2019 Capital Market Assumptions

March 2019

Sellwood
CONSULTING LLC

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INTRODUCTION

Sellwood Consulting updates its capital markets assumptions on an annual basis. Our 2019 assumptions reflect information as of December 31, 2018, unless otherwise noted.

This report documents our process for creating these capital markets assumptions, and we provide detailed methodology for each. Several over-arching principles, however, inform all of our analysis:

1. We believe that forward-looking capital market assumptions are an important, but far from the only important, input for properly constructing portfolios. Great care should be taken not to rely only on mean-variance analysis when constructing portfolios. An analysis that relies only on mean-variance analysis will over-allocate to assets with insignificantly superior risk/return estimates, and assets that are less liquid or less frequently priced, resulting in inferior diversification and the assumption of unintended risks.

2. Our assumptions are forward-looking in nature and reflect a ten-year horizon. They are appropriate for analysis of portfolios with long-term (10 year or greater) horizons. For portfolios with shorter horizons, alternate methods of analysis should be employed.

3. We purposefully use different methods to estimate return and risk. The first part of this paper explains the different methods we employ to estimate the future return of each individual asset class. Later in the paper, we explain a more standardized approach to estimating future risk of the same asset classes.

4. Our return assumptions utilize a build-up approach based on the current values of the individual drivers of expected return that are unique to each asset class.

5. For asset classes where the market provides a current view of forward-looking returns, our assumptions heavily weight the market view.

6. Where possible, all of our return assumptions incorporate current valuations. Where we have identified a current valuation and its long-term mean, our estimates consider a 50% reversion from the current valuation level to its long-term mean over the next ten years.

7. Our assumptions are presented in nominal terms. Where we have used historical returns in our input analysis, we have always transformed them to real, after-inflation, returns, so as to strip out the influence of historical inflation. At the end of the build-up process, where appropriate, we add the market's current measure of forward-looking inflation back to the assumptions to create forward-looking nominal return assumptions.

8. Our base return calculations are of and for compound returns. After calculating a compound return and a risk assumption, we combine the two mathematically to calculate an arithmetic average expected return, which is a necessary input for mean-variance analysis.

9. Our assumptions are passive in nature and assume no active management.

10. Our approach to modeling the expected risk of each asset category is multi-faceted. First, we examine the historical standard deviation of the returns for a proxy index for the asset category (both the full history and most recent 10 years). Next, we examine the historical worst-case annual return experience (or in the case of asset categories that are not priced to market, the worst two years) for the asset class. If necessary, we adjust our risk estimates upward to ensure that the actual worst-case experience had at least a 1% probability of occurring (once every 100 years) under our assumed return and risk distribution parameters. Finally, for asset classes where our confidence in the data available for examination is limited, we qualitatively adjust our risk assumption to reflect this uncertainty.

11. Our correlation coefficient assumptions are mostly derived from history, with an emphasis on the recent past. We seek a proxy for each asset category we have modeled with as long a history as possible, and then calculate our correlation assumptions using a simple average of the following, for each pair of asset categories:
    - Longest-term correlation
    - 10-year correlation
    - 5-year correlation
    - 3-year correlation

    This approach purposefully overweights the recent past, while acknowledging the long-term past. It is also a more conservative measure for correlation benefit to a portfolio, because recent correlations have been higher than they have been historically.

12. We round our assumptions to the nearest 10 basis points, in the case of arithmetic average return, and nearest 25 basis points, in the case of risk.

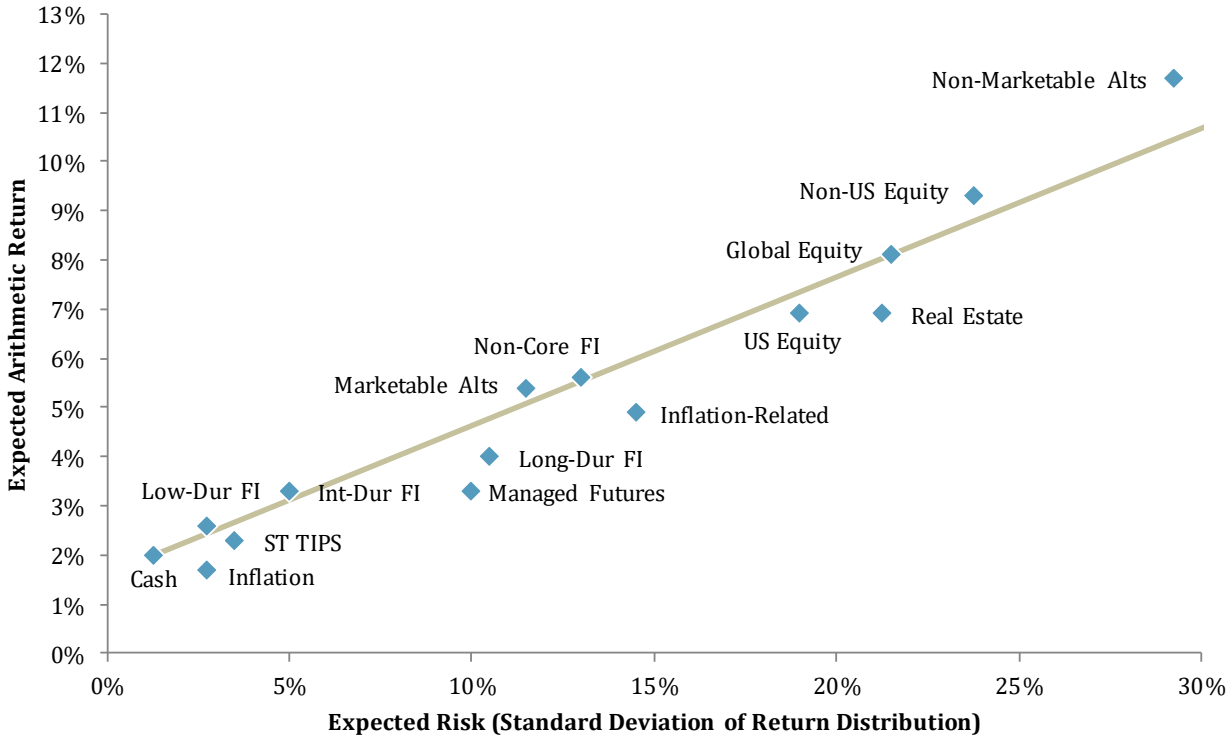
13. Our assumptions are applicable to US-based, non-taxable investors. For taxable clients located in the United States, we maintain a separate methodology that considers the effects of taxes on expected returns and risk.

14. We purposefully design a limited set of mostly non-overlapping assumptions for major asset categories. By focusing on major asset classes, with the most data available for examination, we can develop the most robust assumptions. Asset allocation analysis is a blunt tool, and we believe that input assumptions should not be more granular than the methodology can support. Using a more limited set of assumptions reduces the risk of false precision when implementing them.

15. We strive to construct a set of assumptions that is straightforward, explainable, fully documented, and replicable by other researchers. Our assumptions are as complex as necessary but no more complex than necessary. They have no hidden constraints. We could make them more complicated, but we do not believe that doing so would make them better.

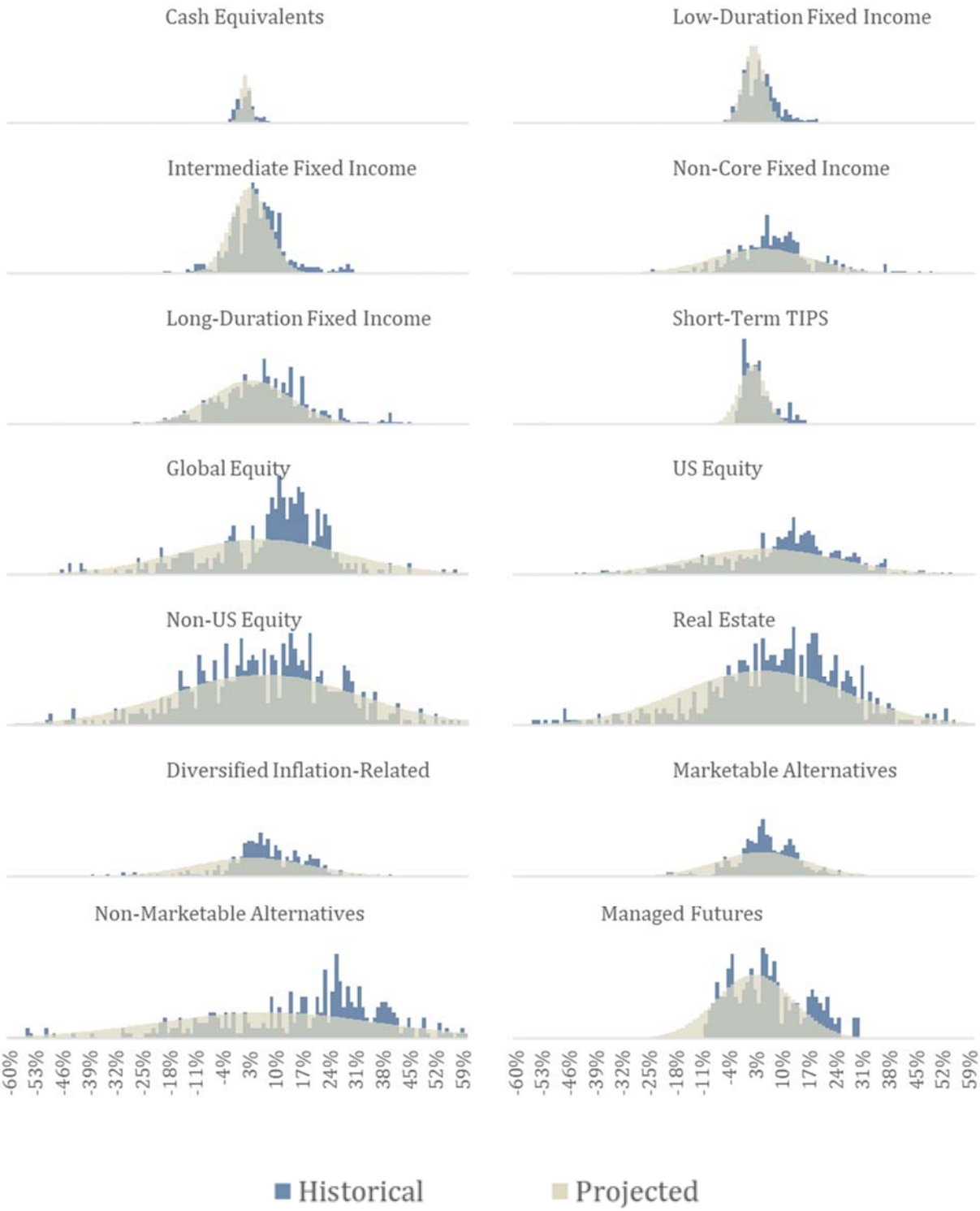
In summary form, our 2019 capital market assumptions follow on the next page.

