



Capital market assumptions: A building block methodology

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 necessary foundation for creating long-term forecasts for the behavior of different asset classes. Specifically, for each of the asset classes in which we invest, we develop assumptions with regard to expected return, standard deviation of return (volatility) and correlation with other asset classes. We evaluate current and historical market data, in the context of a 10-year investment horizon, in order to develop guidelines for our long-term, strategic asset allocation decisions.

This document details our long-term asset class forecasts and the supporting methodology. Invesco Global Solutions' CMAs encompass a broad array of asset classes across equity, fixed income and commodity markets globally.

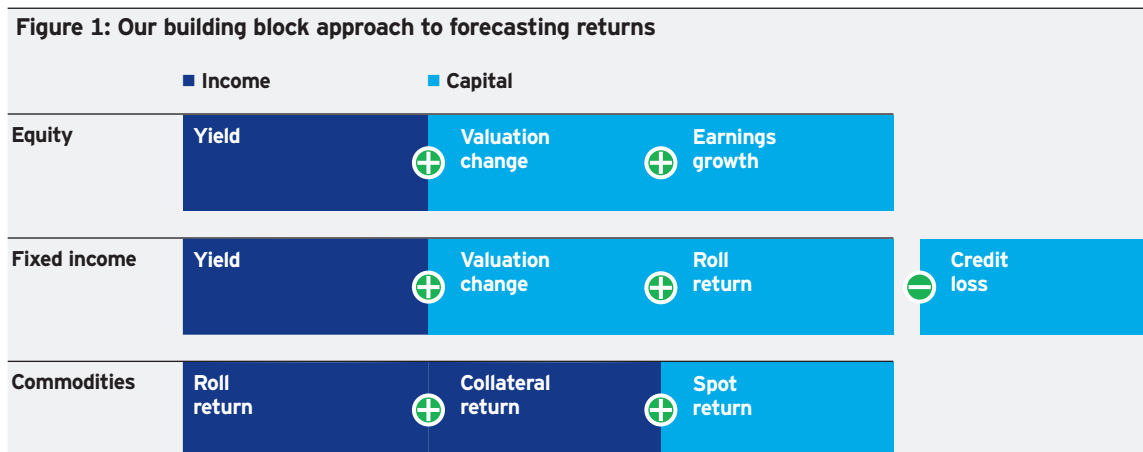
Our capital market
assumptions are based
on a 10-year investment
horizon.

Expected returns: A 'building block' approach to forecasting returns

We employ a fundamentally based "building block" approach to forecasting asset class returns. Building blocks represent a "bottom-up" approach where 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 expected return forecasts.

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 estimates through time where 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.



For illustrative purposes only.

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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 of our forecast therefore consist of estimates for yield (as a driver of income) and earnings growth and valuation change (as drivers of capital appreciation). We begin the forecast by looking at large-cap US equities:

