The Invesco White Paper Series
July 2018

Capital market assumptions: Methodology update

Invesco Global Solutions Development and Implementation team

The Invesco Global Solutions Development and Implementation team (Invesco Global Solutions) is dedicated to designing outcome-oriented, multi-asset portfolios that meet the specific goals of investors. Capital market assumptions (CMAs) are key to this effort. CMAs provide the long-term estimates for the behavior of different asset classes. Specifically, for each of the asset classes which we estimate, we develop assumptions with regard to return, standard deviation of return (volatility) and correlation with other asset classes.

We have expanded the research platform to include additional time horizons and alternative asset classes. This document reviews the building block methodology which underpins the estimates for traditional asset classes (equities, fixed income, commodities) and introduces the recent CMA enhancements.

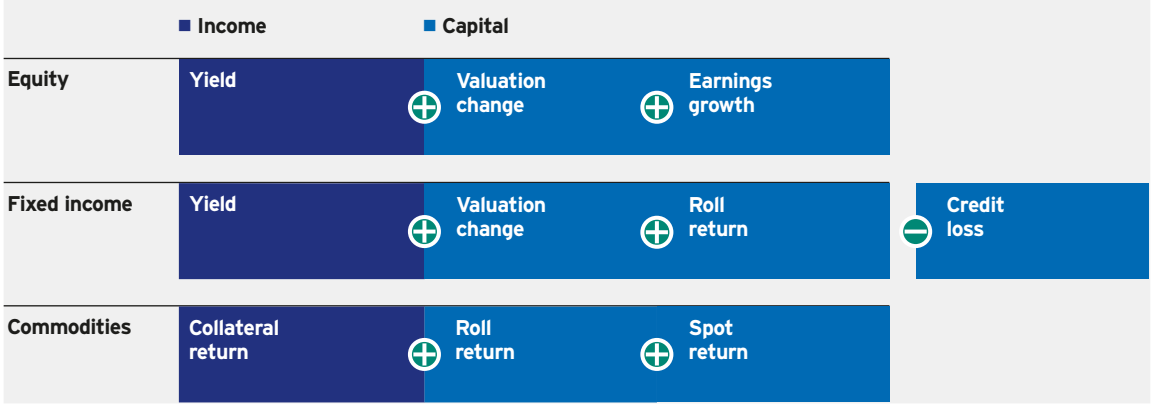
Estimating returns for traditional asset classes: A 'building block' approach

We employ a fundamentally based "building block" approach to estimating asset class returns. Building blocks represent a "bottom-up" approach in which the underlying drivers of asset class returns are used to form estimates (Figure 1).

First, these sources of return are identified by deconstructing returns into income and capital gain components. Next, estimates for each driver are formed using fundamental data such as yield, earnings growth and valuation, and combined to establish estimated returns.

By incorporating fundamental data, our approach allows for the relative attractiveness of asset classes to vary over time. Other approaches based on historical relative returns can provide relatively static risk-premiums through time in which certain asset classes contain constant return advantages. The following section will detail and present the estimates across various equity, fixed income and commodity asset classes.

Figure 1: Our building block approach to estimating returns



For illustrative purposes only.

Equities

The building block methodology reflects a total return approach to equities – accounting for both income and capital appreciation (i.e., the change in price over time). The building blocks therefore consist of estimates for yield (as a driver of income) and earnings growth and valuation change (as drivers of capital appreciation). We begin by looking at large-cap US equities:

1. Total yield

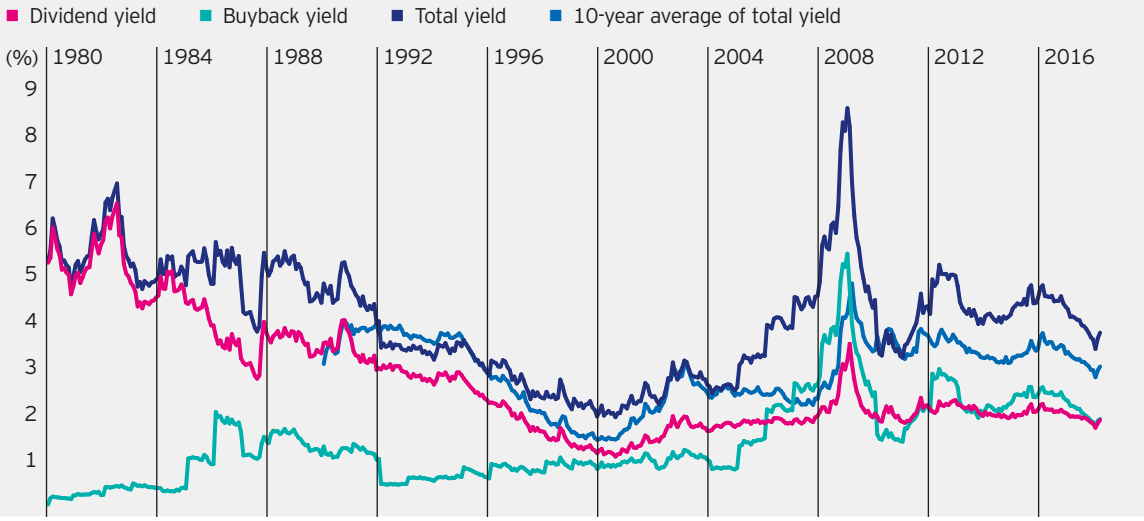
To reflect the impact of both dividend yield and buybacks, we base the estimate for total yield on the 10-year average total yield ratio.

Our approach to estimating yield is based on the 10-year average total yield ratio, which reflects the impact of both dividends paid and shares repurchased by the firm. Estimating the former is relatively straightforward, using current dividend yield – dividend per share divided by the price. Repurchased shares, also known as buybacks, involve a company purchasing some of its outstanding shares, thereby reducing the number available on the open market. We believe it's important to capture the impact of buybacks, particularly in the US, given the structural changes in the US tax code dating back to the 1990s. These changes resulted in a dramatic increase in share buybacks in place of dividends over the past 20 years, which benefited returns in the form of capital gains over income.

While buybacks themselves do not generate income, they represent an alternate way for firms to return capital to shareholders. Given the dramatic decrease in payout ratio due to buyback activity, we account for the effect of buybacks in our yield calculation to provide more meaningful return estimates. We estimate using the 10-year average of the total yield ratio to bridge the gap in terms of how capital is transferred (Figure 2).

Total yield = Dividend yield + Buyback yield

Figure 2: We apply the 10-year average real total payout to current real price to proxy total yield



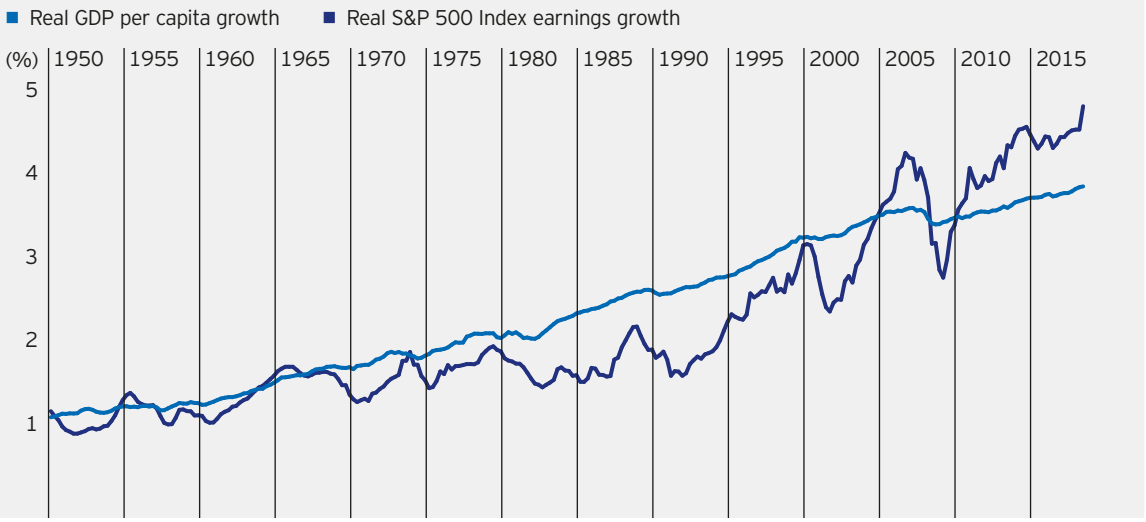
Source: FactSet Research Systems Inc. from January 1980 to December 2017. Based on S&P 500 Index.

2. Earnings growth

Real GDP per capita provides a stable signal over time to estimate earnings growth.

Growth of earnings per share is one of two significant drivers of capital appreciation in stock returns. Although past earnings could provide important insight into estimating the growth of future earnings, this approach is not well-suited due to the volatility in earnings levels that arises from market fluctuations and accounting charges. Given our longer-term outlook, we prefer a more stable estimate of earnings growth through time. Historically, there has been a strong relationship between real US gross domestic product (GDP) per capita growth and real S&P 500 Index earnings growth (Figure 3). Consequently, we use real GDP per capita – which also appears to have been a more stable signal over time – to estimate earnings growth in the model and apply future inflation expectations to that estimate to forecast nominal earnings growth. We use the long-term average because we believe that in the case of developed economies, they are less likely to deviate significantly from their "steady state" growth levels.

Figure 3: Over the long run, real S&P 500 Index earnings growth has tracked real US GDP per capita growth

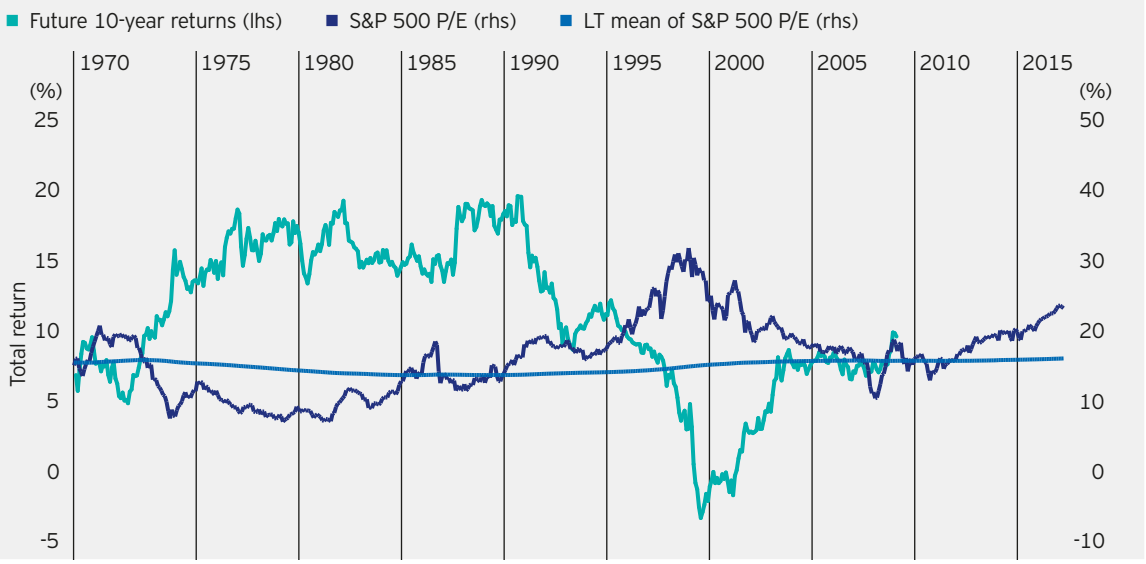


Sources: Robert Shiller Yale Data; FactSet Research Systems Inc. and St. Louis Federal Reserve from January 1950 to December 2017.