2019 Sellwood Consulting Capital Market Assumptions



		Nominal Compound Return	Risk	Nominal Arithmetic Return	Sharpe Ratio
	Inflation	1.71%	2.75%	1.70%	---
Fixed Income	Cash Equivalents	2.00%	1.25%	2.00%	---
	Low-Duration Fixed Income	2.59%	2.75%	2.60%	0.21
	Intermediate Fixed Income	3.16%	5.00%	3.30%	0.23
	Non-Core Fixed Income	4.80%	13.00%	5.60%	0.22
	Long-Duration Fixed Income	3.42%	10.50%	4.00%	0.13
	Short-Term TIPS	2.23%	3.50%	2.30%	0.06
Equity	Global Equity	6.01%	21.50%	8.10%	0.19
	US Equity	5.28%	19.00%	6.90%	0.17
	Non-US Equity	6.80%	23.75%	9.30%	0.20
Alternatives	Real Estate	4.82%	21.25%	6.90%	0.13
	Diversified Inflation-Related	3.89%	14.50%	4.90%	0.13
	Marketable Alternatives	4.80%	11.50%	5.40%	0.24
	Non-Marketable Alternatives	8.04%	29.25%	11.70%	0.21
	Managed Futures	2.87%	10.00%	3.30%	0.09

Historical one-year return distributions (historical real returns, plus our assumed future inflation) are depicted below in blue, and our forward-looking assumed return distributions are shown in tan:



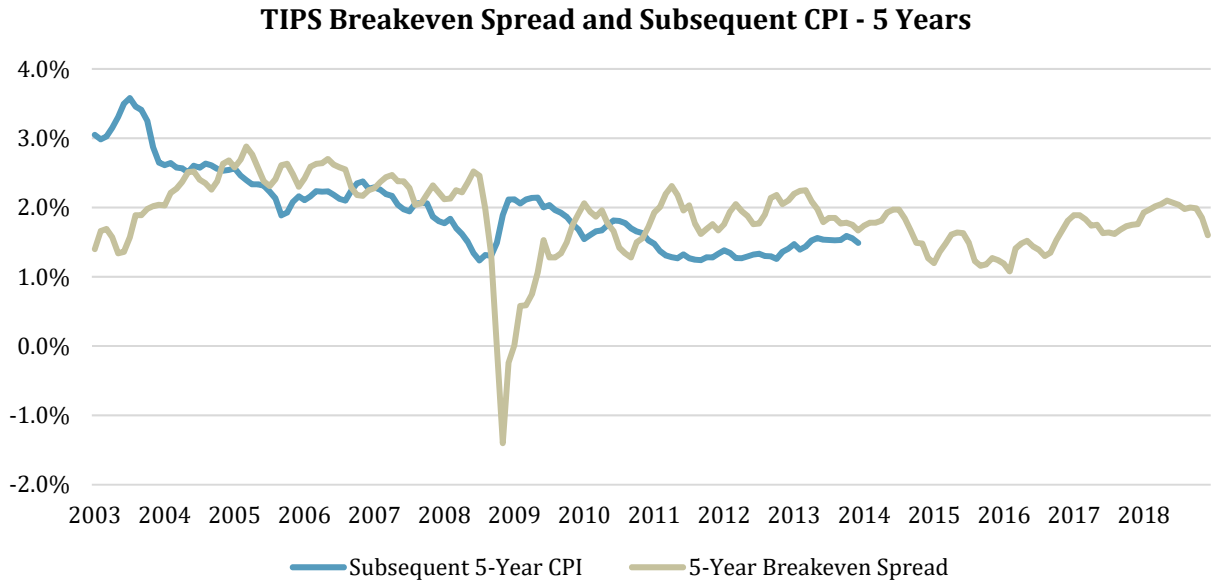
INFLATION

Modeled: US CPI-U Inflation
Compound Return: 1.71%
Arithmetic Average Return: 1.70%
Risk: 2.75%

The market tells us its expectation for forward-looking ten-year inflation, and our assumption reflects that market assumption.

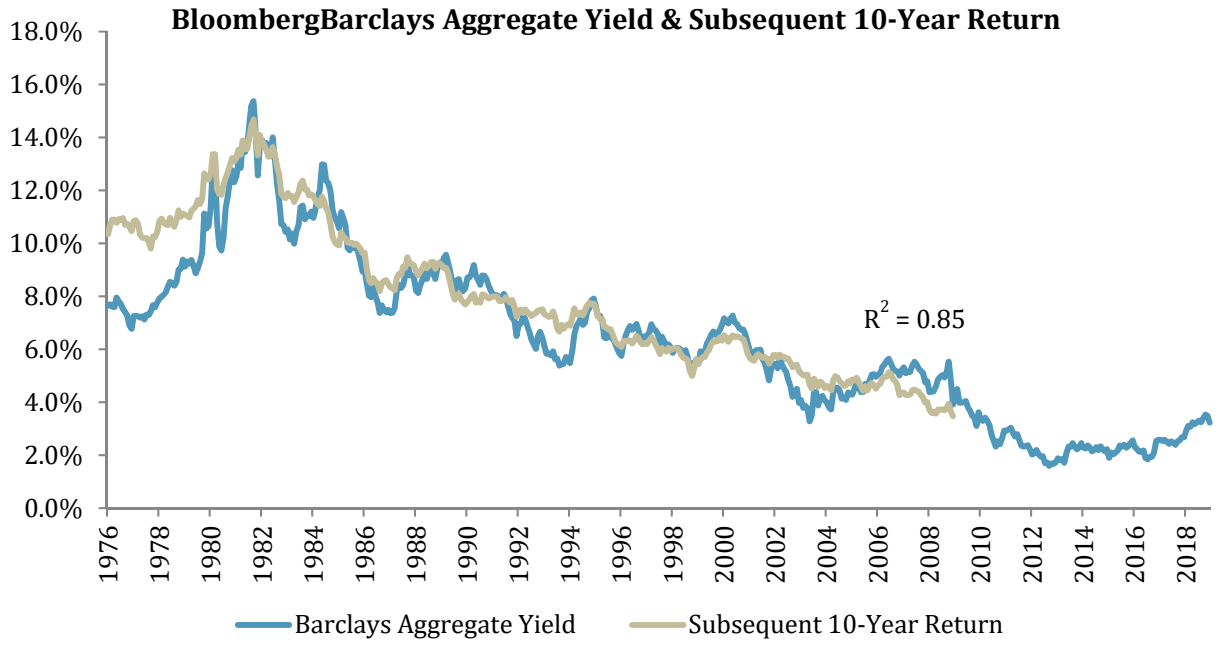
On December 31, 2018, the market's yield for a 10-Year US Treasury Bond was 2.69%, and the real yield for a 10-Year TIPS security was 0.98%. The difference between the two approximates the market's inflation expectation over the next ten years, 1.71%.

The Federal Reserve has published this inflation approximation – the so-called "TIPS breakeven spread" – since 2003. The following chart depicts the full history of this measure, laid against the actual subsequent inflation (as measured by the Consumer Price Index, "CPI") that occurred over the following five years. We have chosen to depict the five-year TIPS breakeven spread and subsequent five-year inflation, because the 10-year values do not yet offer sufficient data for evaluation. With the exception of especially illiquid market periods, which distort the measure because of liquidity differences between TIPS and nominal Treasury Bonds, the measure has done a fair job of predicting subsequent inflation and does not appear to be biased positively or negatively.



FIXED INCOME

Fixed income returns are very dependent on entry yields. For the BloombergBarclays Aggregate Index, since 1976, going-in yields have explained 85% of subsequent 10-year returns:

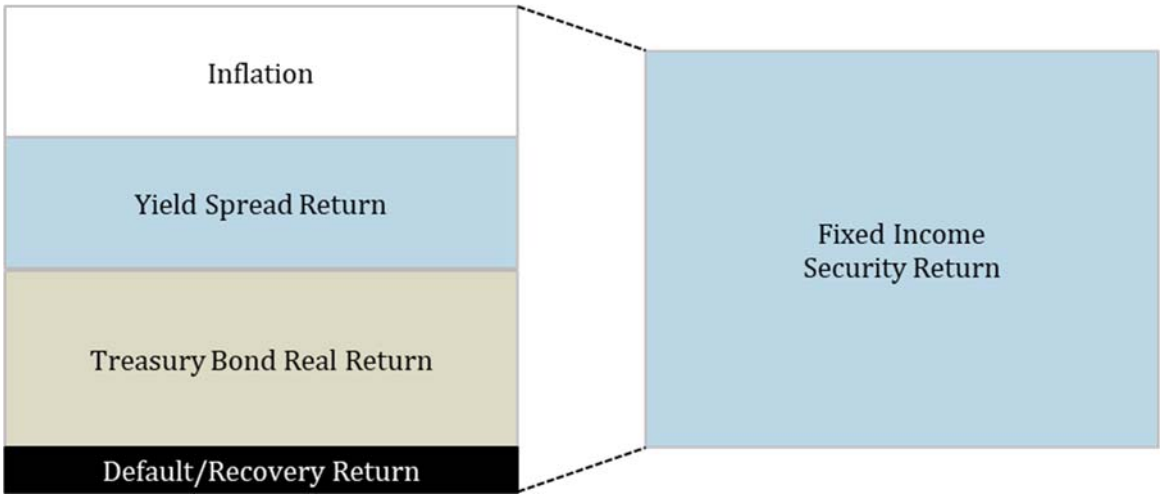


It would be tempting to simply set our bond-market assumptions as the current yield, but to do so would be to ignore prospects for changing interest rates, changing composition of the bond benchmarks, and the negative effects of bond defaults. Instead, we build a valuation model for each bond category for which we assume a return. Still, current yields anchor our analysis: in each case, the compound return assumption that we calculate with this model is close to the current nominal yield for the asset class.