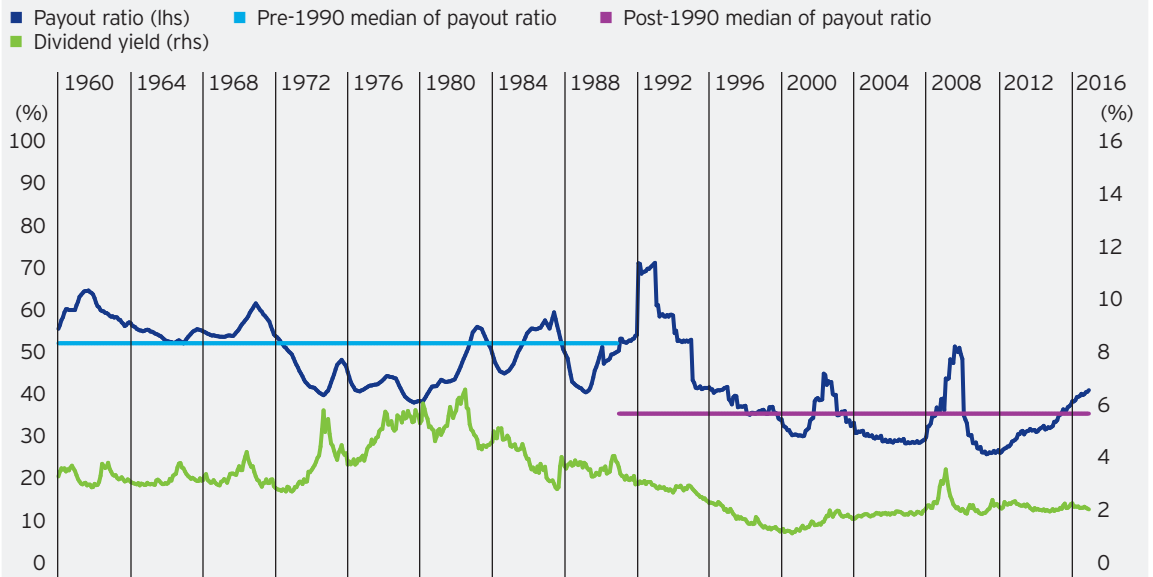


1. Total yield

Our approach to forecasting yield 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 (Figure 2), which benefited returns in the form of capital gains over income.

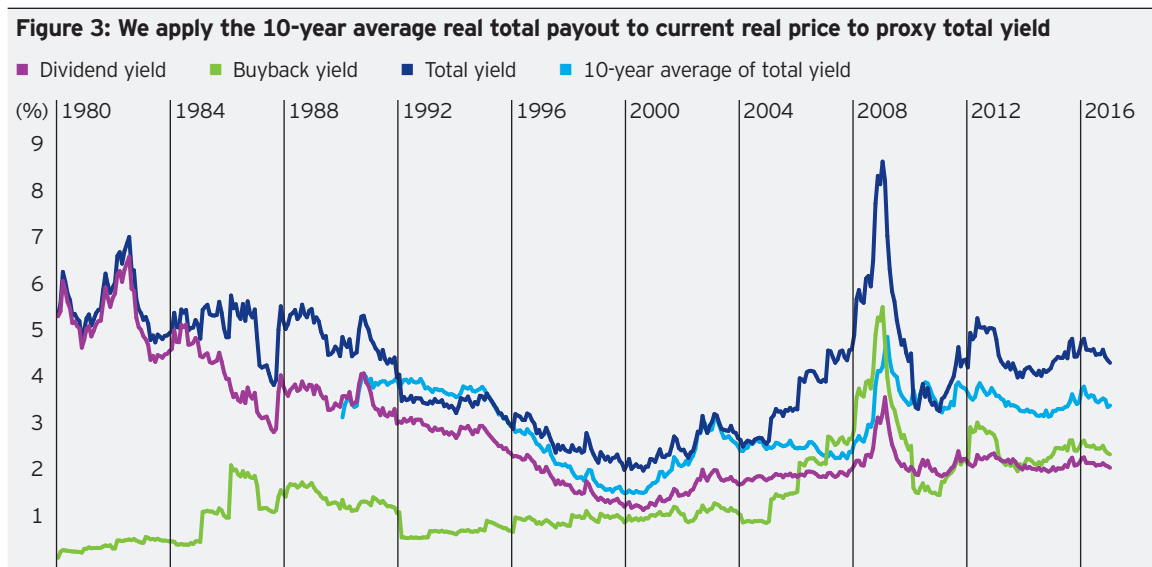
To reflect the impact of both dividend yield and buybacks, we base the estimate for total yield on the 10-year average total yield ratio.

Figure 2: The dividend payout ratio decreased meaningfully after 1990



Sources: Robert Shiller <http://www.econ.yale.edu/~shiller/data.htm>; FactSet from January 1960 to January 2017. Based on S&P 500 Index.