3. Valuation change

The second significant driver of capital appreciation in stock returns is the change in equity valuation – in terms of the ratio of price to earnings (P/E) – over time. In estimating P/E, we recognize existing research (Campbell and Shiller, 1998), which suggests that over time, the P/E ratio should revert back to its long-term mean. In other words, if equities are currently considered "cheap," which means that the current P/E is lower than the long-term average, there should be a catalyst to revert the P/E back to the mean (Figure 4).

Figure 4: The P/E ratio of the S&P 500 Index has tended to revert to the mean



Sources: Robert Shiller Yale Data; FactSet Research Systems Inc. from February 1970 to December 2017.

The first step to estimating valuation change is calculating a long-term mean for the P/E ratio.

Therefore, our first step in estimating the change in equity valuation is to calculate a long-term mean of the P/E ratio. Consistent with academic literature (Lee, Myers and Swaminathan, 1999), we found that the long-term mean of the P/E ratio is a function of prevailing macroeconomic conditions, including the interest rate environment and inflation, as these affect how much an investor would be willing to pay for equities. We model the mean of the long-term P/E ratio though regression analysis, using monthly data.

Estimating the long-term mean of the P/E ratio using regression analysis

A regression of monthly data (January 1970 – March 2018) yielded the following coefficients:

$$\widehat{P/E} = a + bRF + c\pi$$

RF = Risk free rate

π = Inflation

a = 20.81

b = -0.52

c = -0.59

To determine the long-term mean of the P/E ratio, we use the results of the regression analysis along with the figures for the risk-free rate and inflation, which as of March 31, 2018, totaled 2.84% and 2.26%, respectively:

P/E = 20.81 + (-0.52 x 2.84) + (-0.59 x 2.26) = 17.99

Looking at this empirical data, we found that P/E is negatively related to the risk-free rate and inflation, because investors require higher returns as they increase.

For illustrative purposes only. This is over a five-year rolling period based on the S&P 500 Index.
Source: Federal Reserve Bank of St. Louis. As of March 31, 2018.

Next, in order to estimate the potential for valuation change, we look at current valuation relative to a rolling average P/E, as estimated in the above regression analysis. The change in valuation is then annualized, or amortized, over the 10-year time horizon, so it can be either added to or discounted from the total return estimate.

$$Valuation\ change = \left(\frac{\widehat{P/E}}{P/E_{Current}}\right)^{1/10} - 1$$

We then include a scaling factor to account for dislocation in valuation. In other words, extreme dislocations in P/E (high or low versus the average) have a larger impact on estimated returns.

Based on the building blocks above, the estimated return for US Large Cap Equity is derived as follows:

Dividend yield = 1.85%

Buyback yield = 1.15%

Earnings growth = 4.19%

Valuation change = -1.57%

Estimated return = 5.63%

US Large Cap Equity is represented by the S&P 500 Index.

Beyond US large-cap: Consistent approach across all equity classes

In terms of estimating returns for other equity sub-asset classes, one of the benefits of the building block approach is that it's very "portable" – meaning, it can be applied uniformly across all segments of equities including size (mid- and small-cap), style (growth/value), and geography (non-US developed, emerging markets).

Let's take a closer look at some examples:

US small-cap equities. US small-cap equities share the same drivers of return as large-cap equities – yield, earnings growth and valuation change. We estimate return for small-cap equities by looking at those drivers in the context of the US small-cap benchmark, the Russell 2000 Index.

Non-US equities. Our research indicates that, with the exception of the impact of share repurchases on estimating yield (as previously discussed), non-US equities share the same drivers of return as US equities, but are evaluated in the context of the representative benchmark (e.g., MSCI EAFE Index, MSCI World Index).

Figure 5 highlights our approach for estimating returns for the various segments of the market.

Figure 5: Applying building block methodology to equity sub-asset classes

	Valuation change	Earnings growth	Total yield
Large-cap equity	Mean P/E reversal of each index x Scaling factors	⊕ Long-term real US GDP per capita growth x Expected US inflation	⊕ Dividends + Buybacks = Total yield
Small- to mid-cap equity	Mean P/E reversal of each index x Scaling factors	⊕ Earnings growth for different market segments are scaled relative to the S&P 500 Index	⊕ Dividends + Buybacks = Total yield
International equity	Mean P/E reversal of each index x Scaling factors	⊕ Long-term real GDP per capita growth of each country x Expected US inflation	⊕ Dividends + Buybacks = Total yield

For illustrative purposes only.

Estimated equity returns

Figure 6: 10-year estimated equity market total returns (USD)

Asset class	Index	Estimated return (%)	Yield (%)	Earnings growth (%)	Valuation change (%)
Asia Pacific ex-Japan	MSCI APXJ	7.82	2.83	4.72	0.27
Canada	S&P TSX	6.53	2.81	3.63	0.09
Emerging market	MSCI EM	7.79	2.36	5.34	0.08
Eurozone	MSCI Euro Ex-UK	6.56	3.20	3.28	0.08
Japan	MSCI JP	5.00	2.06	2.93	0.01
International developed	MSCI EAFE	6.44	3.16	3.40	-0.13
Europe	MSCI Europe	6.73	3.46	3.49	-0.22
Developed ex-US	MSCI World Ex-US	6.44	3.14	3.42	-0.12
Pacific ex-Japan	MSCI Pacific Ex-JP	7.87	3.87	3.96	0.05
UK	MSCI UK	7.16	4.18	4.03	-1.04
UK large-cap	FTSE 100	7.47	4.10	4.03	-0.66
UK mid-cap	FTSE 250	6.92	2.80	4.77	-0.65
UK small-cap	FTSE Small Cap UK	8.19	3.31	5.71	-0.83
US broad market	Russell 3000	5.73	2.88	4.54	-1.69
US large-cap	S&P 500	5.63	3.00	4.19	-1.57
US mid-cap	Russell Midcap	6.16	2.65	4.96	-1.45
US small-cap	Russell 2000	6.52	1.74	5.94	-1.16
US small-cap/mid-cap	Russell 2500	6.30	2.09	5.57	-1.36
US top 200	Russell Top 200	5.47	3.11	4.20	-1.85
World equity	MSCI ACWI	6.18	2.97	4.06	-0.85
World equity ex-US	MSCI ACWI Ex-US	6.79	2.94	3.91	-0.06

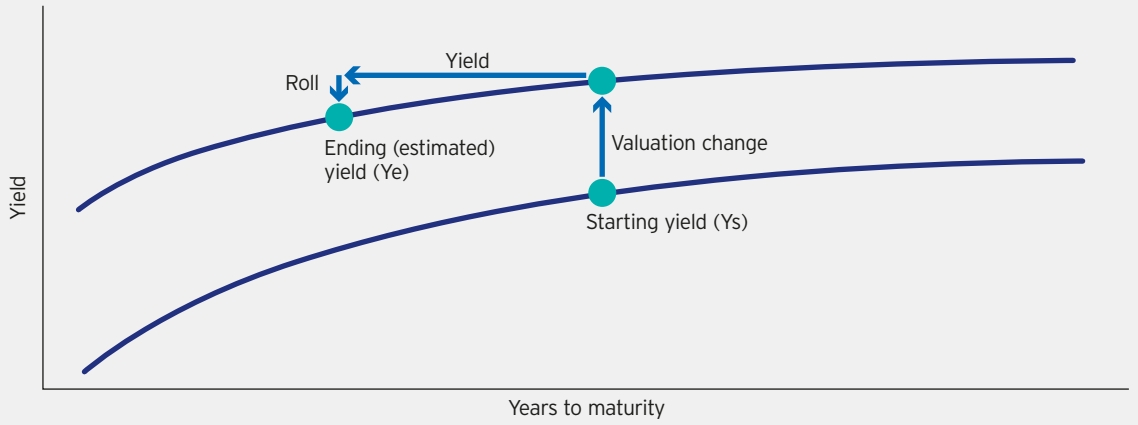
Source: Invesco, estimates as of March 31, 2018. All total returns data is annual. For illustrative purposes only. These estimates are based on our capital market assumptions which are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. Please see page 28 for additional CMA information.

Fixed income

Within fixed income, we also utilize the building block methodology, seeking to isolate and identify the individual drivers of the specific asset class risk premium. As with equities, the drivers of return for fixed income are income (yield) and appreciation (roll return, valuation change, and credit loss).

The estimate for total yield reflects the impact on income from changes of the yield curve over time.

Figure 7: Single-period return decomposition



For illustrative purposes only.

1. Yield

Yield reflects the average income expected to be received from an investment in a fixed income security throughout its life. For the purposes of our CMAs, yield is calculated using an average of the starting (current) and ending (estimated) yield levels.

To calculate the ending (estimated) yield (Y_e), we examine how the current (starting) yield curve (Y_s) could move over time as a result of changes in Treasury interest rates and in the credit spreads over US Treasury interest rates.

$$Y_e = Y_s + \Delta Y_{TSY} + \Delta OAS$$

(i) $\Delta Y_{TSY} = Changes\ in\ Treasury\ interest\ rates\ (at\ a\ given\ duration)$

(ii) $\Delta OAS = Changes\ in\ credit\ spreads\ over\ US\ Treasuries$

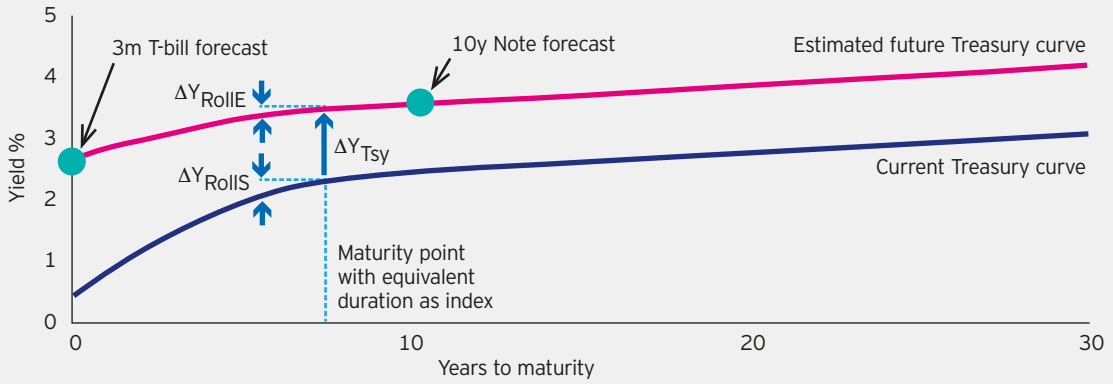
Changes in Treasury interest rates ΔY_{TSY}

As suggested in the relevant academic research (Litterman and Scheinkman, 1991), changes in Treasury interest rates have the potential to effect the position and shape of the future Treasury yield curve, in terms of its level and slope relative to the starting (current) yield curve.