All of our fixed income assumptions use an identical building-block model as our base analysis, but we have made some qualitative adjustments to the analysis, where noted.

Our building block model begins with the fixed income asset class's current real yield and duration. We then examine the long-term average of the real yield, and assume that over the prospective ten-year period, the asset's real yield reverts halfway to that average. For asset categories that pay a yield spread as compensation for higher risk, we use similar calculations to assume the reversion of the yield spread halfway to its historical average. For the most part, we assume that long-term average default and recovery rates will persist into the prospective ten-year period.[1] Given these inputs, we can calculate the asset's expected forward-looking 10-year return using arithmetic.

[1] Our source for historical default and recovery rates for all bonds is Moodys.



We use a US Treasury Bond as our first fixed income building block – the block upon which we stack yield spreads and inflation. To calculate the forward-looking ten-year return for Treasury Bonds, we begin with today's real yield and assume ten-year reversion halfway to the long-term average mean real yield. To capture the longest time horizon possible, we calculate all real yields by adjusting the nominal yield by an inflation series[2]. We assume that the reversion to a mean real yield will occur in even increments in each of the future ten years. We assume further that the security's duration will stay constant over the ten-year period. The last building block, though it is assumed to be zero for a Treasury security, is an assumed default rate, adjusted for an assumed recovery rate. Finally, because all of this analysis is calculated in real terms, we add back the market's inflation assumption to arrive at a nominal return assumption.

Our calculations for the 2-, 5-, 10-, and 20-Year US Treasury Bonds follow. Our assumptions are:

Maturity:	2 years	5 years	10 years	20 years
Duration:	1.90 years	4.62 years	8.42 years	13.72 years
Current Real Yield:	0.26%	1.00%	0.98%	1.09%
Long-Term Average Real Yield:	1.57%	1.98%	2.25%	2.48%
Cumulative Yield Change (10 Years):	+0.65%	+0.49%	+0.63%	+0.69%
Expected Default Rate:	0%	0%	0%	0%

[2] Since 2003, our real yields are based on the constant maturity TIPS yields calculated by the Federal Reserve for maturities longer than 2 years. Prior to 2003, in order to calculate real yields we adjusted the applicable yield with the prior 12-month core CPI index. For example, for a 5-year Treasury bond, we calculate a historical real yield series by subtracting prior 12-month core CPI from historical 5-year Treasury bond yields prior to 2003, and by using the then-current 5-year TIPS breakeven yield after 2003. Because of its lower volatility, the core CPI index has proven a better predictor of subsequent CPI inflation than has the CPI index itself.

2-Year Treasurys -- Total Return

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Real Yield	0.26%	0.33%	0.39%	0.46%	0.52%	0.59%	0.65%	0.72%	0.79%	0.85%	0.92%		
Duration	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90		
Parallel Yield Change		0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.65%	
12-month return		0.14%	0.20%	0.27%	0.33%	0.40%	0.46%	0.53%	0.60%	0.66%	0.73%		
Compound Factor		100.14%	100.20%	100.27%	100.33%	100.40%	100.46%	100.53%	100.60%	100.66%	100.73%	4.40%	0.43%
											market 10-year inflation		1.71%
											nominal 10-yr annualized return		2.14%

5-Year Treasurys -- Total Return

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Real Yield	1.00%	1.05%	1.10%	1.15%	1.20%	1.25%	1.29%	1.34%	1.39%	1.44%	1.49%		
Duration	4.62	4.62	4.62	4.62	4.62	4.62	4.62	4.62	4.62	4.62	4.62		
Parallel Yield Change		0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.05%	0.49%	
12-month return		0.77%	0.82%	0.87%	0.92%	0.97%	1.02%	1.07%	1.12%	1.17%	1.21%		
Compound Factor		100.77%	100.82%	100.87%	100.92%	100.97%	101.02%	101.07%	101.12%	101.17%	101.21%	10.40%	0.99%
											market 10-year inflation		1.71%
											nominal 10-yr annualized return		2.70%

10-Year Treasurys -- Total Return

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Real Yield	0.98%	1.04%	1.11%	1.17%	1.23%	1.30%	1.36%	1.42%	1.49%	1.55%	1.61%		
Duration	8.42	8.42	8.42	8.42	8.42	8.42	8.42	8.42	8.42	8.42	8.42		
Parallel Yield Change		0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.63%	
12-month return		0.45%	0.51%	0.57%	0.64%	0.70%	0.76%	0.83%	0.89%	0.95%	1.02%		
Compound Factor		100.45%	100.51%	100.57%	100.64%	100.70%	100.76%	100.83%	100.89%	100.95%	101.02%	7.56%	0.73%
											market 10-year inflation		1.71%
											nominal 10-yr annualized return		2.44%

20-Year Treasurys -- Total Return

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Real Yield	1.09%	1.16%	1.23%	1.30%	1.37%	1.44%	1.51%	1.58%	1.65%	1.71%	1.78%		
Duration	13.72	13.72	13.72	13.72	13.72	13.72	13.72	13.72	13.72	13.72	13.72		
Parallel Yield Change		0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.69%	
12-month return		0.14%	0.21%	0.28%	0.35%	0.42%	0.48%	0.55%	0.62%	0.69%	0.76%		
Compound Factor		100.14%	100.21%	100.28%	100.35%	100.42%	100.48%	100.55%	100.62%	100.69%	100.76%	4.59%	0.45%
											market 10-year inflation		1.71%
											nominal 10-yr annualized return		2.16%

For each assumption we add our inflation assumption to the expected annualized compound return. Based on this calculation we arrive at the following compound return assumptions:

Our projected nominal 10-year annualized return for each Treasury Bond is:

2 Year	5 Year	10 Year	20 Year
2.14%	2.70%	2.44%	2.16%

Cash Equivalents

Modeled: 91-Day T-Bills
Compound Return: 2.00%
Arithmetic Average Return: 2.00%
Risk:1.25%

We use the model outlined above for Cash Equivalents.

Assumptions (91-Day T-Bills):

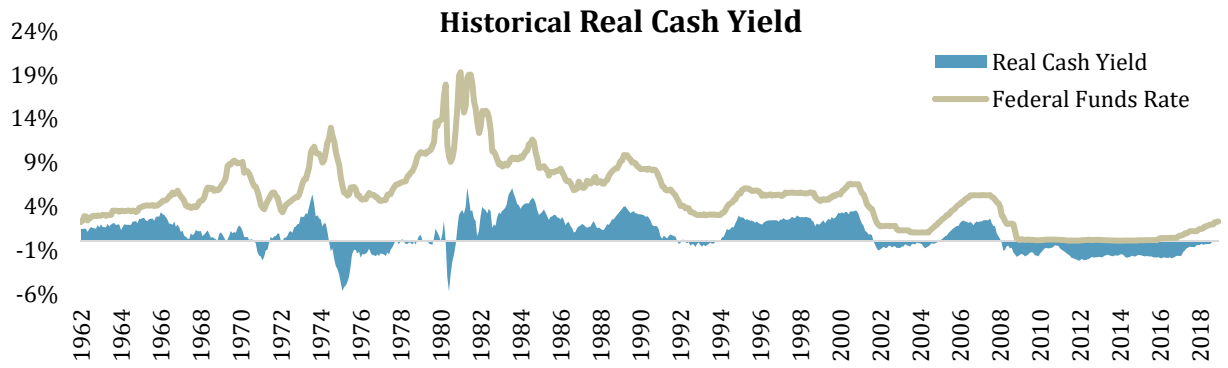
Maturity:	91 days
Duration:	0.25 years
Current Real Yield:	0.15%
Long-Term Average Real Yield:	0.80%
Cumulative Yield Change (10 Years):	+0.32% (halfway from current to long-term average)
Expected Default Rate:	0%

These assumptions yield a nominal compound return expectation of 2.00%:

91-Day T-Bills -- Total Return

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Real Yield	0.15%	0.19%	0.22%	0.25%	0.28%	0.32%	0.35%	0.38%	0.41%	0.45%	0.48%		
Duration	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		
Parallel Yield Change		0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.03%	0.32%	
12-month return		0.15%	0.18%	0.21%	0.24%	0.28%	0.31%	0.34%	0.37%	0.41%	0.44%		
Compound Factor		100.15%	100.18%	100.21%	100.24%	100.28%	100.31%	100.34%	100.37%	100.41%	100.44%	2.95%	0.29%
											market 10-year inflation		1.71%
											nominal 10-yr annualized return		2.00%

We caution that there is an inherent problem with forecasting a 10-year return for an asset that matures every 91 days. Nominal cash returns are highly sensitive to nominal short-term interest rates, which we expect to be as variable over the next decade as they have been historically. As illustrated in the chart below, while investors typically demand a positive real yield from cash, periods of negative real return to cash have existed for considerable periods of time – including the most recent period from February 2008 until real cash yields turned positive again in October 2018. Our risk assumption reflects an appropriate range of uncertainty around our return projection for cash equivalents.



Low-Duration Fixed Income

Modeled: 1-3 Year Aggregate Fixed Income
Compound Return: 2.59%
Arithmetic Average Return: 2.60%
Risk: 2.75%

Our Low-Duration Fixed Income assumption reflects a 50% proportion to both the 2-Year Treasury Bond and corporate bonds. For half the assumed portfolio, then, we add to our 2-Year Treasury bond return expectation a spread for 1-3 year corporate bonds:

Proportion in Corporates:	50%
Spread Duration:	1.56 years
Current Spread:	0.93%
Long-Term Average Spread:	1.24%
Cumulative Spread Change (10 Yrs):	+0.16% (halfway from current to long-term average)

1-3 Year Corporates -- Spread Effect (over Treasurys)

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Spread	0.93%	0.95%	0.96%	0.98%	0.99%	1.01%	1.02%	1.04%	1.06%	1.07%	1.09%		
Duration	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56		
Parallel Yield Change		0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.16%	
12-month return		0.91%	0.92%	0.94%	0.95%	0.97%	0.98%	1.00%	1.02%	1.03%	1.05%		
Compound Factor		100.91%	100.92%	100.94%	100.95%	100.97%	100.98%	101.00%	101.02%	101.03%	101.05%	10.20%	0.98%
												Proportion	50.00%
												Spread Effect (Total)	0.49%

Finally, we make assumptions for the expected default rate and recovery rate for defaulted 1-3 year corporate securities. These calculations only apply to the proportion of the assumption pertaining to corporate securities. The following figures represent the historical average for the asset class:

Assumptions:

Expected Default Rate:	0.15%
Expected Default Recovery Rate:	44%
Default/Recovery Return Contribution:	-0.08%
Multiplied by 0.5 (half of portfolio):	-0.04%

In summary, our return assumption for low-duration fixed income builds up several sources of return:

2-Year Treasury Return:	2.14%
Spread Effect (half of spread):	+0.49%
Default Effect (half):	-0.04%
Return Assumption:	**2.59%**

Combining the 2-Year Treasury Bond return and the expected return from spread, and then subtracting the expected default rate after adjusting for recovery, yields our return assumption of 2.59% in compound terms.