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 base the estimate for total yield on the 10-year average total yield ratio to bridge the gap in terms of how capital is transferred (Figure 3).



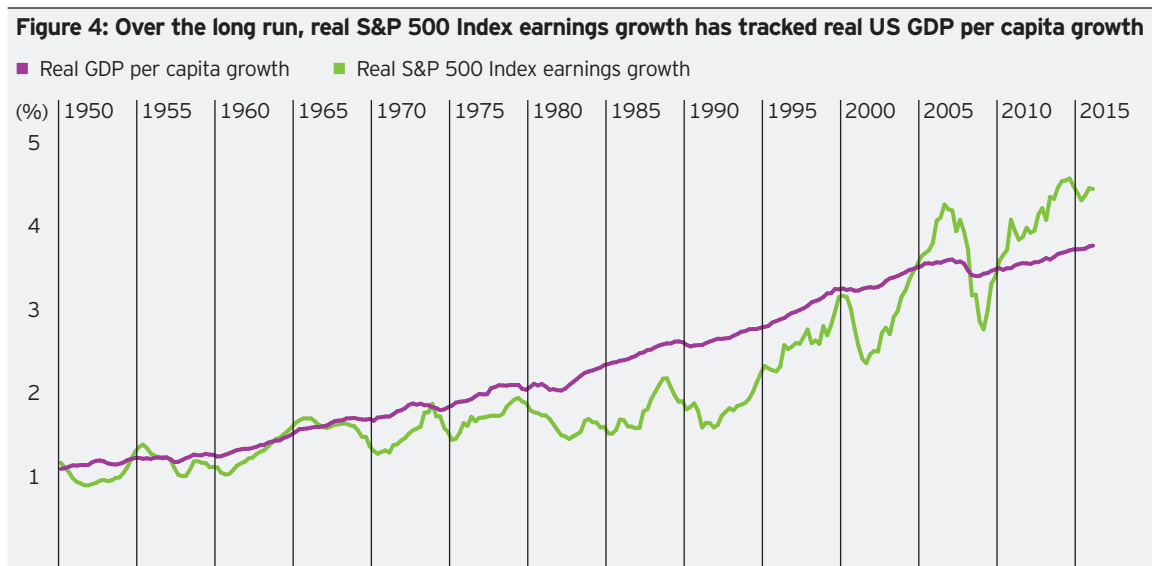
Source: FactSet from January 1980 to January 2017. Based on S&P 500 Index.

Looking back, this measure indicated that in terms of yield, equities were less attractive during the mid- to late-1990s and that following the great financial crisis they were more attractive.

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

2. Earnings growth

Growth of earnings per share is one of two significant drivers of capital appreciation in stock returns. One issue with using past earnings to forecast future earnings growth is 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 4). Consequently, we use real GDP per capita – which also appears to have been a more stable signal over time – to forecast earnings growth in the model.