Charting the future Treasury yield curve involves (1) identifying the yield for three-month Treasury bills and the yield for 10-year Treasury notes, as two specific points which help determine the level (intercept) and slope (Figure 8). (2) Polynomial interpolations is then applied using these two data points, which are sourced from the consensus forecasts of the Federal Reserve Bank of Philadelphia, to generate the estimated future yield curve. (3) For the purposes of estimating the impact of changes in Treasury interest rates on estimated yield ΔY_{TSY} we take the difference in yields, at a specific duration, between the current and estimated future yield curves.

$$\Delta Y_{TSY} = i_{estimated} - i_{current}$$

Figure 8: Treasury curve estimate based on Federal Reserve Bank of Philadelphia consensus



For illustrative purposes only.

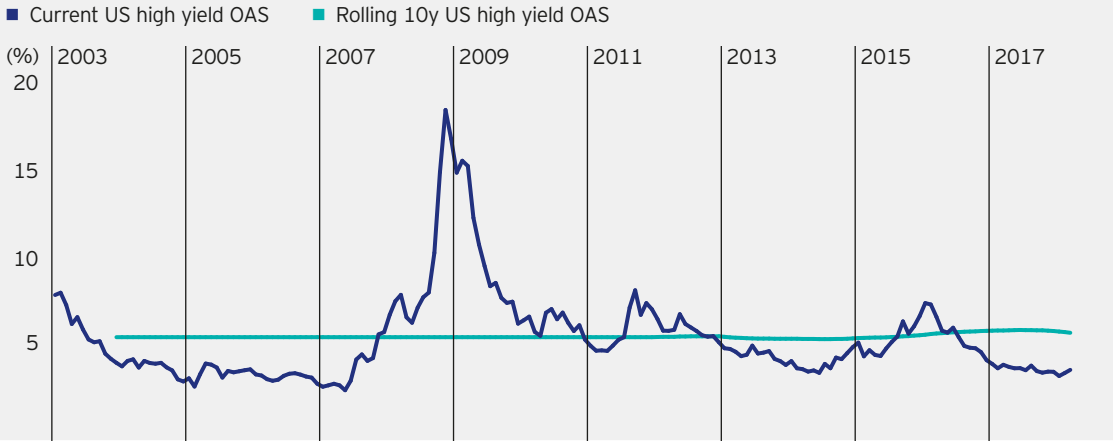
Changes in credit spreads ΔOAS

Another factor impacting the direction of estimated future yield involves movement in credit spreads, which historically have exhibited mean-reverting properties (Prigent et al., 2001). This means, for example, that if spreads are currently very wide relative to the mean, our forward expectations are for spreads to narrow, and for that contraction to have a positive impact on pricing.

We estimate the changes in that spread by looking at the relationship between current credit spreads and their 10-year rolling average (Figure 9). We cap the potential movement in credit spreads to 10% in order to mitigate the impact of extreme credit events (e.g., the global financial crisis).

$$\Delta OAS = OAS_{Current} - OAS_{10-year\ average}$$

Figure 9: High yield credit spreads revert to the long-term (10-year) average



Source: FactSet Research Systems Inc. from January 2003 to March 2018. High yield based on BBG BARC US Credit Index and BBG BARC US Corporate High Yield Index. Option-adjusted spreads (OAS) account for bonds with embedded options, such as callable bonds.

Estimating yield and total yield

Maturity = 6 years
Starting yield = 3.12%

Estimated yield
1 Movement in interest rates
- Interest rates at a maturity of six years on the current yield curve = 3.35%
- Interest rates at a maturity of six years on the future yield curve = 2.69%

2 Movement in credit spreads
- Current credit spread = 0.41%
- Rolling 10-year credit spread = 0.68%

Ending yield = 3.12% + (3.35% - 2.69%) + (0.68% - 0.41%) = 4.05%

Yield estimate = (3.12% + 4.05%)/2 = 3.59%

For illustrative purposes only. Data as of March 31, 2018.

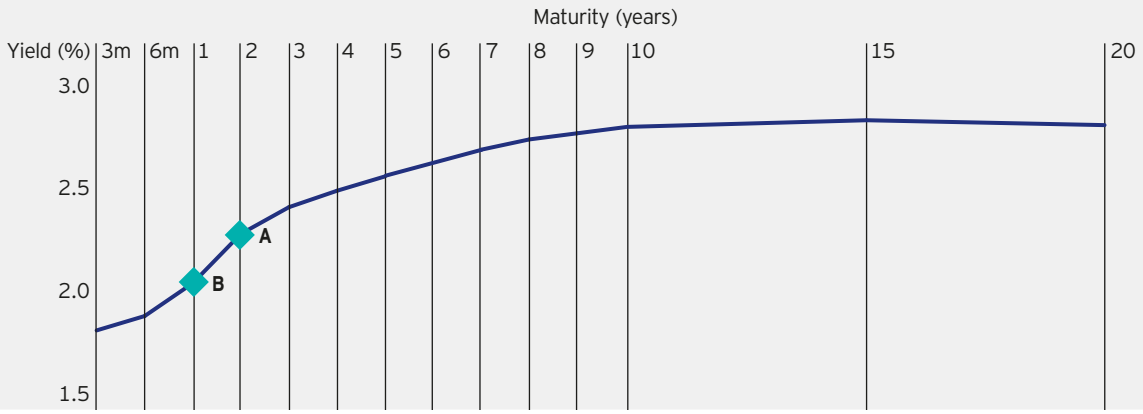
2. Roll return

Roll return reflects the impact of movement *along* the curve – of the passage of time – on the potential return of a fixed income security (i.e., appreciation). Specifically, it looks at the impact on price, all else being equal (i.e., no movement *of* the yield curve), as a bond nears maturity. If the yield curve slopes upward, movement along the curve (toward maturity) will make a positive impact on returns.

Roll return reflects movement along the yield curve – the impact on price from holding a bond over time.

Let's take a closer look at how this works (Figure 10). Consider the current upward sloping yield curve of "on-the-run" (i.e., the most recently issued) US Treasuries with maturities extending from zero to 15 years. Assume that we purchase a two-year US Treasury note (point A), which yielded 2.28% on March 31, 2018. Assuming no changes to the yield curve, a year from now, the maturity of the note would have decreased to one year, which corresponds to a yield (on the current yield curve, which has not changed/moved) of 2.03% (point B). Given the inverse relationship between the price and yield on bonds, in order for the yield on the note we purchased to decrease, the price of the note needs to increase – which represents the capital appreciation.

Figure 10: Roll return reflects the impact on yield and price as a bond is held over time



Source: Bloomberg, as of March 31, 2018.

At *Maturity* = t, the roll return is calculated as follows:

$$Roll\ return = -(t-1)x\Delta y$$

$$\Delta y = Interest\ rate_{t-1} - Interest\ rate_{t}$$

Estimating roll return

In order to determine the roll return, for methodological simplicity, we choose to focus only on the roll impact along the Treasury curve. Similar to the yield computation, we again rely on the average of the starting and estimated future roll and compute the roll return as follows:

Interest rate on current yield curve at:	Interest rate on future yield curve at:
6-year maturity = 2.69%	6-year maturity = 3.35%
5-year maturity = 2.56%	5-year maturity = 3.26%

Current roll return = -5 x (2.56% - 2.69%) = 0.65%

Future roll return = -5 x (3.26% - 3.35%) = 0.45%

Roll return = (0.65% + 0.45%)/2 = 0.55%

For illustrative purposes only. Data as of March 31, 2018.

3. Valuation change

Valuation change reflects the impact on price from movement of the yield curve.

If roll return incorporates the impact on price of movements *along* the curve, valuation change reflects the impact on price from movement *of* the curve. Another way to think about valuation change is that it examines the same dynamic we explored in defining the building block to estimate the return from yield (see Figure 7), but looks at this movement's impact on price, rather than income. As discussed above in the context of returns from yield, this comprises movement due to changes in interest rates and credit spreads, respectively.

We estimate the impact of this change as follows:

For Maturity = t

$$Valuation\ change\ = [1 - t \times (Y_e - Y_s)]^{1/10} - 1$$

From the *total yield* calculation we know that:

$$Y_e - Y_s = \Delta Y_{TSY} + \Delta OAS$$

In other words, the change in yield reflects changes in duration and credit spreads:

$$Valuation\ change\ = [1 - t \times (\Delta Y_{TSY} + \Delta OAS)]^{1/10} - 1$$

Estimating valuation change

Maturity = 6 years
Current yield = 3.12%
Ending yield = 4.06%

Valuation change = [1 - 6 x (4.06% - 3.12%)] 1/10 - 1 = -0.59%

For illustrative purposes only. Data as of March 31, 2018.

4. Credit loss

The estimated impact on return from:

- Bond migration = option-adjusted spread x 40% "haircut"
- Estimated default loss = 10-year median of annual default rates x Average 40% recovery rate

Credit loss captures the potential impact on returns from a downgrade in credit ratings (i.e., bond migration) and from a debt default. Let's examine each of these potential sources of loss:

- **Bond migration.** For investment grade bonds, downgrades – particularly those that place a security below investment grade level – could have a negative impact on returns, as these bonds entail a higher yield which would drive down prices. The estimated impact on return from this process can be estimated by multiplying the option-adjusted spread (OAS) – which measures the spread between a fixed income security and the risk-free rate of return, which is adjusted to account for an embedded option – by the "haircut," a reduction in the stated value of an asset. Our rationale for this methodology is based on observations of historical data, which indicate that loss from credit migration increases as the OAS widens. Also based on historical data, we use a static 40% as the haircut estimate.
- **Estimated default loss.** For riskier fixed income instruments such as high yield, floating rate, preferred stocks and emerging market bonds, default is a more significant driver of potential credit loss. The estimated default loss is a function of the estimated default rate, which is based on the 10-year median of annual default rates published by Standard & Poor's, and the average recovery rate – the proportion of bad debt that can be recovered – for those securities, which we assume is 40% based on historical observations of high yield recovery rates.

Based on the building blocks above, the estimated return for US aggregate bonds is derived as follows:
Current yield = 3.12%
Estimated yield = 4.06%
Roll return = 0.55%
Valuation change (yield curve) = -0.41%
Valuation change (OAS) = -0.17%
Credit loss = -0.16%
Estimated return = 3.40%

US aggregate bonds are represented by the BBG BARC US Agg Bond Index.

