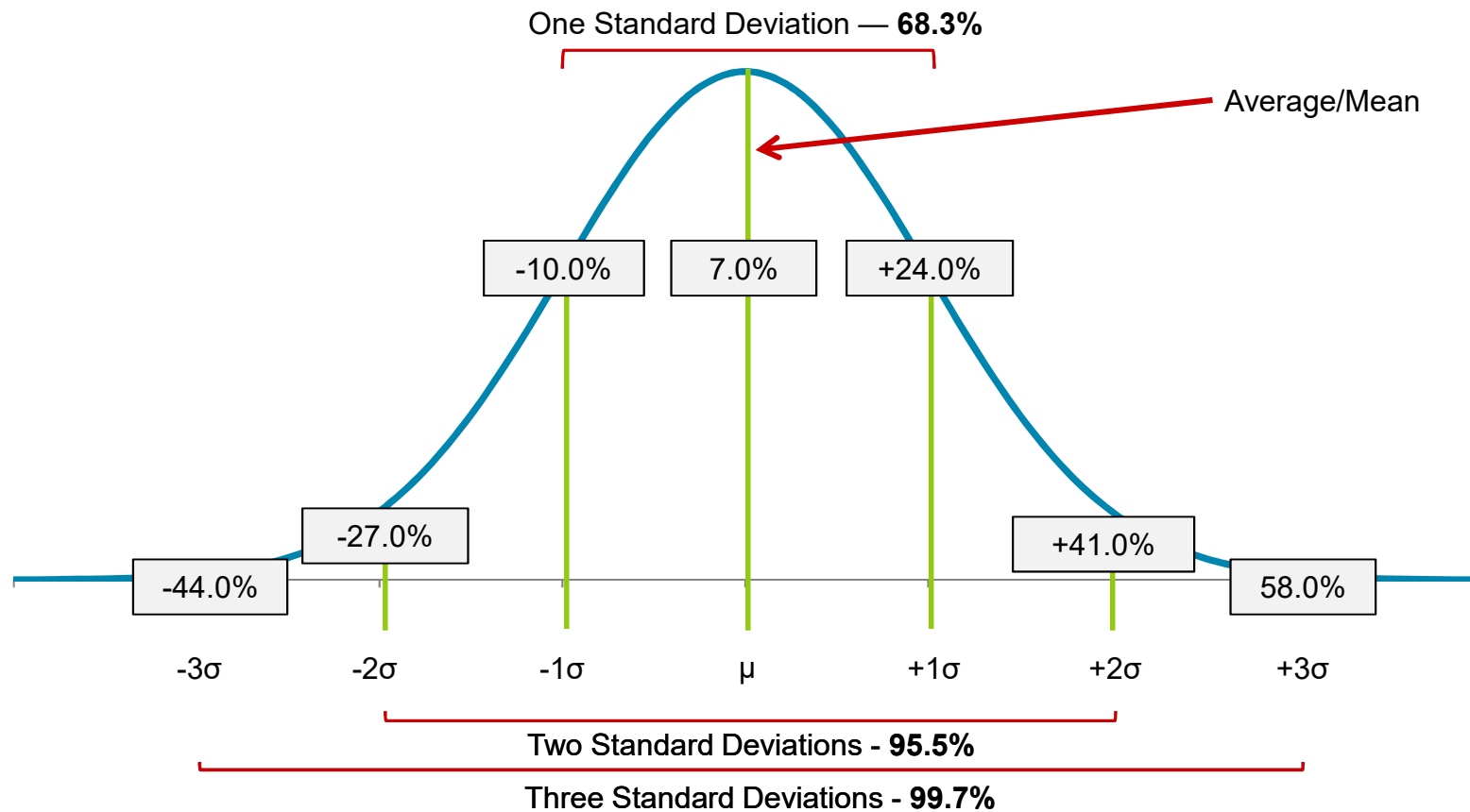


A Closer Look at Investment Risk as Defined by Math

Risk = Variability Around Mean = Standard Deviation

Variability of return around its arithmetic average

Large Cap Equity Average Expected Return of 7.0% with a Standard Deviation of 17.0%