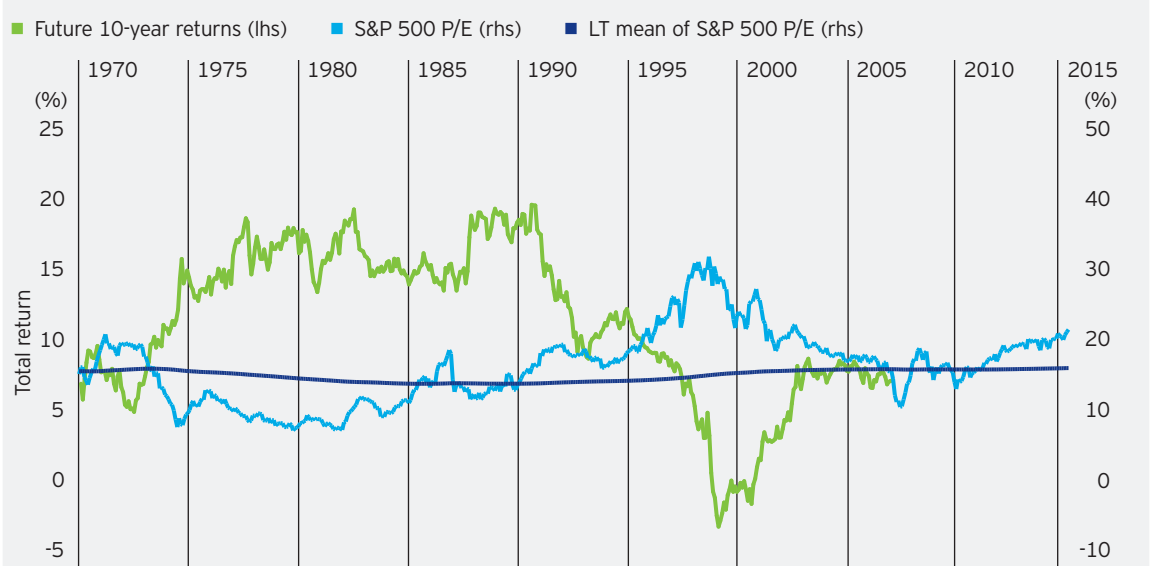


Sources: Robert Shiller <http://www.econ.yale.edu/~shiller/data.htm>; FactSet and St. Louis Federal Reserve from January 1950 to January 2017.

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 forecasting 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 5).

Figure 5: The P/E ratio of the S&P 500 Index has tended to revert to the mean



Sources: Robert Shiller <http://www.econ.yale.edu/~shiller/data.htm>; FactSet from February 1970 to January 2017.

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

Our first step, therefore, in forecasting the change in equity valuation, is to forecast the 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 through regression analysis, using monthly data as follows:

Example 1: Estimating the long-term mean of the P/E ratio using regression analysis

A regression of monthly data (January 1970 – January 2017) yielded the following coefficients:

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

RF = Risk free rate

π = Inflation

a = 20.79

b = -0.52

c = -0.60

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 Jan. 31, 2017 totaled 2.43% and 2.10%, respectively:

$$P/E = 20.79 - 0.52 \times 2.43 - 0.60 \times 2.10 = 18.89$$

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 Jan. 31, 2017.

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.

Next, in order to forecast the potential for valuation change, we look at current valuation relative to the rolling five-year 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.

$$\text{Valuation change} = \left(\frac{\widehat{P/E}_{5 \text{ year}}}{P/E_{\text{current}}} \right)^{1/10} - 1$$

We 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 expected returns.

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

The building block approach is applied uniformly across all segments of the global equity market to include size (mid- and small-cap) and style (growth/value), as well as non-US developed equity and emerging markets. Figure 6 highlights our approach for estimating returns for the various segments of the market.

We apply the basic building blocks of yield, earnings growth and valuation change across equity investment styles and geographies.

As we have mentioned before, one of the benefits of this approach is that you get a better sense of where the returns are coming from (i.e., drivers), and you have the flexibility to explore those factors in greater depth.

It's also a very "portable" methodology in that it can be adapted for different markets. Let's take a closer look at US small-cap equities, which have the same drivers of return as large-cap equities – forecast yield, earnings growth and valuation change. We adapt the methodology for this sub-asset class by looking at these drivers in the context of the US small-cap equity market using the Russell 2000 Index. Another example is international equities. Since we also want to extend our asset allocation decisions to international equities, we must validate that our building block methodology is flexible enough to be relevant and accurate for these markets. The basic building blocks of yield, earnings growth and valuation change are still relevant. As we previously discussed, in forecasting yield, the impact for share repurchases is minimal for international markets relative to the US market. For earnings growth and valuation change, we employ the US equity market methodology using the appropriate benchmark metrics.

Figure 6: Applying building block methodology to equity sub-asset classes			
	Valuation change	Earnings growth	Total yield
US large-cap equity	Mean P/E reversal of each index x Scaling factors	Long-term real US GDP per capita growth x US expected inflation	Dividends + Buybacks = Total yield
US 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.