Estimated fixed income returns

Figure 11: 10-year estimated fixed income market total returns (USD)

Asset class	Index	Estimated return (%)	Yield (%)	Roll return (%)	Valuation change (%)	Credit loss (%)
US MBS	Bloomberg Barclays US MBS	3.77	4.13	0.55	-0.41	0.00
US municipals	BOA ML US Municipal	3.55	4.35	0.37	-0.52	0.00
US HY municipals	Bloomberg Barclays Municipal Bond High Yield	3.18	7.63	0.37	-0.52	-1.64
US intermediate municipals	BOA ML US Municipal (3Y-15Y)	3.45	3.91	0.55	-0.41	0.00
US preferred stocks	BOA ML Fixed Rate Pref Securities	4.52	8.71	0.27	-0.28	-1.64
US TIPS	Bloomberg Barclays US TIPS	2.90	3.61	0.36	-0.67	0.00
US Treasury	Bloomberg Barclays US Treasury	3.03	3.21	0.55	-0.41	0.00
US Treasury (long)	Bloomberg Barclays US Treasury Long	2.09	3.83	0.34	-1.63	0.00
US Treasury (short)	Barclays US Treasury Short	2.32	2.80	0.00	0.00	0.00
US universe	Bloomberg Barclays US Universe	3.57	4.49	0.55	-0.41	-0.30
Asian dollar HY	BOA Merrill Lynch ACHY	6.32	10.20	0.21	-0.21	-1.60
Asian dollar IG	BOA Merrill Lynch ACIG	3.74	5.53	0.37	-0.36	-0.55
Canada aggregate	FTSE TMX Universe Bond	2.53	3.47	0.37	-0.52	-0.22
Canada corporate	BOA Merrill Lynch Canada Corporate	3.06	4.17	0.55	-0.41	-0.44
Canada Treasury	BOA Merrill Lynch Canada Government	2.42	2.61	0.55	-0.41	0.00
EM aggregate	Bloomberg Barclays EM Aggregate	4.35	6.91	0.55	-0.41	-0.96
EM aggregate corporate	Bloomberg Barclays EM Corporate	4.36	7.47	0.37	-0.36	-1.02
EM corporate HY	Bloomberg Barclays Emerging Markets USD Aggregate - Corporate-HY	5.12	9.04	0.37	-0.36	-1.60
EM corporate IG	Bloomberg Barclays Emerging Markets USD Aggregate - Corporate -IG	3.86	5.69	0.55	-0.41	-0.60
EM aggregate sovereign	Bloomberg Barclays EM Sovereign	4.40	6.75	0.36	-0.67	-1.11
Global aggregate	Bloomberg Barclays Global Aggregate	1.84	2.80	0.37	-0.52	-0.15
Global aggregate ex-US	Bloomberg Barclays Global Aggregate Ex-US	0.68	1.85	0.36	-0.67	-0.12
Global corporate	Bloomberg Barclays Global Corporate	2.52	4.35	0.37	-0.52	-0.43
Global corporate ex-US	Bloomberg Barclays Global Corporate Ex-US	1.00	2.10	0.55	-0.41	-0.34
Global IG	Bloomberg Barclays Global Corporate Inv Grd	2.55	4.49	0.37	-0.52	-0.44
Global sovereign	Bloomberg Barclays Global Sovereign	2.93	4.38	0.37	-0.52	-0.35
Global Treasury	Bloomberg Barclays Global Treasuries	1.29	2.00	0.36	-0.67	0.00
Global Treasury ex-US	Bloomberg Barclays Global Treasuries Ex-US	0.72	1.59	0.41	-0.83	0.00
UK aggregate	Bloomberg Barclays Sterling Aggregate	1.00	2.82	0.23	-1.03	-0.13
UK corp	Bloomberg Barclays Sterling Aggregate Non-Gilts - Corporate	1.82	4.38	0.41	-0.83	-0.53
UK gilts	Bloomberg Barclays Sterling Aggregate Gilts	0.97	2.24	0.30	-1.12	0.00
UK linker	BofA Merrill Lynch UK Inflation-Linked Gilt	0.49	2.22	0.34	-1.63	0.00
US aggregate	Bloomberg Barclays US Aggregate	3.40	4.06	0.55	-0.41	-0.16
US aggregate 1 to 3	Bloomberg Barclays US Corporate and Government (1Y-3Y)	2.80	3.38	0.13	-0.14	-0.07
US bank loans	CSFB Leverage Loan Index	4.99	7.49	0.00	-0.10	-1.64
US aggregate credit	Bloomberg Barclays US Aggregate Credit	3.32	5.05	0.37	-0.52	-0.41
US HY corporates	Bloomberg Barclays US High Yield	5.04	9.00	0.27	-0.28	-1.64
US IG corporates	Bloomberg Barclays US Investment Grade	3.15	5.29	0.36	-0.67	-0.44
US IG corporates (long)	Bloomberg Barclays US Long Credit	2.67	5.85	0.38	-1.32	-0.59
US IG corporates (short)	Bloomberg Barclays US Aggregate Credit (1Y-3Y)	3.19	4.26	0.13	-0.14	-0.22

Source: Invesco, estimates as of March 31, 2018. All total returns data is annual. These estimates are based on our capital market assumptions which are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. Please see page 28 for additional CMA information.

Commodities

To estimate commodities returns we analyze the **futures curve**, which is a graphical representation of commodity contracts (agreements to buy or sell a predetermined amount of a commodity at a specific price on a specific date in the future) that expire at different maturities. As with other asset classes, we apply the building block approach to the futures curve to identify yield (collateral return) and appreciation (roll return and spot return) as the main constituents of total return.

Within the asset class, we apply this methodology consistently across the individual commodity sectors that make up the main commodity indices, the S&P GSCI Index and the Bloomberg Commodity Index including Agriculture, Energy, Industrial metals, Livestock, and Precious metals.

1. Collateral return

Collateral return is meant to reflect the value of the return on cash, which is needed as collateral for trading in commodity futures. The return is a function of the fixed income instrument in which the cash is invested – for example, short-term US T-bills.

We use an average of the current US three-month T-bill interest rate and 10-year forecasted US three-month T-bill interest rate from the Federal Reserve Bank of Philadelphia to estimate this value.

2. Roll yield

Roll yield reflects the return from rolling the commodity futures forward – in other words, from wanting to maintain exposure to a commodity after the contract has expired. It reflects the potential return from the movement in the price of the futures contract toward the spot price over time.

We estimate roll yield through the difference between historical excess returns, which includes roll return and the historical spot return, which measures only the price return.

3. Spot return

The spot return attempts to capture the return that can be derived from an increase in the value of a commodity as a real asset, beyond its ability to capture the value of keeping up with long-term inflation.

For the purposes of estimating the real spot return, we use the long-term historical average of real spot monthly returns dating back to 1970, and adjust that for expected inflation over a 10-year time horizon.

Estimated commodity returns

Figure 12: 10-year estimated commodity market total returns (USD)

Asset class	Index	Estimated return (%)	Collateral return (%)	Roll return (%)	Spot return (%)
Agriculture	S&P GSCI Agriculture	1.45	2.25	-2.91	0.10
Energy	S&P GSCI Energy	8.61	2.25	2.66	1.67
Industrial metals	S&P GSCI Industrial Metals	6.20	2.25	-0.26	2.17
Livestock	S&P GSCI Livestock	3.33	2.25	-0.54	-0.37
Precious metals	S&P GSCI Precious Metals	3.67	2.25	-4.17	3.53
Commodities	S&P GSCI	6.22	2.25	0.64	1.31
BB commodities	Bloomberg Commodity Index	4.92	2.25	-0.80	1.44

Source: Invesco, estimates as of March 31, 2018. All total returns data is annual. These estimates are based on our capital market assumptions which are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. Please see page 28 for additional CMA information.

Constructing a multi-asset portfolio: Estimating volatility and correlation

In order to construct multi-asset, goal-oriented portfolios that seek diversification and focus on specific investment outcomes, we also need to evaluate the risk (i.e., volatility) of each asset class, as well as correlations between the different asset classes — how they move relative to each other. One commonly used methodology is to estimate risk and correlation directly from historical data.

Volatility

Volatility is estimated using rolling historical quarterly returns that are normalized for shorter-lived benchmarks.

To estimate volatility for the different asset classes, we use rolling historical quarterly returns of various market benchmarks. Since all of these benchmarks have differing histories within and across asset classes, we normalized the volatility estimates of the shorter-lived benchmarks to ensure that all series are measured over similar time periods. We did this by designating one benchmark to represent the full history for an asset class (Figure 13). The sub-asset classes with shorter histories are then adjusted based on their relationship to the representative benchmark. For example, to estimate the volatility of US small-cap equities over the entire history of the asset class dating back to 1970, we look at the relationship between the Russell 2000 Index (the benchmark for US small-cap equity) and the S&P 500 Index, as the representative benchmark for US equity, during the period in which they overlapped.

Figure 13: Benchmarks designated to represent the full history for an asset class

Asset class	Representative Index	History
US equity	S&P 500 Index	1970
International equity	MSCI EAFE Index	1970
US government bonds	BBG BARC US Treasury Index	1976
Corporate and other bonds	BBG BARC US Aggregate Index	1976
Commodities	S&P GSCI Index	1970

Full history dates shown include back-tested performance, which is hypothetical and subject to inherent limitations.

Correlation

Correlations are calculated using the trailing 20 years of monthly index returns.

Correlation, or the extent to which asset classes move in the same direction, plays an important role in constructing a multi-asset portfolio that seeks to maximize the potential benefits of diversification. For our strategic capital market assumptions, we calculate correlation coefficients using the trailing 20 years of monthly index returns, which we believe is appropriate in covering a majority of asset classes while incorporating multiple business cycles.

A correlation coefficient is a statistical measure that can range in value from -1.0 (perfect negative correlation) to 1.0 (perfect positive correlation). It's important to recognize that correlations among asset classes can change over time. Since we believe that recent asset class correlations could have a more meaningful effect on future observations, we place greater weight on more recent observations by applying a 10-year half-life to the time series in our calculation.

Expanding our CMA methodology: Time horizons

In order to facilitate our efforts to engage in more "active-strategic" portfolio management, which involves the potential to actively position our strategic portfolios within the business cycle, we expanded our CMA methodology to support a shorter time horizon of five years. While still drawing on the building block approach that underpins the 10-year time horizon, the methodology for the five-year time horizon incorporates estimating elements that are appropriate for understanding the behavior of asset classes over a shorter holding period.

Equities

The building blocks for estimating equity returns for a five-year time horizon are generally the same as those identified for the 10-year time horizon — yield, earnings growth and valuation. However, the way in which each of these buildings blocks is constructed may change to better reflect shorter-term market dynamics.