Intermediate Fixed Income

Modeled: US Investment-Grade Aggregate and Hedged Non-US Aggregate Fixed Income
Compound Return: 3.16%
Arithmetic Average Return: 3.30%
Risk: 5.00%

The base level of our building-block approach for Intermediate Fixed Income is the 5-Year Treasury Bond, outlined above. To this expected return, we add an expectation for spread return:

Spread Duration:	3.13 years
Current Spread (BC Aggregate):	0.54%
Long-Term Average Spread:	0.55%
Cumulative Spread Change (10 Yrs):	+0.01% (halfway from current to long-term average)

BC Aggregate -- Spread Effect (over Treasurys)

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Spread	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%		
Duration	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13		
Parallel Yield Change		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	
12-month return		0.53%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%	0.54%		
Compound Factor		100.53%	100.54%	100.54%	100.54%	100.54%	100.54%	100.54%	100.54%	100.54%	100.54%	5.50%	0.54%
												Proportion	100.00%
												Spread Effect (Total)	0.54%

Our assumptions for default and recovery rates are in line with history. We subtract a default contribution based on these input variables:

Expected Default Rate:	0.15%
Expected Default Recovery Rate:	44%
Default/Recovery Return Contribution:	-0.08%

In summary:

5-Year Treasury Return	2.70%
Spread Effect	+0.54%
Default Effect	-0.08%
Return Assumption	**3.16%**

Adding the 5-Year US Treasury Bond return, the expected spread return, and adjusting for defaults yields a compound return expectation of 3.16%.

We believe that this approach works equally well for US Aggregate fixed income and for Non-US Aggregate fixed income where the currency exposure is hedged back to the US dollar. By stripping out currency exposure, the Non-US fixed income investor is left with a portfolio of fixed income securities expecting similar underlying characteristics to the US fixed income portfolio.

Non-Core Fixed Income

Modeled: US and Non-US Below-Investment-Grade & Emerging Markets Fixed Income
Compound Return: 4.80%
Arithmetic Average Return: 5.60%
Risk: 13.00%

Our Non-Core Fixed Income assumption combines US below-investment-grade (high yield) bonds and emerging markets sovereign bonds. We assume a 50% weighting to each asset class.

The maturity of the high-yield index is currently 6.0 years. To match this maturity, we assume the return for a synthetic 6.0-year Treasury bond by appropriately weighting the expected returns we calculated for the 5- and 10-year Treasury bonds. The current maturity of an index of emerging markets sovereign bonds is 11.7 years. To match this duration, we calculate a spread over a weighted average of expected returns for 10- and 20-year US Treasury Bonds that yields an expected return for a 11.7-year Treasury Bond. To these expected returns, we then add a spread building block, and finally subtract a default building block.

	High Yield Bonds	Emerging Market Debt
Maturity:	6.0 years	11.7 years
Synthetic Treasury Assumed Return:	2.65%	2.39%
Spread Duration:	3.79 years	6.48 years
Current Spread:	5.33%	3.97%
Long-Term Average Spread:	5.65%	3.51%
Cumulative Spread Change (10 Yrs):	+0.16%	-0.23%

High Yield -- Spread Effect (over Treasurys)

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Spread	5.33%	5.35%	5.36%	5.38%	5.39%	5.41%	5.43%	5.44%	5.46%	5.47%	5.49%		
Duration	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79		
Parallel Yield Change		0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.16%	
12-month return		5.27%	5.29%	5.30%	5.32%	5.33%	5.35%	5.37%	5.38%	5.40%	5.41%		
Compound Factor		105.27%	105.29%	105.30%	105.32%	105.33%	105.35%	105.37%	105.38%	105.40%	105.41%	68.26%	5.34%
												Proportion	50.00%
												Spread Effect (Total)	2.67%

EMD -- Spread Effect (over Treasurys)

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Spread	3.97%	3.94%	3.92%	3.90%	3.88%	3.85%	3.83%	3.81%	3.78%	3.76%	3.74%		
Duration	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48	6.48		
Parallel Yield Change		-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.23%	
12-month return		4.12%	4.09%	4.07%	4.05%	4.02%	4.00%	3.98%	3.96%	3.93%	3.91%		
Compound Factor		104.12%	104.09%	104.07%	104.05%	104.02%	104.00%	103.98%	103.96%	103.93%	103.91%	48.20%	4.01%
												Proportion	50.00%
												Spread Effect (Total)	2.01%

Our assumed return contribution from our spread building block approach, before accounting for defaults, is (assuming 50% of the portfolio for each asset class):

High Yield Bonds	Emerging Market Debt
2.67%	2.01%

Our final building block is an adjustment for expected default and recovery rates. The quality composition of the emerging markets debt universe has changed over time, so we do not apply historical universe-wide default and recovery rates. Instead, we examine the historical default and recovery rates by bond quality rating and apply those rates to the current universe quality composition. Historically, investment-grade emerging markets issues have experienced 1.7% default rates. Speculative-grade emerging markets issues have experienced 10.4% default rates. The universe is currently 50% investment grade and 50% speculative grade; applying these proportions results in an expected default rate of 6.1%. Historical recovery rates in default, regardless of rating, has been 65%.

We subtract the expected unrecovered default from the total yield:

	Default Rate	Recovery Rate	Unrecovered Rate	Default Effect
High Yield	4.4%	39%	61%	-2.66%
EM Debt	6.1%	65%	35%	-2.13%

In summary:

	High Yield	EM Debt	Combined
Treasury Return	2.65%	2.39%	---
Spread Effect	+5.34%	+4.01%	---
Default Effect	-2.66%	-2.13%	---
Return Assumption	5.33%	4.28%	**4.80%**

We average the High Yield and Emerging Markets Debt assumptions to arrive at our forward-looking compound return expectation for non-core fixed income: 4.80%.

Long-Duration Fixed Income

Modeled: US Long-Term Government/Credit Fixed Income
Compound Return: 3.42%
Arithmetic Average Return: 4.00%
Risk: 10.50%

Our model assumes 50% each in (i) 10- and 20-Year US Treasury Bonds and (ii) long-duration US investment-grade corporate bonds. While the composition of some long-duration fixed income indexes differs slightly from this approach, we believe that most differences will cancel each other out.

Treasury Component

For the Treasury component, we use our basic model to average the expected returns for 10- and 20-year Treasury Bonds (outlined above) to approximate the return of a 15-year Treasury Bond. This average expected return for the Treasury component is 2.30%.

Spread Component

We add a spread component consisting of long-term US investment-grade corporate bonds:

Proportion in Corporates:	50%
Spread Duration:	12.57 years
Current Spread:	2.15%
Long-Term Average Spread:	1.74%
Cumulative Spread Change (10 Yrs):	-0.20% (halfway from current to long-term average)
Expected Default Rate:	0.15%
Expected Default Recovery Rate:	44%

Long Corporates -- Spread Effect (over Treasurys)

Year	0	1	2	3	4	5	6	7	8	9	10	Cumulative	Annualized
Starting Spread	2.15%	2.13%	2.11%	2.09%	2.07%	2.05%	2.03%	2.01%	1.99%	1.97%	1.95%		
Duration	12.57	12.57	12.57	12.57	12.57	12.57	12.57	12.57	12.57	12.57	12.57		
Parallel Yield Change		-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.20%	
12-month return		2.41%	2.39%	2.37%	2.34%	2.32%	2.30%	2.28%	2.26%	2.24%	2.22%		
Compound Factor		102.41%	102.39%	102.37%	102.34%	102.32%	102.30%	102.28%	102.26%	102.24%	102.22%	25.71%	2.31%
												Proportion	50.00%
												Spread Effect (Total)	1.16%

In summary:

Treasury Return:	2.30% (average of 10- and 20-year Treasurys)
Spread Effect (half of spread):	+1.16% (50% proportion)
Default Effect (half):	-0.04% (50% proportion)
Return Assumption	**3.42%**

Short-Term US Treasury Inflation Protected Securities (TIPS)

Modeled: Short-Term US TIPS
Compound Return: 2.23%
Arithmetic Average Return: 2.30%
Risk: 3.50%

We employ a similar process to our TIPS calculation for our Short-Term TIPS assumption, although we model a proxy for the BloombergBarclays US 0-5 Year TIPS Index, which currently has a maturity of 2.5 years.

A portfolio of 85% 2-year Treasury Bonds and 15% 5-year Treasury bonds results in a hypothetical Treasury bond with 2.5-year maturity. Assuming our inflation expectation of 1.71% per year for the prospective 10-year period, the expected Short-Term TIPS return is simply a weighted average of our return expectations for the nominal 2-year and 5-year Treasury bonds.