Forecasted equity returns

Figure 7: 10-year expected equity market total returns (USD)

Asset class	Index	Expected return (%)	Yield (%)	Earnings growth (%)	Valuation change (%)
US large-cap	S&P 500	6.35	3.25	3.93	-0.83
US small-cap	Russell 2000	5.73	1.79	5.55	-1.62
US mid-cap	Russell Midcap	6.12	2.67	4.66	-1.21
US top 200	Russell Top 200	6.38	3.36	3.94	-0.93
US small-cap/mid-cap	Russell 2500	6.06	2.16	5.23	-1.32
US broad market	Russell 3000	6.25	3.05	4.26	-1.06
International	MSCI World Ex-US	6.02	3.08	3.39	-0.44
Developed markets	MSCI EAFE	5.99	3.12	3.37	-0.50
Europe	MSCI Europe	5.96	3.42	3.35	-0.82
Canada	S&P TSX	6.34	2.63	3.58	0.13
UK	MSCI UK	5.65	3.91	4.00	-2.26
Eurozone	MSCI Euro Ex-UK	6.08	3.22	3.09	-0.23
Japan	MSCI JP	4.85	2.00	2.78	0.06
Pacific ex-Japan	MSCI Pacific Ex-JP	8.39	3.80	4.59	0.00
Asia Pacific ex-Japan	MSCI APXJ	8.37	3.01	4.38	0.97
Emerging market	MSCI EM	8.21	2.53	4.67	1.01
World equity ex-US	MSCI ACWI Ex-US	6.54	2.95	3.69	-0.10
World equity	MSCI ACWI	6.43	3.11	3.82	-0.50

Source: Invesco, estimates as of Feb. 28, 2017. All total returns data is annual. For illustrative purposes only.

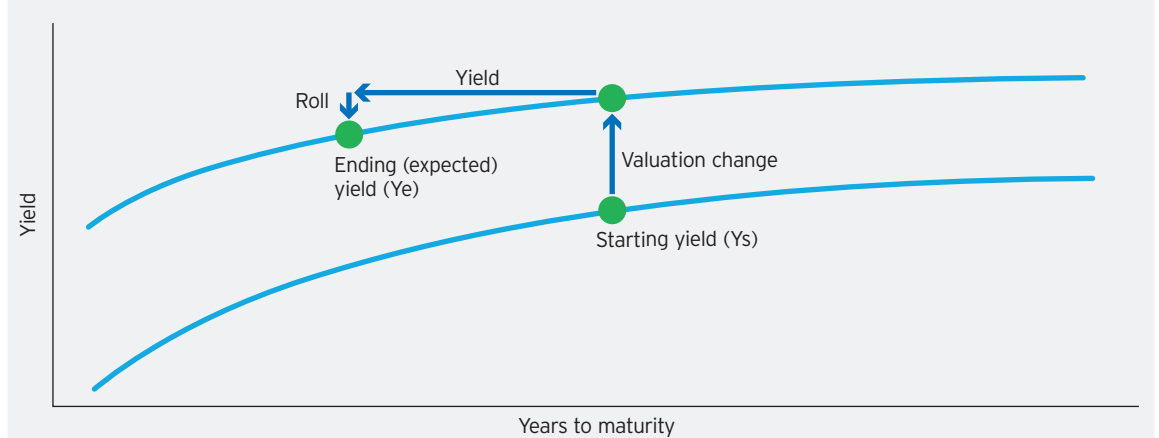
Fixed income

Within fixed income, we also utilize the building block methodology to forecast returns over a 10-year horizon. Again, we seek 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 and valuation change).



The forecast for total yield reflects the average for the starting (current) yield and expected yield.

Figure 8: Single period return decomposition



For illustrative purposes only.