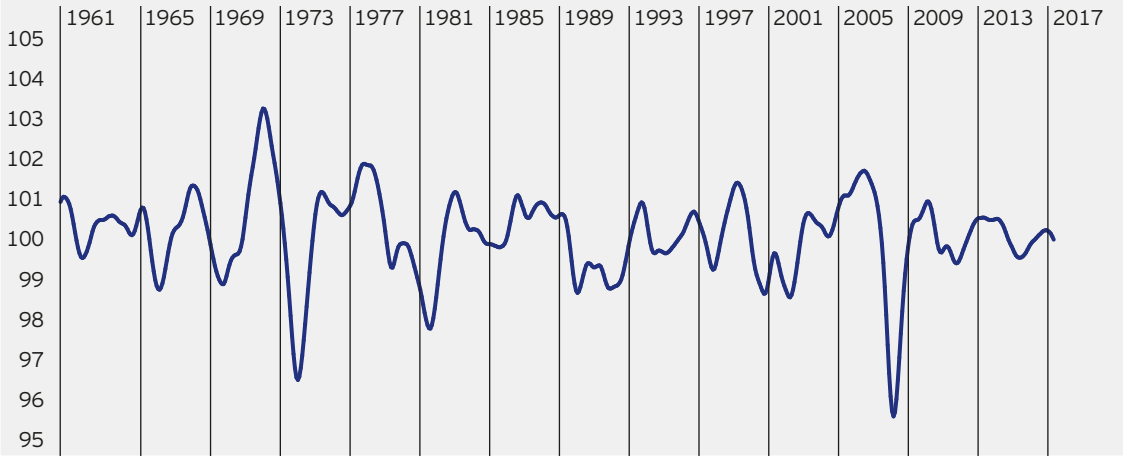
- **Yield.** Yield is estimated for the 10-year time horizon using the 10-year average total yield ratio, which reflects the impact of both dividend yield and buybacks. The same measure is used to estimate yield for the five-year time horizon.

- **Earnings growth.** Long-term real GDP per capita provides a stable signal over time to estimate earnings growth across a 10-year time horizon. For a shorter time horizon, it needs to be adjusted to reflect a short-holding period.

Earnings growth = Long-term real GDP growth + Real GDP growth adjustment + Five-year expected inflation

According to academic research (Pritchett and Summers, 2014), economic growth rates globally have mean-reverting properties — meaning that future growth rates move in an opposite direction to current growth rates. This is particularly important in a five-year time horizon, since we are not looking across the full economic cycle. We use the OECD Composite Leading Indictor (CLI) to gauge these short-term trends in economic growth. The CLI is designed to provide early signals of turning points in business cycles showing fluctuations of economic activity around its long-term potential level (which is normalized at 100).

Figure 14: Composite leading indicator (CLI) — OECD



Source: OECD, data through April 30, 2018.

Regression analysis is applied on a country-by-country basis to determine the relationship between the forward five-year GDP growth rate and short-term economic movements, using historical data dating back to 1970.

Five-year real GDP growth = Long-term real GDP growth – b x (CLI - 100)
b = Relationship between short-term economic movements and forward five-year real GDP growth

For the regression run as of Dec. 31, 2017, US data indicated that short-term economic movements have led to an adjustment down of 0.30% in the forward five-year real GDP growth. Globally, we would expect that the pace of mean-reversion for each country would depend on its level of economic development. In other words, for countries that are considered "mature" or "developed" economies, and for which the rate of long-term growth is stable, we would expect a quicker reversion to the mean — and vice versa for emerging economies. For example, we expect that for Japan, which is considered a mature, slow-growing economy, short-term economic movements would revert more quickly to the long-term average. At the same time, we expect that in emerging markets, whose long-term growth rates are still evolving, short-term economic movements would revert less quickly to their amorphous long-term averages (see Figure 15). Although we expect these relationships to remain stable over the medium-term, we re-run the regressions and review the resulting data quarterly.

Figure 15: We expect the pace of mean-reversion to depend on a country's level of economic development

Region/Country	Pace of mean-reversion
United States	0.30
United Kingdom	0.27
Japan	0.48
Eurozone	0.29
Canada	0.33
Emerging markets	0.23
Asia Pacific ex-Japan	0.22

Source: OECD, Invesco as of Dec. 31, 2017.

- **Valuation change.** Across a full business cycle, valuation change involved estimating the potential for the current P/E level to revert to an estimated long-term average over a 10-year time horizon. Over a shorter time frame, we look at the potential for the P/E to revert back to the long-term average in five years' time.

Figure 16: Five-year vs. 10-year capital market assumptions for US large-cap equities

Time horizon	Estimated return (%)	Yield (%)	Earnings growth + inflation (%)	Earnings growth adjustment (%)	Valuation change (%)	Scaling factor
10 years	5.63	3.00	4.19	–	-1.57	0.79
5 years	4.20	3.00	4.23	0.07	-3.10	0.79

Source: Invesco, as of March 31, 2018. Capital market assumptions are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. For illustrative purposes only. Please see page 28 for additional CMA information.

Fixed income

As with equities, the building blocks for estimating fixed income returns over a five-year time horizon are the same as those identified for the 10-year time horizon – yield, roll return, valuation change and credit loss. However, how each of these buildings blocks is defined may need to change to better reflect shorter-term market dynamics.

- **Yield.** Return from yield reflects an average of the starting (current) and an estimate of the ending yield. For a five-year time horizon, we use an estimate of the five-year yield curve to evaluate ending yield, instead of the 10-year yield curve that we used for the long-term time horizon. To estimate the future yield curve, we use the same process, evaluating two specific points on the future curve to help determine its level and shape. For the estimated five-year yield curve, we use the yield for the three-month Treasury bills and the yield for five-year Treasury notes. As previously discussed, another factor impacting the direction of potential future yield involves movement in credit spreads, which we estimate by looking at the relationship between current credit spreads and their 10-year rolling average.
- **Roll return.** As previously discussed, the estimate for roll return reflects an average of the roll return from the current yield curve and the roll return from the ending (estimated) yield curve. As with the return from yield, instead of the 10-year estimated yield curve, we use the five-year estimated yield curve to calculate the average roll return.
- **Valuation change.** The same methodology is used to estimate valuation change over a five-year time horizon as was used over a 10-year time horizon. The main difference, however, is that the impact on price from the shift to the ending yield curve is amortized over five years.
- **Credit loss.** No change from the estimate used for the 10-year time horizon.

Figure 17: Five-year vs. 10-year capital market assumptions for US aggregate bonds

Time horizon	Estimated return (%)	Yield (%)	Estimated yield (%)	Roll return (%)	Valuation change (%)	Credit loss (%)
10 years	3.40	3.12	4.06	0.55	-0.58	-0.16
5 years	3.35	3.12	3.45	0.63	-0.40	-0.16

Source: Invesco, as of March 31, 2018. Capital market assumptions are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. For illustrative purposes only. Please see page 28 for additional CMA information.

Commodities

The building blocks of collateral return, roll return, and spot return are used to construct the estimate for commodity returns.

- **Collateral return.** The return is a function of the fixed income instrument in which the cash is invested as collateral for the commodity investment. To estimate this value, we use an average of the current US three-month T-bill interest rate and five-year (instead of the 10-year) forecasted US three-month T-bill interest rate from the Federal Reserve Bank of Philadelphia.
- **Roll return.** There is no change from the estimate used for the 10-year time horizon in estimating the roll return for the five-year time horizon.
- **Spot return.** For the purposes of estimating the real spot return, we use the same long-term historical average of real spot monthly returns dating back to 1970, which we adjust for expected inflation over a five-year time period, as forecasted by the Federal Reserve Bank of Cleveland. An additional adjustment is made to better estimate for a five-year time horizon. Specifically, that adjustment is based on a regression of historical data including the forward five-year real spot returns and economic conditions as measured by the previously mentioned CLI. The adjustment is grounded in academic research (Rogoff, Rossi and Chen 2010) which argues that macroeconomic conditions in commodity-exporting countries help explain future price movements in commodities.

Figure 18: Five-year vs. 10-year capital market assumptions for energy

Time horizon	Estimated return (%)	Collateral return (%)	Roll return (%)	Real spot return (%)	Inflation (%)	Real spot return adjustment (%)
10 years	8.61	2.25	2.66	1.67	2.00	–
5 years	6.68	1.85	2.66	1.67	1.89	-1.39

Source: Invesco, as of March 31, 2018. Capital market assumptions are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. For illustrative purposes only. Please see page 28 for additional CMA information.

Expanding our CMA methodology: Alternatives

In addition to a shorter time horizon, we have expanded our capital market assumptions to include alternatives, reflecting the increased use of this asset class in our portfolios. However, estimating returns for such investments is more complex than evaluating equities and fixed income, as the range of alternatives ("alts") available runs the entire spectrum of risk. Long/short strategies, for example, behave differently than commodities, and both behave differently than global macro. And for any alternative category, it can be a challenge to know how much of the return is true, uncorrelated alpha, and how much can be attributed to broad market exposures (e.g., S&P 500 Index). In fact, academic research (Hasanhodzic and Lo, 2007; and Fung and Hsieh, 2004) suggests that a significant portion of hedge fund returns is attributable to conventional asset class and factor risks. Leaning into this research, we construct linear models using available market indexes from our traditional asset class CMAs, and measure the proportion of the estimated returns and volatility that are attributable them.

Our capital market assumptions consider 17 hedge fund asset classes and two real estate investment trust asset classes (Figure 19). For each of these, we perform a regression-based analysis that seeks to decompose returns as follows:

$$HF_i = a + \sum_j bX_i$$

i = hedge fund index
j = market/conventional asset class risk factor

Where *j* = US Large Cap, US Mid Cap, US Small Cap, International Developed Equities, Emerging Market Equities, US Treasuries, US Investment Grade Bonds, US High Yield Bonds, International Fixed Income, Emerging Market Bonds, and Commodities.

All returns (*j*) are orthogonalized based on Chow and Klein (2013), which examines the impact of individual market exposures on the return variation of risky assets. Coefficients are estimated using rolling 84-month Stepwise regressions. The regression results decompose hedge fund index returns into systemic risk (beta) and idiosyncratic risk (manager-specific alpha).