Applying these weights to our return projections for those bonds results in a 10-year Short-Term TIPS return assumption of 2.23%:

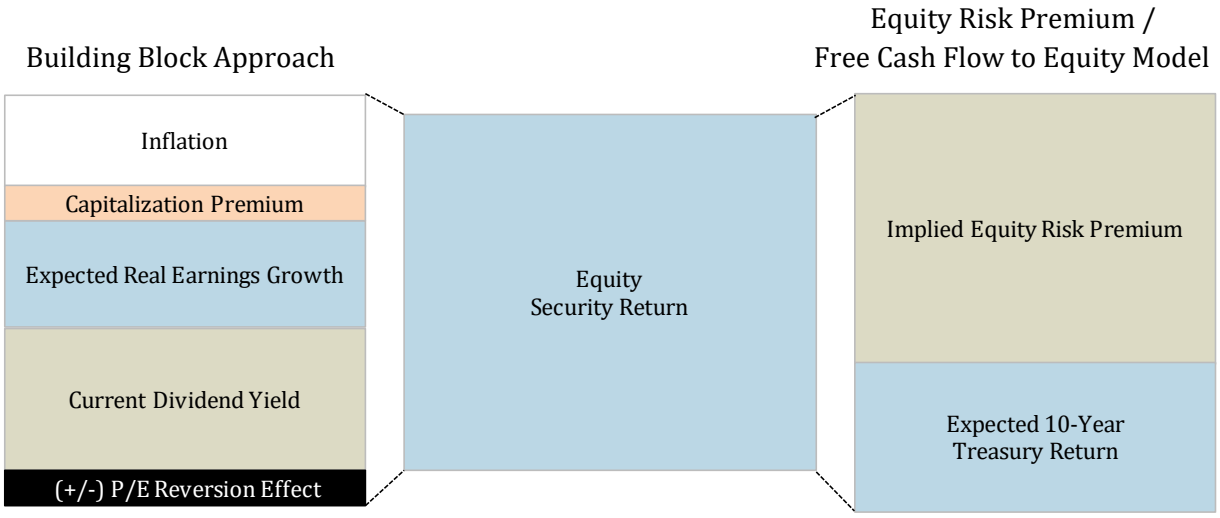
(85% x 2.14%) + (15% x 2.70%) = **2.23%.**

EQUITY

To derive our equity return assumptions, we use two methodologies:

(i) a building-block approach using the so-called Shiller price-to-earnings (P/E) measure; and

(ii) an equity risk premium estimate that averages the current implied equity risk premium based on a free cash flow to equity model and the historical average equity risk premium.



Where our building blocks call for a P/E measure, we assume that this current valuation metric will revert halfway to its long-term mean over the prospective ten-year period. Our approach employs "Shiller earnings," which represent a ten-year average, adjusted for inflation. We believe that this approach appropriately smoothes the impact of year-to-year earnings volatility, and research shows that of all the varied ways to calculate a P/E ratio, the Shiller P/E measure has historically shown the highest predictive power over future 10-year returns.[3]

Our building block approach is consistent across equity categories:

Assumed (Expected) US Inflation
+ Current Dividend Yield
+ Expected Real Earnings Growth
+ Reversion effect of P/E (halfway to long-term mean, over 10 years)

[3] Vanguard. Forecasting stock returns: What signals matter, and what do they say now? https://personal.vanguard.com/pdf/s338.pdf

US Equity

Modeled: US Equities, All Capitalizations
Compound Return: 5.28%
Arithmetic Average Return: 6.90%
Risk: 19.00%

We create a return assumption for the entire US market by calculating return estimates for large- and small-cap equity and applying those returns to the current market capitalization weights. The current weights, 92% large, and 8% small[4], yield a US Equity assumption of 5.28% in compound terms:

(92% x 5.28%) + (8% x 5.28%) = **5.28%.**

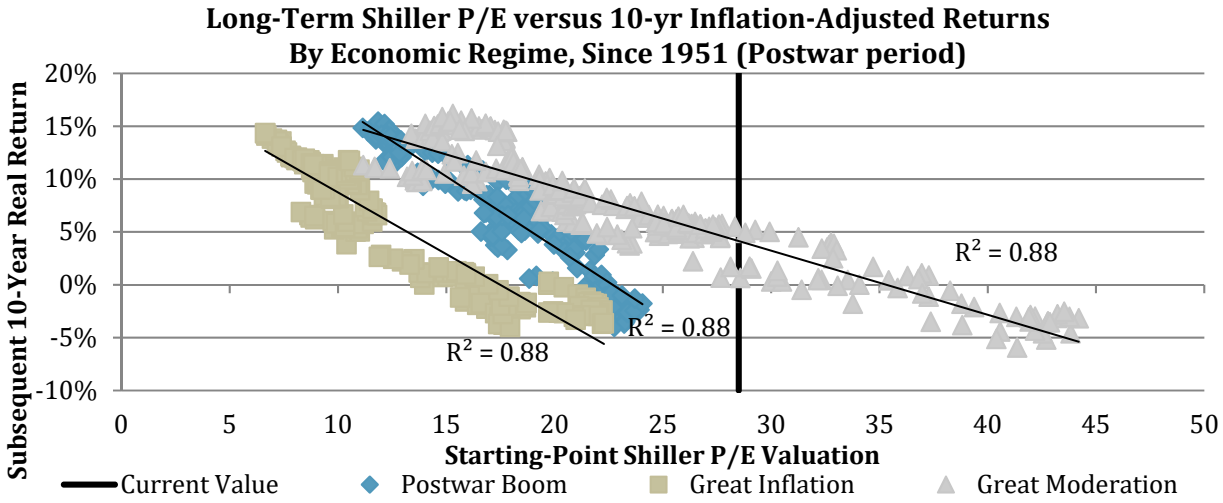
US Large-Cap Equity

Our return assumption for the US large-cap equity portion of the US Equity assumption is the average of two separate approaches:

(i) a valuation-based building-block approach and;
(ii) a free cash flow to equity model.

Building Block Approach

We find the Shiller P/E metric to be the most useful of various valuation metrics from the perspective of utility in forecasting returns. The following chart depicts the Shiller P/E metric for the US market, since 1951 (the post-WWII period). The Shiller P/E at a given point in time is depicted on the horizontal axis, and the subsequent 10-year inflation-adjusted return is depicted on the vertical axis. We have decomposed the data array into three economic regimes – the post-war boom (in blue; 1951-1965); the great inflationary period (in tan; 1966-1984); and the great moderation (in grey; 1985-2018). Examining the data this way yields useful insights and, importantly, high predictive power for the Shiller P/E metric over subsequent real return. The S&P 500's current position on the chart is indicated by the bold vertical line.



[4] FTSE/Russell.

For the valuation-based building block component of the US large-cap return, we create our building blocks from the S&P 500 Index:

1.71% Inflation
2.09% Current Dividend Yield
1.54% Long-Term Compound Average Real Earnings Growth (Since 1871)

For the valuation building block, we measure expected P/E reversion halfway to long-term mean:

	Shiller P/E	
Current	28.50	
Long-Term Average	16.92	
Annual Reversion Effect	-2.54%	(halfway to long-term average)

The building blocks approach results in an expected compound return for US large-cap equity of 2.80%. This approach represents half of our calculation for US large-cap equity.

Equity Risk Premium / Discounted Free Cash Flow Model

For the implied equity risk premium, we reference and modify a discounted free cash flow model created by Professor Aswath Damodaran of the Stern School of Business[5] that uses a free cash flow to equity approach to account for dividends as well as stock buybacks.

Our modified free-cash-flow-to-equity model employs several input variables:

Beginning (current) S&P 500 level =	2,506.85
Base year free cash flow to equity, S&P 500 =	$136.65[6]
Expected S&P 500 earnings growth over next 5 years =	3.57%[7]
Expected S&P 500 earnings growth past year 5=	2.44%[8]

We apply a standard discounted cash flow methodology to these variables and solve for the rate of growth that makes the discounted forecasted value of the S&P 500 identical to today's value.

$$2{,}506.85 = \frac{136.65(1.0357)^1}{(1+r)^1} + \frac{136.65(1.0357)^2}{(1+r)^2} + \frac{136.65(1.0357)^3}{(1+r)^3} + \frac{136.65(1.0357)^4}{(1+r)^4} + \frac{136.65(1.0357)^5}{(1+r)^5} + \frac{136.65(1.0357)^5\,(1.0244)}{(r-0.0244)(1+r)^5}$$

Solving for *r* yields the expected nominal return for the S&P 500 over the next 10 years, under these assumptions. That rate of return is 8.31%. Subtracting our assumed 10-Year Treasury return of 2.44% results in an expected equity risk premium of 5.87%.

[5] http://pages.stern.nyu.edu/~adamodar/
[6] 2018 S&P 500 Dividends = $52.25 + buybacks = $84.40.
[7] I/B/E/S analyst consensus earnings growth over the next year is 4.12%. Historically, the I/B/E/S consensus analyst forecast has overstated subsequent actual earnings growth by 15.6%. We reduce our assumption for earnings growth by 13.5% (1-(1/1.156)) accordingly.
[8] Our forecasted return for the 10-year Treasury Bond, as a proxy for the ten-year risk-free rate.

This implied equity risk premium is higher than what history has delivered. To moderate this, we average the current implied forward-looking equity risk premium (5.87%) and the long-term historical geometric average realized equity risk premium (4.77%) to derive an equity risk premium estimate of 5.32% for US large-cap equity. Substituting this assumed equity risk premium into the model results in a return estimate of 7.76%.

Combining the Two Approaches

Averaging the expected returns generated by the building-blocks approach and the discounted free cash flow model yields an expected compound return of 5.28% for US large-cap equity.

US-Small Cap Equity

Our return assumption for the US small-cap equity portion of the US Equity assumption uses a similar building blocks approach as our approach for US large-cap. Because data is much more limited for small-cap equities than for large-cap equities, we evaluate small-cap equities relative to large-cap equities rather than relative to their own history. For US small-cap equity, we compare the build-up method for the Russell 2000 Index and S&P 500 Index over the longest common time period for the two indexes (1979-2018). The build-up method is only half of our US large-cap equity assumed return, so we divide the premium in half and add or subtract it from our final US large-cap equity return.

While our assumption models the full universe of small-cap stocks, the data we use excludes companies with negative earnings. Our analysis has shown that, as compared to using the data from the full universe of small-cap stocks, using the dataset that excludes negative earners has yielded higher predictive power over future returns of the full index, which includes the negative earners.