1. Total yield

Yield reflects the average cash flow (income) expected to be received from an investment in a fixed income security. With some exceptions, these cash flows are generally fixed throughout the life of the bond. Since the yield level is forecasted to change over the full period, the yield component of the return is computed as the average of the starting and ending yield levels.

Expected yield

The expected 10-year yield reflects the yield forecasted as a result of changes **along** the current yield curve, **of** the current yield curve, and **between** the current and forecasted future yield curves.

Let's take a closer look at the potential impact of these yield curve movements.

To forecast the expected yield that results from the potential movement of the yield curve, we need to account for changes both in (i) Treasury interest rates and in (ii) credit spreads over US Treasuries:

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

(i) ΔY_{TSY} = Changes in Treasury interest rates (at a given duration)

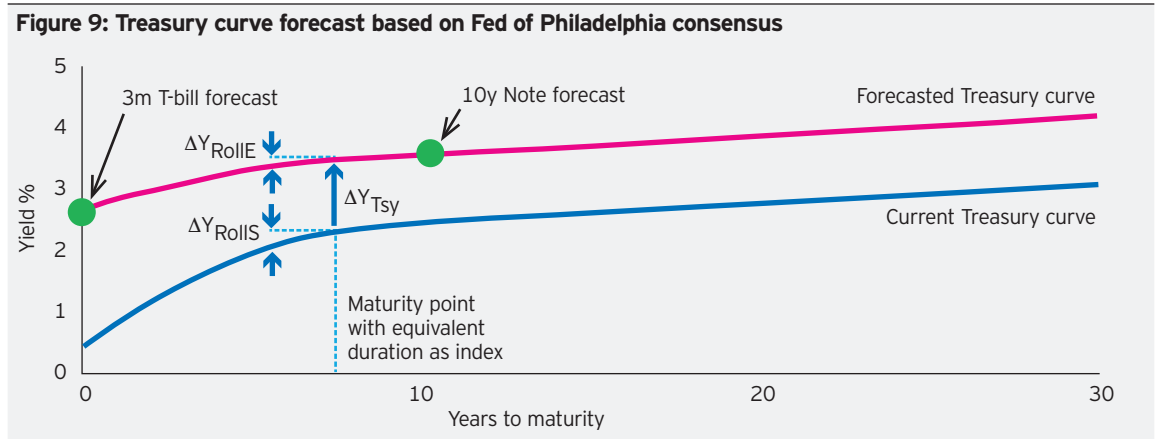
(ii) ΔOAS = Changes in credit spreads over US Treasuries

The **current yield curve** is our point of departure.

(i) Changes in Treasury interest rates

$$\Delta Y_{TSY} = \text{Interest rate}_{\text{Forecasted Treasury curve}} - \text{Interest rate}_{\text{Current Treasury curve}}$$

To forecast this driver, we rely on consensus forecasts from the Federal Reserve Bank of Philadelphia (Philadelphia Fed) for three-month Treasury bills, as well as 10-year Treasury notes (Figure 9).