For example, for the HFRI Fund Weighted Composite Index:
Estimated returns = 4.36%
Contribution of equity factors to estimated returns = 2.75%
Contribution of fixed income and commodities to estimated returns = 0.58%
Contribution of manager specific alpha to estimated returns = 1.03%

Alternatives: Estimated risk and correlation

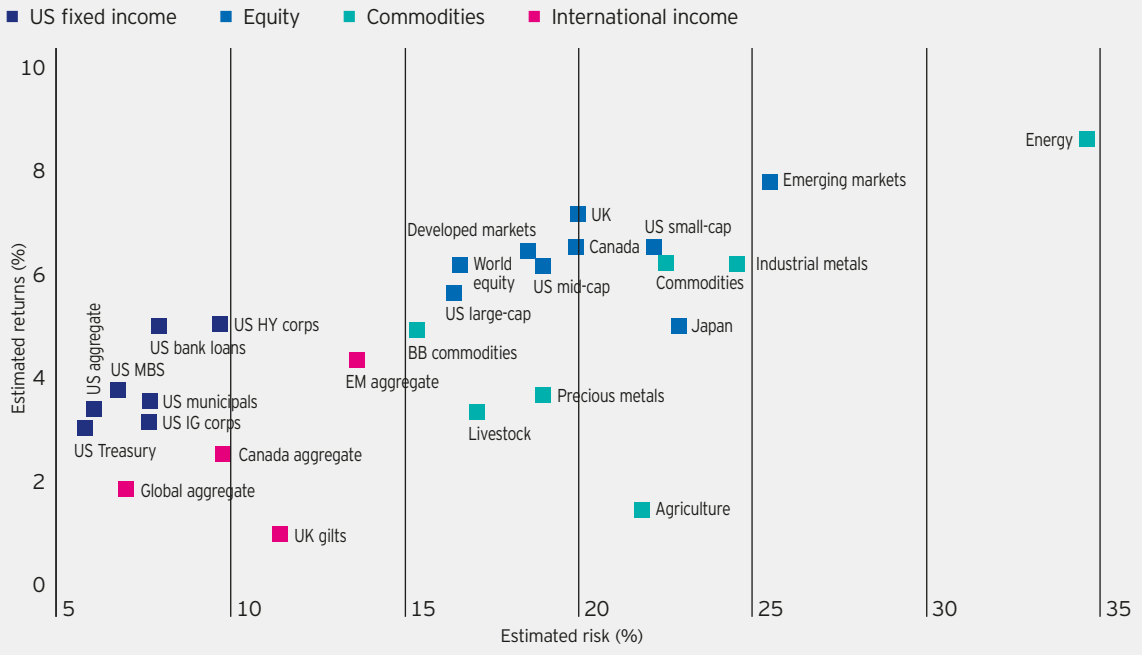
Figure 19: 10-year estimated alternatives total returns (USD)

Asset	Index	Estimated return (%)	Systematic return (%)	Alpha (%)
CISDM CTA	CISDM CTAs Index	5.65	0.98	4.68
CISDM event driven	CISDM Event Driven Index	5.34	3.38	1.95
CISDM global macro	CISDM Global Macro Index	2.42	0.70	1.72
CISDM long/short	CISDM Long/Short Index	5.91	3.40	2.50
CISDM market neutral	CISDM Equity Market Neutral Index	4.54	0.72	3.83
CS event driven	Credit Suisse Event Driven Index	4.34	3.59	0.75
CS global macro	Credit Suisse Global Macro Index	5.09	1.55	3.55
CS long/short	Credit Suisse Long/Short Index	5.18	3.64	1.53
CS managed futures	Credit Suisse Managed Future Index	3.28	1.03	2.25
CS market neutral	Credit Suisse Equity Market Neutral Index	1.15	1.04	0.11
Hedge funds	HFRI HF Index	4.36	3.33	1.03
CISDM hedge funds	CISDM HF Index	5.12	3.21	1.91
CS hedge funds	Credit Suisse HF Index	2.44	-0.45	2.89
HF event driven	HFRI Event Driven Index	5.44	3.45	1.99
HF global macro	HFRI Macro Index	2.82	1.18	1.64
HF long/short	HFRI Equity Hedge Index	6.07	4.79	1.29
HF market neutral	HFRI Equity Market Neutral Index	2.81	1.29	1.52

Source: Invesco, estimates as of March 31, 2018. All total returns data is annual. These estimates are based on our capital market assumptions which are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. Please see page 28 for additional CMA information.

Estimated asset class returns

Figure 20: 10-year asset class estimated risk/return (USD)



Source: Invesco, estimates as of March 31, 2018. Proxies listed in figure 21. For illustrative purposes only. These estimates are based on our capital market assumptions which are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. Please see page 28 for additional CMA information.

Figure 21: 10-year asset class estimated total returns and standard deviations (USD)

Asset class	Asset	Index	Return (%)	Risk (%)	Return/risk
US equity	US large-cap	S&P 500	5.63	16.41	0.34
	US small-cap	Russell 2000	6.53	22.15	0.30
	US mid-cap	Russell Midcap	6.16	18.96	0.33
	US top 200	Russell Top 200	5.47	16.30	0.34
	US small-mid	Russell 2500	6.32	20.67	0.31
	US broad market	Russell 3000	5.73	17.12	0.33
Global equity	International	MSCI ACWI Ex-US	6.81	18.72	0.36
	Developed	MSCI EAFE	6.46	18.52	0.35
	Europe	MSCI Europe	6.76	18.52	0.36
	Canada	S&P TSX	6.52	19.92	0.33
	UK	MSCI UK	7.17	19.96	0.36
	Eurozone	MSCI Euro X UK	6.60	19.61	0.34
	Japan	MSCI JP	5.03	22.87	0.22
	Pacific ex-Japan	MSCI Pacific X JP	7.87	25.13	0.31
	Asia Pacific ex-Japan	MSCI APXJ	7.82	25.91	0.30
	Emerging markets (EM)	MSCI EM	7.81	25.50	0.31
	Global equity	MSCI ACWI	6.19	16.57	0.37
US bonds	US Treasury	BBG BARC US Treasury	3.03	5.79	0.52
	US Treasury (short)	BBG BARC US Treasury Short	2.32	1.59	1.46
	US Treasury (long)	BBG BARC US Treasury Long	2.09	11.47	0.18
	US TIPS	BBG BARC US TIPS	2.90	5.84	0.50
	US aggregate	BBG BARC US Aggregate	3.40	6.06	0.56
	US universe	BBG BARC US Universe	3.57	5.78	0.62
	US aggregate credit	BBG BARC US Aggregate Credit	3.32	7.56	0.44
	US IG corporates	BBG BARC US Investment Grade	3.15	7.65	0.41
	US aggregate 1 to 3	BBG BARC US Aggregate Credit (1Y-3Y)	3.19	3.33	0.96
	US IG corporates (long)	BBG BARC US Long Credit	2.67	9.78	0.27
	US HY corporates	BBG BARC US High Yield	5.04	9.67	0.52
	US MBS	BBG BARC US MBS	3.77	6.75	0.56
	US municipals	BofA ML US Taxable Municipal	3.55	7.66	0.46
	US intermediate municipals	BofA ML US Taxable Muni (3Y-15Y)	3.45	6.20	0.56
	US bank loans	CSFB Leverage Loan Index	4.99	7.93	0.63
	US preferred stocks	BofA ML Fixed Rate Pref Securities	4.52	12.34	0.37
Global bonds	UK aggregate	BBG BARC Sterling Aggregate	2.38	13.56	0.18
	UK gilts	BBG BARC Sterling Aggregate Gilts	2.22	11.40	0.19
	UK corporates	BBG BARC Sterling Aggregate Non-Gilts - Corporate	3.46	15.34	0.23
	UK linker	BofA Merrill Lynch UK Inflation-Linked Gilt	0.92	12.63	0.07
	Canada aggregate	FTSE TMX Universe Bond	3.16	9.78	0.32
	Canada Treasury	BOA Merrill Lynch Canada Government	2.84	9.18	0.31
	Canada corporate	BOA Merrill Lynch Canada Corporate	3.48	10.76	0.32
	Global aggregate	BBG BARC Global Aggregate	3.04	6.98	0.44
	Global Treasury	BBG BARC Global Treasuries	2.92	8.75	0.33
	Global sovereign	BBG BARC Global Sovereign	2.93	6.71	0.44
	Global corporate	BBG BARC Global Corporate	3.21	7.50	0.43
	Global IG	BBG BARC Global Corporate Inv Grd	2.55	7.69	0.33
	Global aggregate ex-US	BBG BARC Global Aggregate- Ex US	2.74	10.58	0.26
	Global Treasury ex-US	BBG BARC Global Treasuries- Ex US	2.97	10.66	0.28
	Global corporate ex-US	BBG BARC Global Corporate- Ex US	2.96	12.76	0.23
EM bonds	EM aggregate	BBG BARC EM Aggregate	4.35	13.61	0.32
	EM aggregate sovereign	BBG BARC EM Sovereign	4.40	12.51	0.35
	EM aggregate corporate	BBG BARC EM Corporate	4.36	15.27	0.29
	EM corporate IG	BBG BARC Emerging Markets USD Aggregate - Corporate -IG	3.86	8.40	0.46
	EM corporate HY	BBG BARC Emerging Markets USD Aggregate - Corporate-HY	5.12	15.30	0.33
	Asian dollar IG	BOA Merrill Lynch ACIG	3.74	8.96	0.42
	Asian dollar HY	BOA Merrill Lynch ACHY	6.32	19.17	0.33
Commodity	Agriculture	S&P GSCI Agriculture	1.45	21.80	0.07
	Energy	S&P GSCI Energy	8.61	34.61	0.25
	Industrial metals	S&P GSCI Industrial Metals	6.20	24.54	0.25
	Livestock	S&P GSCI Livestock	3.33	17.08	0.20
	Precious metals	S&P GSCI Precious Metals	3.67	18.97	0.19
	Commodities	S&P GSCI	6.22	22.50	0.28
	BB commodities	Bloomberg Commodity	4.92	15.33	0.32

Figure 21: 10-year asset class estimated total returns and standard deviations (USD)

Asset class	Asset	Index	Return (%)	Risk (%)	Return/risk
	US REITs	FTSE NAREIT Equity	5.11	19.45	0.26
	Global REITs	FTSE EPRA/NAREIT Developed	6.01	17.50	0.34
	Global infrastructure	S&P Global Infrastructure	6.34	16.92	0.37
	Private equity	DJ Private Equity Total Return	7.33	27.04	0.27
	Hedge funds	HFRI HF	4.37	8.57	0.51
	HF long/short	HFRI Equity Hedge	6.09	11.00	0.55
	HF market neutral	HFRI Equity Market Neutral	2.81	4.01	0.70
Alternatives	HF global macro	HFRI Macro	2.83	8.34	0.34
	HF event driven	HFRI Event Driven	5.36	8.72	0.61
	CISDM hedge funds	CISDM HF	5.13	8.90	0.58
	CISDM long/short	CISDM Long/Short	5.91	9.63	0.61
	CISDM market neutral	CISDM Equity Market Neutral	4.38	2.85	1.53
	CISDM global macro	CISDM Global Macro	2.42	6.25	0.39
	CISDM event driven	CISDM Event Driven	5.25	7.64	0.69
	CISDM CTA	CISDM CTAs	5.65	8.47	0.67

Source: Invesco, estimates as of March 31, 2018. All total returns data is annual. These estimates are based on our capital market assumptions which are forward looking, are not guarantees, and they involve risks, uncertainties and assumptions. Please see page 28 for additional CMA information.