Our building blocks for US small-cap equity are as follows:

1.72%	Inflation
1.59%	Current Dividend Yield
2.49%	Long-Term Real Earnings Growth

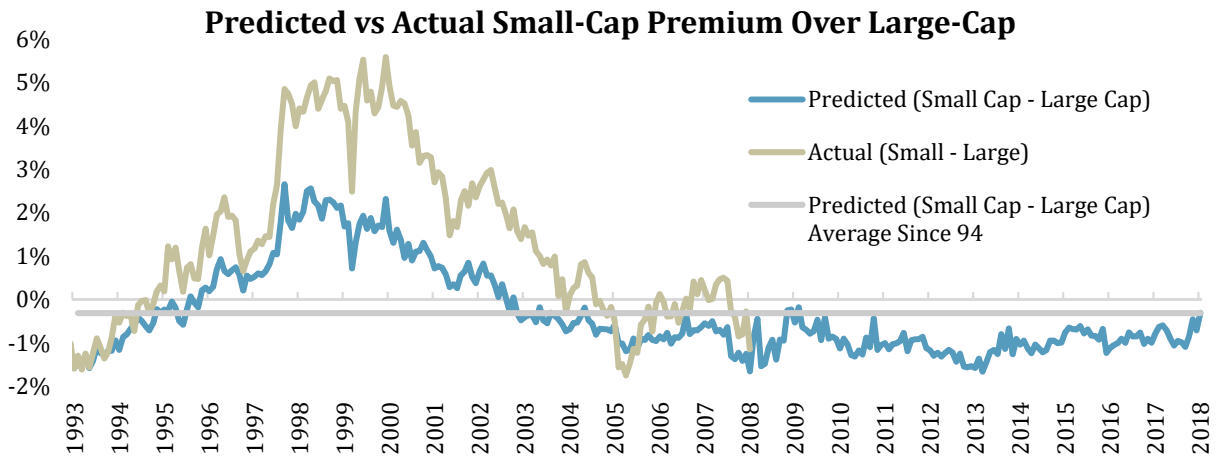
We measure expected P/E reversion halfway to long-term mean:

	Shiller P/E	
Current	25.50	
Long-Term Average	21.94	
Annual Reversion Effect	-0.75%	(halfway to long-term average)

The build-up approach results in an expected compound return for US small-cap equity of 3.34%, a negative premium of 0.31% relative to US large-cap equity using a similar methodology over the longest common time period (1988-2018) for which we have reliable data.

US Large-Cap Build-up	3.65%
US Small-Cap Build-up	3.34%
Small-Cap Premium	-0.31%

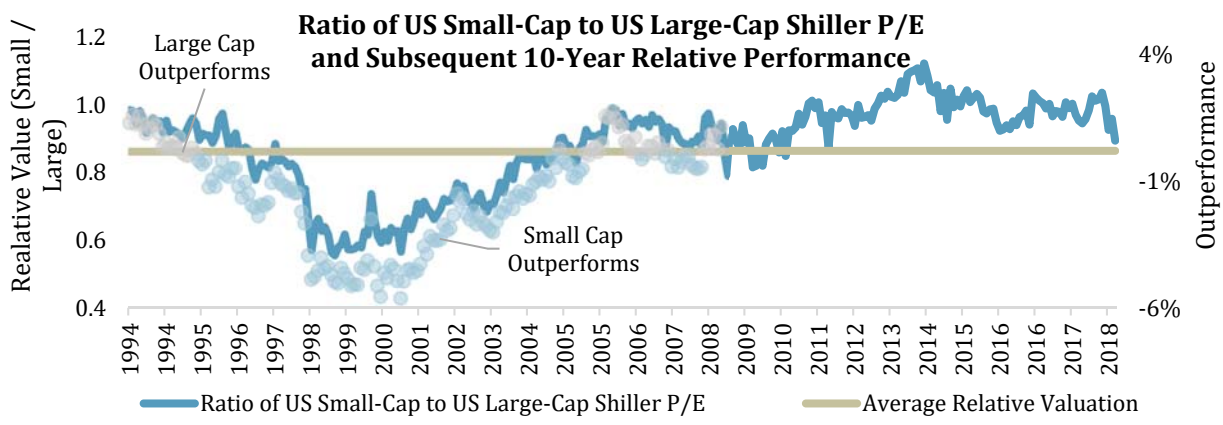
Since 1994, this approach has systematically understated subsequent 10-year returns to small-cap stocks, by 0.31% per year:



To account for this bias, we take the difference between the model's current predicted premium (-0.31%) and the long-term average predicted premium (-0.31%) and apply only the differential. Then, we add only half of that differential to our assumption for US large-cap equities, because the building-blocks calculation itself represented only half of our calculation of US large-cap equity return.

US Large-Cap Assumed Return:	5.28%	
Small-Cap Premium:	0.00%	(half of the calculated premium)
Return Assumption:	5.28%	

Our modeling results in the same expected return for small-cap stocks and large-cap stocks. History has shown that small-cap stocks have outperformed their large-cap counterparts only when beginning at a relative valuation discount, which is not the case today:



Non-US Equity

Modeled: Non-US Equities, All Regions & Capitalizations
Compound Return: 6.80%
Arithmetic Average Return: 9.30%
Risk: 23.75%

Our return assumption for Non-US Equity is intended to model the entire non-US equity market. It assumes the current weighting of large-cap and small-cap markets equities in the international equity market – 87% large-cap and 13% small-cap[9]. These weights are applied to underlying non-US large-cap equity and non-US small-cap equity assumptions. This weighting yields a compound return assumption of 6.80%:

(87% x 6.80%) + (13% x 6.80%) = **6.80%.**

Non-US Large Cap Equity

We build separate assumptions for developed and emerging non-US markets, and then weigh them according to current market weights to construct our non-US large-cap equity assumption, which is intended to model equities of both developed and emerging markets.

Over the longest common period for which we have both US (S&P 500 Index) and non-US developed markets (MSCI EAFE Index – "EAFE") earnings data (since 1993), non-US developed markets have grown at only 51% times the rate of US large-capitalization stocks, in real terms. We apply this proportion to our assumed long-term earnings growth rate for US large-capitalization stocks (1.54%) to yield an assumed non-US developed markets earnings growth rate of 0.79%.

Over the longest common period for which we have both US (S&P 500 Index) and emerging (MSCI EM Index – "EM") markets earnings (1995), emerging market earnings have grown at 2.76 times the rate of US large-capitalization stocks. Going forward, we do not expect this extraordinary growth rate to continue indefinitely and have cut the long-term ratio in half to 1.38. We apply this proportion to our assumed long-term earnings growth rate for US large-capitalization stocks to yield an assumed emerging markets earnings growth rate of 2.12%.

For developed and emerging markets, our assumed building blocks are as follows:

	EAFE	EM
Inflation	1.71%	1.71%
Current Dividend Yield	3.68%	2.91%
Adjusted Compound Average Real Earnings Growth	0.79%	2.12%

We measure expected Shiller P/E reversion halfway to long-term mean:

[9] MSCI, Morningstar Direct

	EAFE	EM	
Current	15.4	12.2	
Long-Term Average	13.2[10]	13.2[11]	
Annual Reversion Effect	-0.76%	0.34%	(halfway to long-term average)

This approach yields an expected compound return for developed-markets Non-US Large-Capitalization Equities of 5.42%, a premium of 2.62% relative to our calculation of US Large-Cap Equity using similar build-up methodology.

	EAFE	EM
US Large-Cap Build-up	2.80%	2.80%
Non-US Build-up	5.42%	7.08%
Non-US Premium	+2.62%	+4.28%

Adding half of this premium to our assumption for US large-cap equity

	EAFE	EM
US Large-Cap Assumed Return	5.28%	5.28%
Non-US Premium	+1.31%	+2.14%
Return Assumption	6.59%	7.42%

Developed markets currently comprise 75%, and emerging markets 25%, of the non-US total equity market capitalization. Applying those weights to our developed and emerging markets assumptions yields a non-US large-capitalization compound return assumption of 6.80%.

Non-US Small Cap Equity

Due to lack of data availability in the non-us small-cap equity space, we assume the same small-cap premium for non-US small cap-equity as our assumption for US small-cap equity. We calculated a US small-cap equity premium of 0.0%, which yields a compound assumption of 6.80%.

Global Equity

Modeled: World Equities, All Capitalizations
Compound Return: 6.01%
Arithmetic Average Return: 8.10%
Risk: 21.50%

We create a return assumption for the global equity market by applying our US and Non-US Equity return estimates to the total world market capitalization weights. The current weights, 52% US, and 48% Non-US, yielding a Global Equity assumption of 6.01% in compound terms:

$$(52\% \times 5.28\%) + (48\% \times 6.80\%) = \mathbf{6.01\%}$$

[10] Over the longest common period for which we have both US (S&P 500) and Developed Non-US (MSCI EAFE) earnings series (since 1995), EAFE has traded at an average valuation level approximately 78% of the level of the S&P 500. We apply this fraction to our assumption for the long-term P/E of US large-capitalization stocks to arrive at our assumed long-term average valuation level to which we expect non-US large-capitalization stocks to revert.

[11] Limited data ability in emerging markets limits are ability to calculate a meaningful Long-Term Average Shiller P/E. As such, we set the Long-Term Average Emerging Market Shiller P/E equal to our Developed Non-US Long-Term Average.

ALTERNATIVES

Alternative assets share a common element of not easily being modeled with public-market index proxies. As well, we are more reluctant to rely on their long-term history, given growth in assets allocated to such strategies over the last several decades and the dynamic nature of strategies employed. Instead, we employ a build-up approach to identify and model their sources of return.