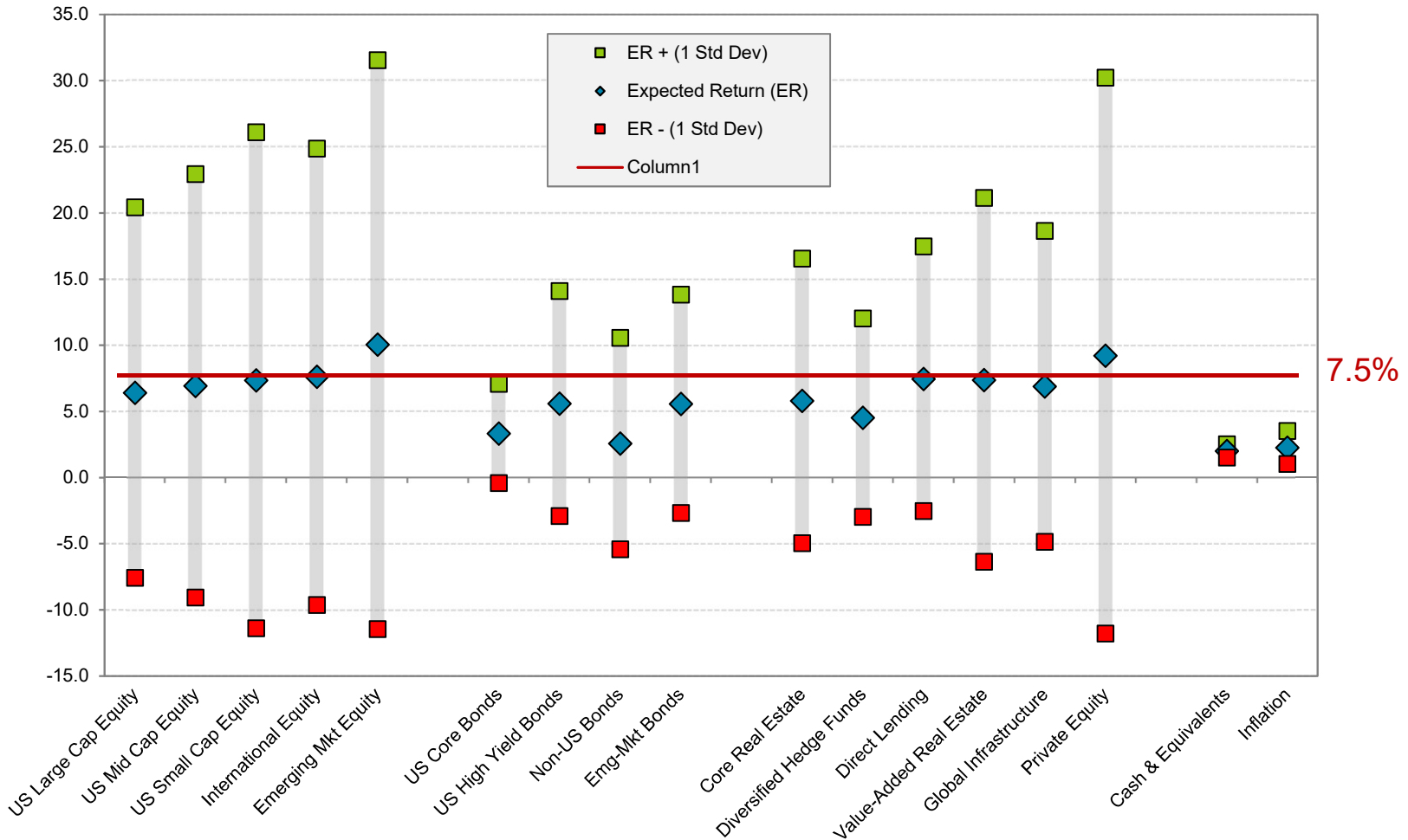
Other Investment Risks Not Captured by Standard Deviation