About risks

The value of investments and any income will fluctuate (this may partly be the result of exchange rate fluctuations) and investors may not get back the full amount invested.

Appendix: Asset class correlation matrices

Note: For Figures 22 through 32 the index proxies are represented in Figure 21, located on pages 17–18.

Figure 22: Correlation matrix for equities versus equities

0.05 to 0.25 ■ 0.26 to 0.50 ■ 0.51 to 0.75 ■ 0.76 to 1.00

	US large-cap	US mid-cap	US small-cap	Canada	MSCI EAFE	UK	MSCI Europe	Japan	Asia Pacific ex-Japan	Emerging market	China Shanghai A Share	World equity	MSCI world ex-US
US large-cap	1.00												
US mid-cap	0.94	1.00											
US small-cap	0.83	0.93	1.00										
Canada	0.78	0.82	0.75	1.00									
MSCI EAFE	0.86	0.85	0.75	0.80	1.00								
UK	0.82	0.80	0.67	0.78	0.93	1.00							
MSCI Europe	0.85	0.84	0.74	0.78	0.98	0.94	1.00						
Japan	0.62	0.61	0.53	0.59	0.76	0.61	0.63	1.00					
Asia Pacific ex-Japan	0.73	0.74	0.66	0.76	0.79	0.71	0.74	0.62	1.00				
Emerging market	0.76	0.78	0.71	0.83	0.84	0.76	0.79	0.64	0.95	1.00			
China Shanghai A Share	0.31	0.31	0.28	0.37	0.34	0.31	0.32	0.24	0.45	0.43	1.00		
World equity	0.95	0.92	0.82	0.85	0.97	0.91	0.94	0.71	0.83	0.87	0.36	1.00	
MSCI world ex-US	0.87	0.86	0.76	0.83	1.00	0.94	0.98	0.76	0.80	0.85	0.35	0.97	1.00

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 23: Correlation matrix for equities versus US bonds

-0.50 to -0.25 | -0.24 to -0.05 | -0.04 to 0.05 | 0.06 to 0.25 | 0.26 to 0.50 | 0.51 to 0.75

	US Treasury	US TIPS	US aggregate	US IG Corps	US HY Corps	US MBS	US municipals	US bank loans	US preferred stocks
US large-cap	-0.32	0.03	-0.09	0.20	0.64	-0.16	-0.04	0.47	0.34
US mid-cap	-0.31	0.08	-0.06	0.25	0.70	-0.15	0.03	0.56	0.36
US small-cap	-0.33	-0.01	-0.12	0.16	0.64	-0.20	-0.05	0.48	0.29
US small- to mid-cap	-0.32	0.03	-0.09	0.20	0.67	-0.18	-0.01	0.51	0.32
Canada	-0.24	0.19	0.02	0.31	0.66	-0.05	0.07	0.53	0.32
MSCI EAFE	-0.26	0.13	0.01	0.32	0.68	-0.08	0.05	0.52	0.38
UK	-0.27	0.12	-0.01	0.30	0.65	-0.07	0.08	0.55	0.35
MSCI Europe	-0.27	0.10	-0.01	0.29	0.67	-0.08	0.04	0.51	0.36
Japan	-0.18	0.12	0.00	0.24	0.48	-0.07	0.00	0.37	0.30
Asia Pacific ex-Japan	-0.21	0.16	0.03	0.31	0.64	-0.07	0.04	0.46	0.34
Emerging market	-0.23	0.19	0.02	0.32	0.69	-0.06	0.03	0.49	0.34
China Shanghai A Share	-0.15	0.06	-0.04	0.11	0.25	-0.06	-0.05	0.26	0.08
World equity	-0.30	0.10	-0.03	0.29	0.70	-0.12	0.01	0.53	0.38
MSCI world ex-US	-0.26	0.14	0.01	0.32	0.69	-0.08	0.05	0.53	0.38

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 24: Correlation matrix for equities versus global bonds

■ 0.05 to 0.25 ■ 0.26 to 0.50 ■ 0.51 to 0.75

	UK gilts	Global aggregate	Global aggregate ex-US	Canada Treasury	EM aggregate sovereign	Asian dollar IG
US large-cap	0.16	0.16	0.21	0.47	0.52	0.30
US mid-cap	0.16	0.16	0.21	0.51	0.55	0.34
US small-cap	0.13	0.08	0.13	0.45	0.48	0.26
US small- to mid-cap	0.14	0.12	0.16	0.48	0.52	0.31
Canada	0.25	0.29	0.33	0.73	0.60	0.42
MSCI EAFE	0.34	0.35	0.41	0.56	0.56	0.37
UK	0.42	0.33	0.38	0.56	0.49	0.34
MSCI Europe	0.35	0.34	0.40	0.54	0.53	0.33
Japan	0.18	0.23	0.27	0.39	0.43	0.31
Asia Pacific ex-Japan	0.23	0.28	0.32	0.55	0.58	0.43
Emerging market	0.25	0.30	0.34	0.61	0.67	0.45
China Shanghai A Share	0.17	0.07	0.09	0.30	0.23	0.19
World equity	0.26	0.28	0.33	0.57	0.58	0.37
MSCI world ex-US	0.33	0.35	0.41	0.59	0.57	0.38

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 25: Correlation matrix for equities versus commodities

■ -0.05 to 0.05 ■ 0.06 to 0.25 ■ 0.26 to 0.50 ■ 0.51 to 0.75

	Agriculture	Energy	Industrial metals	Livestock	Precious metals	Commodities	BB commodities
US large-cap	0.28	0.25	0.46	0.05	0.07	0.31	0.36
US mid-cap	0.29	0.31	0.48	0.07	0.13	0.37	0.42
US small-cap	0.22	0.28	0.41	0.05	0.10	0.32	0.34
US small- to mid-cap	0.25	0.30	0.45	0.06	0.12	0.35	0.38
Canada	0.37	0.50	0.61	0.05	0.36	0.58	0.64
MSCI EAFE	0.33	0.35	0.52	0.05	0.20	0.41	0.48
UK	0.32	0.38	0.55	0.06	0.19	0.45	0.50
MSCI Europe	0.32	0.33	0.51	0.04	0.17	0.40	0.45
Japan	0.21	0.29	0.34	0.07	0.14	0.31	0.34
Asia Pacific ex-Japan	0.32	0.31	0.54	0.06	0.25	0.37	0.46
Emerging market	0.34	0.37	0.57	0.05	0.31	0.44	0.53
China Shanghai A Share	0.12	0.18	0.33	0.06	0.14	0.21	0.25
World equity	0.34	0.33	0.54	0.05	0.18	0.40	0.46
MSCI world ex-US	0.34	0.37	0.54	0.05	0.21	0.44	0.50

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 26: Correlation matrix for equities versus alternatives

■ 0.05 to 0.25 ■ 0.26 to 0.50 ■ 0.51 to 0.75 ■ 0.76 to 1.00

	US REITs	Global REITs	Global infrastructure	Private equity	Hedge funds	HF long/short	HF market neutral	HF global macro	HF event driven
US large-cap	0.60	0.73	0.77	0.86	0.77	0.80	0.34	0.24	0.74
US mid-cap	0.68	0.79	0.78	0.85	0.84	0.86	0.40	0.30	0.82
US small-cap	0.64	0.71	0.67	0.78	0.80	0.83	0.37	0.29	0.79
US small- to mid-cap	0.66	0.75	0.72	0.81	0.84	0.86	0.40	0.31	0.82
Canada	0.51	0.69	0.80	0.74	0.86	0.85	0.39	0.43	0.81
MSCI EAFE	0.58	0.79	0.89	0.90	0.82	0.83	0.40	0.35	0.78
UK	0.54	0.74	0.85	0.84	0.75	0.76	0.41	0.31	0.74
MSCI Europe	0.57	0.75	0.87	0.88	0.79	0.80	0.41	0.34	0.76
Japan	0.39	0.60	0.64	0.75	0.64	0.64	0.25	0.27	0.58
Asia Pacific ex-Japan	0.49	0.73	0.78	0.76	0.79	0.78	0.26	0.35	0.72
Emerging market	0.52	0.74	0.82	0.78	0.86	0.83	0.32	0.41	0.79
China Shanghai A Share	0.16	0.27	0.38	0.33	0.39	0.39	0.22	0.17	0.36
World equity	0.61	0.79	0.87	0.90	0.85	0.86	0.39	0.33	0.81
MSCI world ex-US	0.58	0.79	0.89	0.90	0.84	0.85	0.41	0.36	0.80

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 27: Correlation matrix for US bonds versus US bonds

-0.35 to -0.11 | -0.10 to 0.10 | 0.11 to 0.35 | 0.36 to 0.68 | 0.69 to 1.00

	US Treasury	US Treasury (long)	US Treasury (short)	US TIPS	US aggregate	US universe	US aggregate 1 to 3	US aggregate credit	US investment grade corps	US investment grade corps (long)	US high yield corps	US MBS	US municipals	US intermediate municipals	US bank loans	US preferred stocks
US Treasury	1.00															
US Treasury (long)	0.92	1.00														
US Treasury (short)	0.27	0.12	1.00													
US TIPS	0.66	0.60	0.12	1.00												
US aggregate	0.91	0.85	0.23	0.77	1.00											
US universe	0.82	0.76	0.18	0.79	0.98	1.00										
US aggregate 1 to 3	0.75	0.52	0.58	0.60	0.79	0.74	1.00									
US aggregate credit	0.65	0.63	0.06	0.72	0.88	0.94	0.64	1.00								
US investment grade corps	0.59	0.59	0.04	0.70	0.85	0.91	0.60	1.00	1.00							
US investment grade corps (long)	0.63	0.70	0.00	0.68	0.85	0.90	0.50	0.96	0.96	1.00						
US high yield corps	-0.17	-0.15	-0.15	0.30	0.18	0.37	0.03	0.51	0.55	0.49	1.00					
US MBS	0.83	0.73	0.31	0.64	0.90	0.86	0.76	0.69	0.64	0.63	0.04	1.00				
US municipals	0.55	0.53	0.06	0.54	0.69	0.69	0.47	0.67	0.65	0.62	0.27	0.57	1.00			
US intermediate municipals	0.65	0.59	0.11	0.58	0.74	0.73	0.57	0.69	0.66	0.63	0.20	0.64	0.95	1.00		
US bank loans	-0.35	-0.31	-0.16	0.17	-0.03	0.12	-0.12	0.28	0.32	0.22	0.78	-0.15	0.20	0.07	1.00	
US preferred stocks	0.12	0.12	-0.02	0.27	0.30	0.36	0.27	0.48	0.50	0.42	0.42	0.10	0.32	0.31	0.23	1.00

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 28: Correlation matrix for US bonds versus global bonds