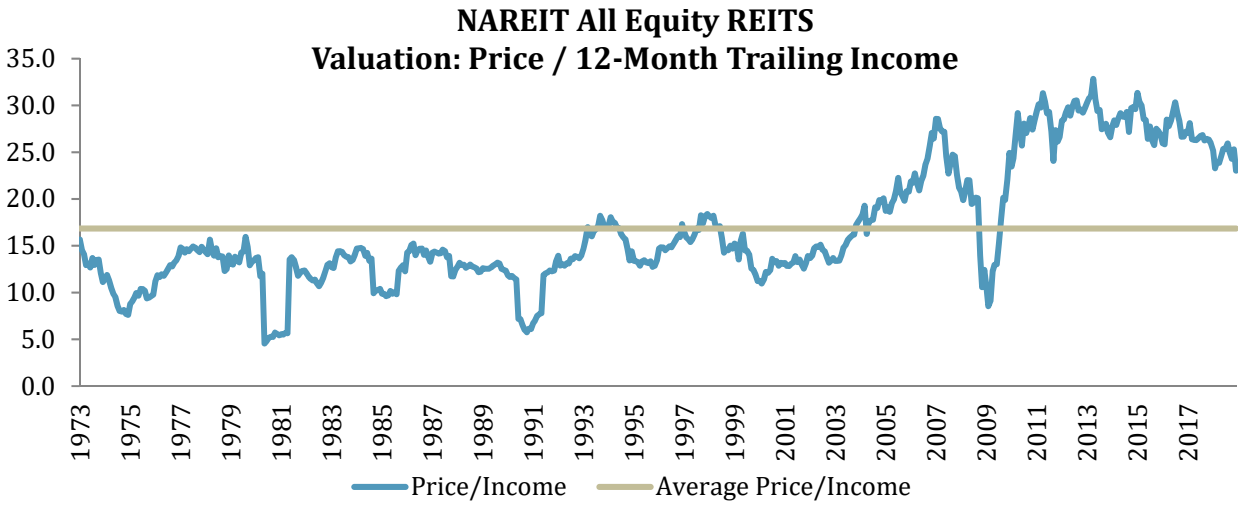
Real Estate

Modeled: Public (US Equity REITs) and Open-Ended Private Core Real Estate
Compound Return: 4.82%
Arithmetic Average Return: 6.90%
Risk: 21.25%

Our expected return reflects going-in cap rates for public equity and core private real estate.

For public equity REITs, we calculate the current cap rate, defined as income divided by price, of the FTSE NAREIT All Equity REITS Index: 4.34%.

The following chart depicts the inverse of the cap rate for the equity REIT benchmark: its historical price-to-income ratio. The present low cap rate is explained by high valuations relative to the index's own history.



Our cap rate assumption for core private real estate is based on the Urban Land Institute consensus estimate of the NCREIF capitalization rate as of December 31, 2018: 5.30% in compound terms.[12] This cap rate reflects current income return on an unlevered basis and excludes capital appreciation.

Averaging these two cap rates yields a return assumption of 4.82%.

[12] Urban Land Institute. http://uli.org/research/centers-initiatives/center-for-capital-markets/barometers-forecast-and-data/uli-real-estate-consensus-forecast/

We note that the primary driver of return for core real estate over the long term has been income, not appreciation. For equity REITS, in real terms since 1973, historical price appreciation has averaged 0.10% per year, and income has averaged 3.21% per year.

Diversified Inflation-Related

Modeled: Diversified portfolio containing 1/3 each: Real Estate, Commodities, and US TIPS
Compound Return: 3.89%
Arithmetic Average Return: 4.90%
Risk: 14.50%

We assume a diversified portfolio containing 1/3 each in US TIPS, Real Estate, and Commodities.

The US TIPS component is the expected return for US TIPS, which we model using the same methodology as our Short-Term TIPS assumption outlined above, except for the entire US TIPS market: 2.54%, in compound terms.

The Real Estate component is our Real Estate Assumption: 4.82% in compound terms.

For the Commodities component, we build a model assuming that commodity return can be decomposed into three sources: collateral reinvestment yield, commodity spot return, and roll yield.

We assume 0% for roll yield, knowing that it has been positive and negative over various historical periods, as the buying and selling balance between commodity investors and commodity consumers has shifted. Over the last decade, roll yield has been negative.

For spot return, we calculate a series of the last 10 years of real prices for the Bloomberg Commodity Index and assume that the current real price of the index will revert halfway to its 10-year average, in even increments over the next 10 years. The current real spot price for the Bloomberg Commodity Index is 85.9, and its 10-year average real price is 139.2. Reverting halfway to this average real price implies a compound real spot return of 2.47% per year.

In summary, for the Commodities component:

Collateral:	2.00% (our assumed nominal return for Cash Equivalents)
Spot return:	2.29% (halfway to long-term average)
Roll yield:	0.00%
Commodity return:	**4.30%**

For the Diversified Inflation-Related assumption, we assume a compound return of:

1/3 (TIPS) + 1/3 (Real Estate) + 1/3 (Commodities)
= 1/3 (2.54%) + 1/3 (4.82%) + 1/3 (4.30%) = **3.89%**

Marketable Alternatives

Modeled: Hedge Funds of Funds, Global GTAA, & Daily-Valued Alternative Strategies
Compound Return: 4.80%
Arithmetic Average Return: 5.40%
Risk: 11.50%

We assume a diversified portfolio that will tend to approximate the following market exposures over time:

20% US Equity
20% Non-US Equity
30% Intermediate Fixed Income
30% Non-Core Fixed Income

Weighting those assumptions accordingly results in a compound return assumption of 4.81%.

This approach does not explicitly reflect the use of leverage in marketable alternatives strategies. Alternatives vehicles that employ leverage can earn higher returns, but due to the mechanics of performance-based fee schedules, also subtract higher fees from those returns. Given that our assumption set is intended to be passive in nature and not reflect active management, for hedge funds, we are assuming an industry average hedge fund of funds.

Non-Marketable Alternatives

Modeled: Venture Capital, Private Equity, & Distressed Credit, in Lockup Vehicles
Compound Return: 8.04%
Arithmetic Average Return: 11.70%
Risk: 29.25%

We assume a diversified portfolio that will tend to approximate the following market exposures over time, plus a premium for illiquidity:

50% US Equity
50% Non-Core Fixed Income
+ 3.00% illiquidity/leverage premium

Weighting those assumptions accordingly results in a compound return assumption of 8.04%.

Given that our assumption set is intended to be passive in nature and not reflect active management, we are assuming an industry-average active manager or collection of active managers.

Managed Futures

Modeled: Managed Futures Strategies Targeting 10% Volatility
Compound Return: 2.87%
Arithmetic Average Return: 3.30%
Risk: 10.00%

Using the SG Trend Index, an index of actual, "live" managed futures strategies, we calculate the excess return to cash that managed futures strategies have returned since January 1, 2000 (the index's inception date). We scale that premium based on a targeted 10% volatility level and arrive at a historical annualized arithmetic average premium over cash of 1.74%. Recognizing that this premium benefited from a very favorable start date for the index (the beginning of a protracted, trending bear market, followed by a protracted, trending bull market until 2007), we cut this historical premium in half for forward-looking purposes.

We then add back our Cash Equivalent return assumption of 2.00% to come up with a 2.87% return assumption for Managed Futures.

2.00% + 0.87% = **3.30%**

RISK

Our risk assumptions are mostly derived from history, but we have enhanced historical metrics with qualitative overlays in several asset categories.

For each asset category, we began by examining the following historical annual returns:

Inflation	US CPI
Cash Equivalents	91-Day T-Bills
Low-Duration Fixed Income	BloombergBarclays 1-3 Year Government/Credit
Intermediate Fixed Income	BloombergBarclays US Aggregate
Non-Core Fixed Income	50% ML High Yield Master II, 50% JP Morgan EMBI back to 1994; 100% ML High Yield Master II before 1994
Long-Duration Fixed Income	BloombergBarclays Long Government/Credit
Short-Term TIPS	BloombergBarclays US 0-5 Year TIPS
Global Equity	MSCI ACWI IMI
US Equity	Russell 3000 back to 1979; S&P 500 before 1979
Non-US Equity	MSCI ACWI ex US IMI back to 1994; MSCI EAFE before 1994
Real Estate	FTSE NAREIT, NCREIF Property, and NCREIF ODCE (separately)
Diversified Inflation-Related	1/3 each: FTSE NAREIT, BloombergBarclays US TIPS, Bloomberg Commodity
Marketable Alternatives	HFRI Fund of Funds; and 30% our US Equity series, 30% our Non-US Equity series, 20% our Intermediate Fixed Income series, and 20% our Non-Core Fixed Income series (separately)
Non-Marketable Alternatives	Average of 2x our US Equity series and 2x our Non-Core Fixed Income series

In each case, we calculated the longest-term standard deviation of returns possible for the category. Then, we calculated the standard deviation of annual returns over the last ten years. The average of these two figures represents our base-case risk assumption.

Next, we examined the worst annual return for each proxy index, going back as far as possible into history. We assumed this return as the worst-case scenario. In some cases, the normal return distribution implied by our return and risk assumptions suggested that the actual worst-case scenario had less than a 1% probability (1 in 100 years) of occurring. Because we are uncomfortable assuming that observed reality – what has actually happened in the real world – is extremely unlikely, we adjusted our risk assumption upward until the actual, real-world worst-case scenario had at least a 1% probability of occurring under our assumed normal return distribution. To perform this probability analysis for private real estate, we examined rolling two-year periods to account for the fact that declines, as measured by appraisals and illiquidity, occur more slowly than in public markets.

Finally, based on this analysis and our qualitative assessment of the quality and longevity of our return data, we made several qualitative adjustments, where noted. The results of this risk analysis follow.

The following table depicts actual standard deviations of annual return, measured in the long term (as far back as history will allow), for the last ten years, and the average of those two figures.

Adding or subtracting our qualitative adjustment results in the Risk Assumption at the far right.

	Standard Deviation of Returns				
	Long Term	10 Years	Average	Qualitative Adjustment	Risk Assumption (Rounded)
Cash Equivalents	0.59%	3.29%	1.94%	-0.75%	1.25%
Low-Duration Fixed Income	1.04%	4.61%	2.83%		2.75%
Intermediate Fixed Income	3.21%	6.82%	5.01%		5.00%
Non-Core Fixed Income	13.23%	12.58%	12.90%		13.00%
Long-Duration Fixed Income	10.18%	10.98%	10.58%		10.50%
Short-Term TIPS	3.54%	3.68%	3.61%		3.50%
Global Equity	15.16%	18.32%	16.74%	4.75%	21.50%
US Equity	12.36%	17.10%	14.73%	4.25%	19.00%
Non-US Equity	18.72%	22.71%	20.71%	3.00%	23.75%
Real Estate	11.72%	20.08%	15.90%	5.25%	21.25%
Diversified Inflation-Related	10.11%	12.29%	11.20%	3.25%	14.50%
Marketable Alternatives	5.57%	9.80%	7.68%	3.88%	11.50%
Non-Marketable Alternatives	22.26%	26.71%	24.48%	4.75%	29.25%
Managed Futures	9.24%	10.04%	9.64%	0.36%	10.00%

The following table examines the probability of the actual experienced worst case occurring under our assumed normal distribution of returns, as implied by our expected return and standard deviation of returns, after accounting for qualitative adjustments to risk.