Beyond Variability – Other Risks Are Always Present

<p>Interest Rate: Bonds decline in value when rates rise</p>	<p>Social/political/legislative: Investment landscape changes</p>
<p>Business: Underlying operational volatility/uncertainty</p>	<p>Currency/Exchange Rate: Change in price of one currency against another</p>
<p>Credit: Bond issuer defaults on interest/principal payment</p>	<p>Leverage: Amplifies losses</p>
<p>Call: Debt security called prior to maturity</p>	<p>Fiduciary: Potential non-arm's length transactions</p>
<p>Inflationary: Value of security eroded by inflation</p>	<p>Valuation: Some assets are difficult to price</p>
<p>Liquidity: Lock-up terms or gates during market stress</p>	<p>Headline: Manager makes the headlines or negative press</p>
<p>Systemic/market: Correlations go to "1" (like 2008)</p>	<p>Blow-up: Manager/strategy blows up</p>

Blending the Return & Risk in a Single View

Expected Returns & Risk (Std Dev) Relative to a 7.5% Return Assumption

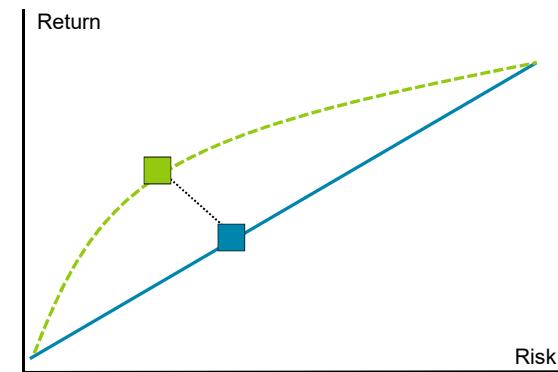


Understanding How Correlation Fits into the Process

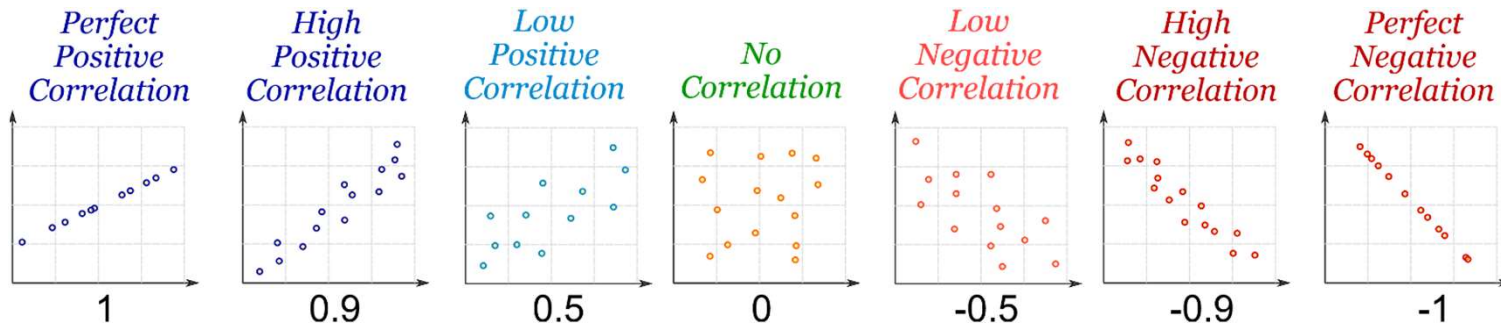
Understanding Correlations

Where the magic happens: How asset class pairs move relative to one another

- A statistical measure of co-movement with a range between +1 and -1.
 - **+1** = Perfect positive correlation. Assets move in tandem in the same direction.
 - **0** = No correlation. Assets move independently of one another – essentially no distinguishable pattern, more random.
 - **-1** = Perfect negative correlation. Assets move in opposite directions – one goes up the other goes down and vice versa.
- It is important to remember that correlations are not constant through time.