-0.17 to -0.11 | -0.10 to 0.10 | 0.11 to 0.35 | 0.36 to 0.68 | 0.69 to 0.85

	Global aggregate	Global treasury	Global sovereign	Global corporate	Global investment grade	Canada aggregate	Canada Treasury	Canada corporate	Global aggregate ex-US	Global treasury ex-US	Global corporate ex-US	Emerging markets aggregate	Emerging markets aggregate sovereign	Emerging markets aggregate corporate	Emerging markets corporate investment grade	Emerging markets corporate high yield	Asian dollar investment grade	Asian dollar high yield
US Treasury	0.60	0.61	0.49	0.39	0.39	0.17	0.22	0.07	0.43	0.49	0.13	0.11	0.14	0.15	0.34	0.01	0.39	-0.11
US Treasury (long)	0.49	0.51	0.41	0.32	0.32	0.11	0.16	0.01	0.33	0.39	0.03	0.12	0.16	0.12	0.32	0.01	0.36	-0.11
US Treasury (short)	0.15	0.18	0.10	0.03	0.02	0.04	0.07	0.00	0.10	0.12	0.08	-0.04	-0.03	-0.10	0.01	-0.07	0.02	-0.17
US TIPS	0.66	0.63	0.72	0.67	0.66	0.47	0.49	0.42	0.54	0.54	0.46	0.44	0.43	0.60	0.66	0.37	0.63	0.37
US aggregate	0.71	0.68	0.71	0.66	0.66	0.39	0.42	0.32	0.53	0.56	0.37	0.36	0.37	0.49	0.62	0.27	0.60	0.20
US universe	0.73	0.68	0.79	0.76	0.76	0.51	0.52	0.45	0.56	0.57	0.48	0.54	0.53	0.63	0.75	0.46	0.71	0.37
US aggregate 1 to 3	0.62	0.60	0.55	0.53	0.53	0.28	0.30	0.23	0.49	0.51	0.41	0.18	0.17	0.35	0.40	0.11	0.42	0.06
US aggregate credit	0.69	0.61	0.78	0.84	0.85	0.55	0.53	0.51	0.54	0.53	0.53	0.56	0.54	0.72	0.78	0.50	0.71	0.47
US investment grade corps	0.67	0.58	0.76	0.84	0.85	0.55	0.53	0.52	0.52	0.51	0.52	0.57	0.54	0.73	0.77	0.50	0.71	0.49
US investment grade corps (long)	0.63	0.57	0.73	0.77	0.78	0.50	0.50	0.46	0.49	0.48	0.46	0.54	0.54	0.65	0.75	0.47	0.66	0.42
US high yield corps	0.28	0.19	0.52	0.60	0.61	0.58	0.52	0.62	0.27	0.20	0.52	0.66	0.61	0.78	0.67	0.68	0.49	0.73
US MBS	0.60	0.58	0.59	0.48	0.47	0.31	0.34	0.23	0.43	0.47	0.26	0.30	0.31	0.38	0.50	0.22	0.53	0.13
US municipals	0.45	0.41	0.50	0.49	0.50	0.29	0.29	0.26	0.33	0.33	0.19	0.30	0.31	0.37	0.48	0.24	0.45	0.21
US intermediate municipals	0.51	0.48	0.51	0.49	0.49	0.28	0.29	0.24	0.38	0.41	0.20	0.27	0.28	0.32	0.46	0.20	0.44	0.14
US bank loans	0.05	-0.06	0.26	0.39	0.41	0.40	0.33	0.49	0.07	-0.02	0.27	0.40	0.33	0.61	0.40	0.46	0.35	0.65
US preferred stocks	0.34	0.30	0.38	0.51	0.50	0.27	0.25	0.30	0.31	0.29	0.36	0.27	0.26	0.32	0.38	0.24	0.24	0.24

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 29: Correlation matrix for US bonds versus commodities

-0.30 to -0.11 | -0.10 to 0.10 | 0.11 to 0.35 | 0.36 to 0.43

	Agriculture	Energy	Industrial metals	Livestock	Precious metals	Commodities	BB commodities
US Treasury	0.01	-0.14	-0.24	-0.11	0.22	-0.15	-0.09
US Treasury (long)	-0.06	-0.21	-0.30	-0.06	0.18	-0.22	-0.16
US Treasury (short)	0.00	0.04	-0.01	-0.07	0.05	0.02	0.04
US TIPS	0.23	0.17	0.13	-0.01	0.42	0.21	0.29
US aggregate	0.10	-0.05	-0.09	-0.10	0.30	-0.04	0.05
US universe	0.16	0.03	0.02	-0.08	0.34	0.05	0.15
US aggregate 1 to 3	0.15	0.01	-0.02	-0.15	0.27	0.02	0.11
US aggregate credit	0.21	0.07	0.10	-0.05	0.32	0.10	0.21
US investment grade corps	0.21	0.08	0.12	-0.05	0.31	0.11	0.22
US investment grade corps (long)	0.16	0.02	0.03	-0.03	0.27	0.05	0.15
US high yield corps	0.27	0.27	0.43	0.01	0.17	0.33	0.39
US MBS	0.04	-0.10	-0.13	-0.13	0.30	-0.10	-0.02
US municipals	0.02	-0.06	-0.07	-0.05	0.12	-0.05	-0.01
US intermediate municipals	0.01	-0.10	-0.12	-0.10	0.18	-0.10	-0.05
US bank loans	0.16	0.37	0.42	0.09	0.05	0.40	0.38
US preferred stocks	0.22	0.10	0.20	0.02	0.03	0.14	0.21

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 30: Correlation matrix for global bonds versus global bonds

0.19 to 0.35 0.36 to 0.68 0.69 to 1.00

	Global aggregate	Global treasury	Global sovereign	Global corporate	Global investment grade	Canada aggregate	Canada Treasury	Canada corporate	Global aggregate ex-US	Global treasury ex-US	Global corporate ex-US	Emerging markets aggregate	Emerging markets aggregate sovereign	Emerging markets aggregate corporate	Emerging markets corporate investment grade	Emerging markets corporate high yield	Asian dollar investment grade	Asian dollar high yield
Global aggregate	1.00																	
Global treasury	0.98	1.00																
Global sovereign	0.89	0.81	1.00															
Global corporate	0.88	0.79	0.92	1.00														
Global investment grade	0.85	0.74	0.91	0.99	1.00													
Canada aggregate	0.61	0.55	0.71	0.72	0.70	1.00												
Canada Treasury	0.63	0.59	0.71	0.70	0.68	0.99	1.00											
Canada corporate	0.56	0.49	0.66	0.70	0.69	0.99	0.97	1.00										
Global aggregate ex-US	0.97	0.97	0.85	0.85	0.81	0.60	0.62	0.56	1.00									
Global treasury ex-US	0.97	0.99	0.80	0.79	0.74	0.55	0.57	0.49	0.99	1.00								
Global corporate ex-US	0.84	0.74	0.84	0.88	0.87	0.66	0.66	0.64	0.88	0.79	1.00							
Emerging markets aggregate	0.38	0.42	0.76	0.71	0.72	0.61	0.60	0.61	0.33	0.29	0.63	1.00						
Emerging markets aggregate sovereign	0.38	0.45	0.78	0.70	0.70	0.59	0.58	0.58	0.33	0.30	0.62	0.98	1.00					
Emerging markets aggregate corporate	0.55	0.41	0.77	0.77	0.78	0.68	0.64	0.68	0.50	0.42	0.62	0.94	0.88	1.00				
Emerging markets corporate investment grade	0.58	0.53	0.87	0.80	0.81	0.66	0.65	0.64	0.50	0.46	0.64	0.89	0.87	0.90	1.00			
Emerging markets corporate high yield	0.34	0.33	0.69	0.65	0.65	0.61	0.59	0.63	0.31	0.26	0.61	0.98	0.96	0.93	0.84	1.00		
Asian dollar investment grade	0.51	0.52	0.81	0.79	0.81	0.56	0.54	0.54	0.41	0.38	0.55	0.74	0.73	0.88	0.85	0.70	1.00	
Asian dollar high yield	0.28	0.23	0.62	0.65	0.66	0.60	0.56	0.64	0.26	0.19	0.55	0.78	0.73	0.91	0.76	0.80	0.74	1.00

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 31: Correlations matrix for global bonds versus commodities

-0.16 to -0.11 | -0.10 to 0.10 | 0.11 to 0.35 | 0.36 to 0.57

	Agriculture	Energy	Industrial metals	Livestock	Precious metals	Commodities	BB commodities
Global aggregate	0.33	0.18	0.25	-0.11	0.49	0.23	0.36
Global treasury	0.32	0.13	0.23	-0.16	0.50	0.19	0.33
Global sovereign	0.39	0.22	0.33	-0.07	0.46	0.29	0.43
Global corporate	0.39	0.29	0.38	-0.04	0.44	0.36	0.48
Global investment grade	0.37	0.29	0.37	-0.03	0.41	0.36	0.47
Canada aggregate	0.35	0.41	0.48	0.03	0.47	0.47	0.55
Canada Treasury	0.35	0.39	0.45	0.03	0.48	0.46	0.54
Canada corporate	0.35	0.44	0.52	0.04	0.44	0.50	0.57
Global aggregate ex-US	0.35	0.23	0.31	-0.10	0.48	0.29	0.40
Global treasury ex-US	0.32	0.17	0.25	-0.13	0.48	0.22	0.35
Global corporate ex-US	0.46	0.40	0.48	-0.02	0.42	0.47	0.55
EM aggregate	0.24	0.21	0.33	0.02	0.35	0.26	0.35
EM aggregate sovereign	0.22	0.17	0.29	0.01	0.33	0.21	0.31
EM aggregate corporate	0.35	0.32	0.41	0.05	0.41	0.38	0.48
EM corporate investment grade	0.31	0.18	0.27	0.02	0.36	0.24	0.35
EM corporate high yield	0.23	0.27	0.39	0.03	0.34	0.31	0.39
Asian dollar investment grade	0.21	0.16	0.21	0.03	0.36	0.21	0.29
Asian dollar high yield	0.29	0.27	0.46	0.04	0.29	0.34	0.42

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 32: Correlation matrix for commodities versus commodities

-0.04 to 0.10 | 0.11 to 0.35 | 0.36 to 0.68 | 0.69 to 1.00

	Agriculture	Energy	Industrial metals	Livestock	Precious metals	Commodities	BB commodities
Agriculture	1.00						
Energy	0.26	1.00					
Industrial metals	0.33	0.40	1.00				
Livestock	-0.04	0.12	0.07	1.00			
Precious metals	0.29	0.24	0.35	-0.04	1.00		
Commodities	0.41	0.98	0.50	0.15	0.31	1.00	
BB commodities	0.63	0.82	0.64	0.13	0.49	0.90	1.00

Source: Invesco, data from March 31, 1998 to March 31, 2018. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

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All data provided by Invesco, in U S D and as of June 30, 2018.

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