We measure the actual worst-case scenario in "sigmas," or standard deviations from our assumed mean return. Measuring this way, we ask, "How likely was the actual experienced worst case, according to the distribution parameters we have assumed?" We have qualitatively adjusted several asset classes to ensure that the probability of the actually experienced worst case is always greater than 1%, meaning we assume that the experienced worst case has at least a one-in-a-hundred-year chance of happening under our assumptions. We have made similar adjustments for asset classes with limited return history, to ensure that our assumptions imply that the actual observed worst case was at least a 1.5% probability (roughly, one-in-60-year chance of happening). When making qualitative adjustments to meet these criteria, we adjust the numbers only enough to meet these criteria.

	Worst Year		Actual Worst Case, in Sigmas from Assumption	Implied Probability of Actual Worst Case Occurring
Cash Equivalents	0.02%	2014	1.66	4.8%
Low-Duration Fixed Income	0.55%	1994	0.73	23.4%
Intermediate Fixed Income	-2.92%	1994	1.24	10.8%
Non-Core Fixed Income	-18.86%	2008	1.90	2.9%
Long-Duration Fixed Income	-8.83%	2013	1.21	11.3%
Short-Term TIPS	-2.03%	2008	1.20	11.6%
Global Equity	-42.01%	2008	2.33	1.0%
US Equity	-37.31%	2008	2.33	1.0%
Non-US Equity	-45.99%	2008	2.33	1.0%
Real Estate	-42.24%	1974	2.32	1.0%
Diversified Inflation-Related	-28.61%	2008	2.32	1.0%
Marketable Alternatives	-21.37%	2008	2.31	1.0%
Non-Marketable Alternatives	-56.17%	2008	2.32	1.0%
Managed Futures	-8.11%	2018	1.14	12.7%
Alternate benchmarks for Real Estate and Non-Marketable Alternatives:				
NCREIF Property (2 Years)	-22.23%	2008-9	1.38	8.4%
NCREIF ODCE (2 Years)	-36.79%	2008-9	2.07	1.9%
Marketable Alternatives (build-up)	-20.75%	2008	2.26	1.2%

Our qualitative adjustments to Risk were as follows:

Cash Equivalents (-0.75%)

While the long-term standard deviation of returns to cash has been greater than 3%, that volatility was experienced at higher levels of cash return. We believe it is unlikely for the distribution of returns to cash equivalents to be as wide as historically observed, given its current low level of return. We qualitatively adjust the risk to cash equivalents downward by 75 basis points.

Global Equity (+4.75%), US Equity (+4.25%), Non-US Equity (+3.00%), Real Estate (+5.25%), Diversified Inflation-Related (+3.25%), Non-Marketable Alternatives (+4.75%)

These categories were adjusted upward to make their actual worst-case experience greater than a 2% probability of occurring under the assumed distribution.

Marketable Alternatives (+3.88%)

This adjustment averages our two approaches for modeling the history for this asset category. The upward adjustment makes the risk assumption halfway between the historically measured volatility of each approach (HFRI Fund of Funds Index, and build-up approach). Then, we add a premium of 2.75% to make the actual worst-case experience greater than a 2% probability of occurring under our assumed distribution.

Managed Futures (+0.36%)

This adjustment adds or subtracts to achieve a 10.00% target volatility target.

CORRELATION COEFFICIENTS

Our forward-looking correlation assumptions are mostly derived from long-term history but emphasize the recent past. Our process first identifies a reasonable proxy for each asset category, typically an index that represents the asset class. For several asset classes, we have used our judgment to construct a proxy return stream for the asset class that either has a longer history for evaluation, or to construct a marketable proxy for a non-marketable asset.

Our correlation assumptions are based on these return streams:

Inflation	US CPI
Cash Equivalents	91-Day T-Bills
Low-Duration Fixed Income	BloombergBarclays 1-3 Year Government/Credit
Intermediate Fixed Income	BloombergBarclays US Aggregate
Non-Core Fixed Income	50% ML High Yield Master II, 50% JP Morgan EMBI back to 1994; 100% ML High Yield Master II before 1994
Long-Duration Fixed Income	BloombergBarclays Long Government/Credit
Short-Term TIPS	BloombergBarclays US 0-5 Year TIPS
Global Equity	MSCI ACWI IMI back to 1994; MSCI ACWI before 1994
US Equity	Russell 3000 back to 1979; S&P 500 before 1979
Non-US Equity	MSCI ACWI ex US IMI back to 1994; MSCI EAFE before 1994
Real Estate	FTSE NAREIT, NCREIF, and NCREIF ODCE
Marketable Alternatives	HFRI Fund of Funds
Diversified Inflation-Related	1/3 each: FTSE NAREIT, BloombergBarclays US TIPS, Bloomberg Commodity
Non-Marketable Alternatives	Average of 2x the Non-Core Fixed Income series and 2x the US Equity series
Managed Futures	SG Trend Index

Using those streams, we constructed a correlation matrix that takes the simple average of four other correlation matrices – constructed with 3 years, 5 years, and 10 years of data, and one with as much data as possible going back to each series' inception. Averaging these four measures gives acknowledgement to the long-term history while emphasizing the recent past, when correlations have been higher than long-term history has delivered. This approach is therefore conservative in assuming the diversification benefit that will appear from correlation in our modeling.

We qualitatively adjusted only the real estate correlation coefficients, because of their illiquidity. Our assumed coefficients for real estate average the calculated coefficients for public REITs and private real estate.

Finally, we ran our calculated correlation coefficients through the Ibbotson statistical correlation matrix tester, which made slight adjustments to ensure that the matrix is positive semi-definite.

Our assumed return correlation matrix follows:

Sellwood Consulting 2019 Correlation Coefficient Assumptions

	Inflation	Cash Equivalents	Low-Duration Fixed Income	Intermediate Fixed Income	Non-Core Fixed Income	Long-Duration Fixed Income	Short-Term TIPS	Global Equity	US Equity	Non-US Equity	Real Estate	Diversified Inflation-Related	Marketable Alternatives	Non-Marketable Alternatives	Managed Futures
Inflation	**1.00**	-0.03	-0.06	-0.14	0.18	-0.17	0.23	0.11	0.09	0.11	-0.02	0.17	0.14	0.13	-0.24
Cash Equivalents	-0.03	**1.00**	0.19	0.00	-0.16	-0.06	0.00	-0.11	-0.10	-0.11	-0.04	-0.04	-0.11	-0.13	-0.03
Low-Duration Fixed Income	-0.06	0.19	**1.00**	0.82	0.26	0.62	0.64	-0.12	-0.19	-0.05	0.21	0.26	-0.14	-0.05	0.22
Intermediate Fixed Income	-0.14	0.00	0.82	**1.00**	0.37	0.93	0.54	-0.04	-0.11	0.03	0.34	0.33	-0.06	0.05	0.34
Non-Core Fixed Income	0.18	-0.16	0.26	0.37	**1.00**	0.38	0.44	0.69	0.57	0.74	0.52	0.65	0.55	0.78	0.06
Long-Duration Fixed Income	-0.17	-0.06	0.62	0.93	0.38	**1.00**	0.40	0.02	-0.04	0.08	0.38	0.33	0.00	0.11	0.37
Short-Term TIPS	0.23	0.00	0.64	0.54	0.44	0.40	**1.00**	0.16	0.08	0.22	0.29	0.53	0.12	0.21	0.17
Global Equity	0.11	-0.11	-0.12	-0.04	0.69	0.02	0.16	**1.00**	0.95	0.95	0.59	0.65	0.81	0.96	0.10
US Equity	0.09	-0.10	-0.19	-0.11	0.57	-0.04	0.08	0.95	**1.00**	0.81	0.62	0.62	0.75	0.96	0.11
Non-US Equity	0.11	-0.11	-0.05	0.03	0.74	0.08	0.22	0.95	0.81	**1.00**	0.50	0.62	0.79	0.88	0.08
Real Estate	-0.02	-0.04	0.21	0.34	0.52	0.38	0.29	0.59	0.62	0.50	**1.00**	0.83	0.36	0.66	0.20
Diversified Inflation-Related	0.17	-0.04	0.26	0.33	0.65	0.33	0.53	0.65	0.62	0.62	0.83	**1.00**	0.45	0.70	0.17
Marketable Alternatives	0.14	-0.11	-0.14	-0.06	0.55	0.00	0.12	0.81	0.75	0.79	0.36	0.45	**1.00**	0.76	0.27
Non-Marketable Alternatives	0.13	-0.13	-0.05	0.05	0.78	0.11	0.21	0.96	0.96	0.88	0.66	0.70	0.76	**1.00**	0.10
Managed Futures	-0.24	-0.03	0.22	0.34	0.06	0.37	0.17	0.10	0.11	0.08	0.20	0.17	0.27	0.10	**1.00**

APPENDIX: SOURCES

We are grateful to several data sources for our analysis. They were:

FRED, The St. Louis Fed Federal Reserve Economic Data

https://fred.stlouisfed.org/

FTSE NAREIT

https://www.reit.com/data-research/reit-indexes/ftse-nareit-us-real-estate-index-historical-values-returns
http://www.ftse.com/products/indices/russell-us

Professor Aswath Damodaran, Stern School of Business

http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/implpr.html
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2581517

Research Affiliates

http://www.researchaffiliates.com

Blackrock

http://www.blackrock.com

PIMCO

http://www.pimco.com

Standard & Poors

http://www.standardandpoors.com

Urban Land Institute

http://uli.org/research/centers-initiatives/center-for-capital-markets/barometers-forecast-and-data/uli-real-estate-consensus-forecast/

Morgan Stanley Capital International

http://www.msci.com/

Moodys

https://www.moodys.com/researchdocumentcontentpage.aspx?docid=PBC_151031
https://www.moodys.com/researchdocumentcontentpage.aspx?docid=PBC_154805

Professor Robert Shiller

http://www.econ.yale.edu/~shiller/data.htm

Vanguard

https://personal.vanguard.com/pdf/s338.pdf