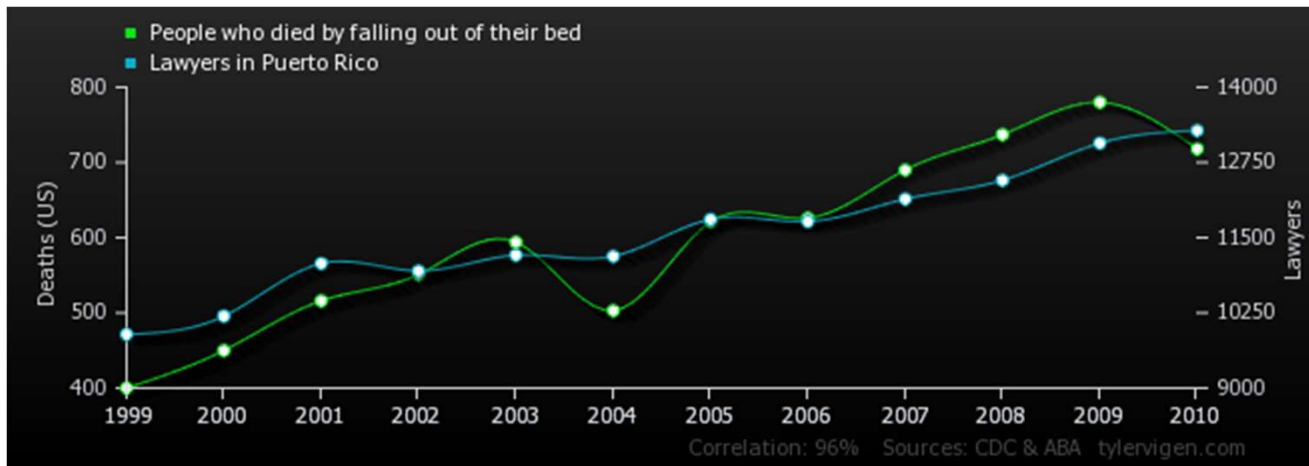


$$\sigma_p^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j \rho_{ij}$$

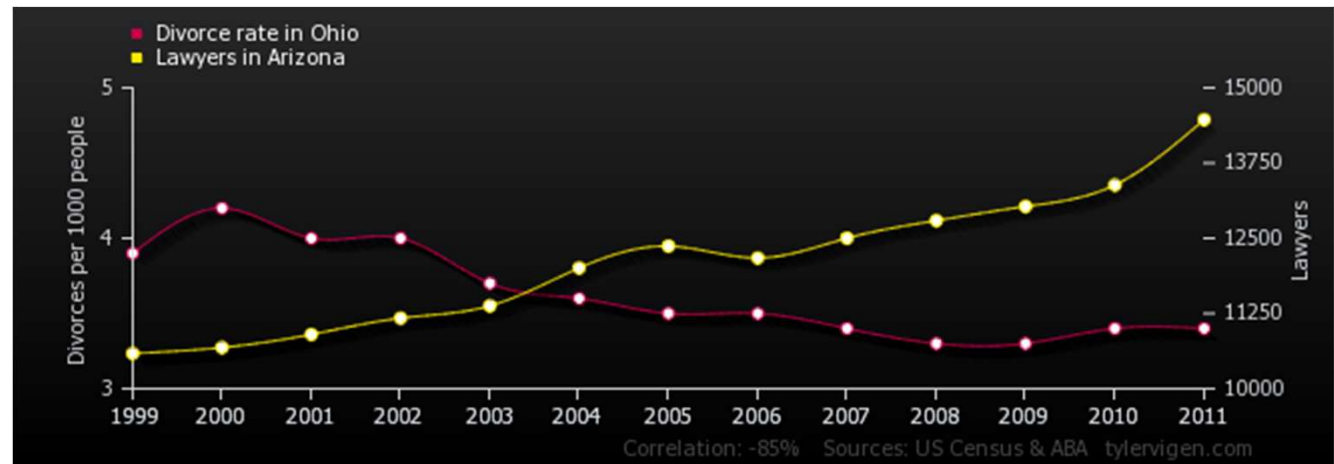


Is it Really Magic? Beware of Spurious Correlation

Don't Believe Everything You See



Correlation = 0.9571
96%



Correlation = -0.8547
85%

Correlation does not necessarily equal causation





Disclosures

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