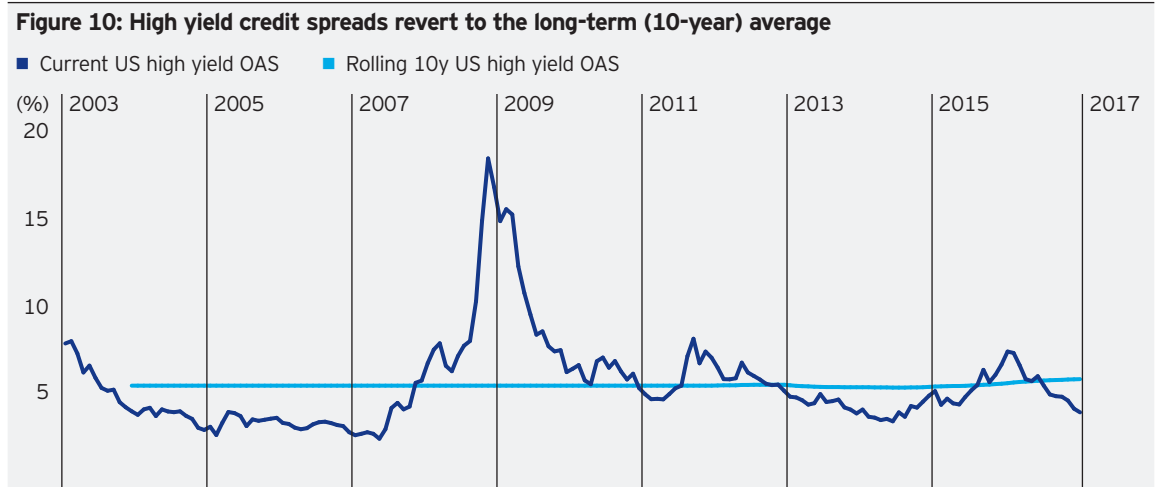
For illustrative purposes only.

(ii) Changes in credit spreads

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

Academic research (Prigent et al., 2001) has indicated that credit spreads have historically exhibited mean-reverting properties. 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 forecast the changes in that spread by looking at the relationship between current credit spreads and their 10-year rolling average (Figure 10). 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).



Source: FactSet from January 2003 to January 2017. High yield based on BBG BARC US Credit Index, Barclays US Corp. High Yield Index. Option-adjusted spreads (OAS) account for bonds with embedded options, such as callable bonds.

Example 2: Forecasting expected and total yield

Maturity = 6 years
Starting yield = 2.61%

Expected yield

1 Movement in interest rates

- Interest rates at a maturity of six years on the current yield curve = 2.05%
- Interest rates at a maturity of six years on the future yield curve = 2.72%

2 Movement in credit spreads

- Current credit spread = 0.44%
- Rolling 10-year credit spread = 0.72%

Expected yield forecast = 2.61% + (2.72% - 2.05%) + (0.72% - 0.44%) = 3.56%

Total yield forecast = (2.61% + 3.56%)/2 = 3.09%

For illustrative purposes only. Data as of Jan. 31, 2017.

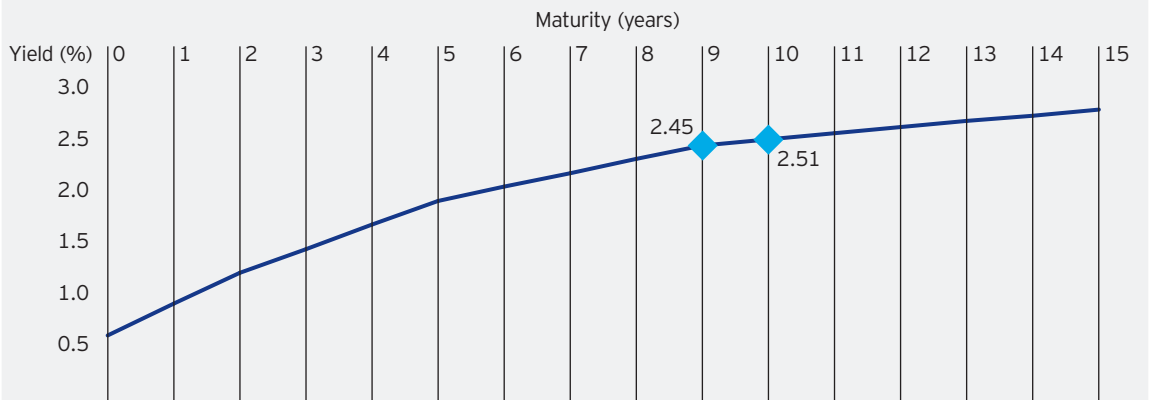
2. Roll return

Roll return reflects the impact 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 11). 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 10-year US Treasury bond, which yields 2.51% on Jan. 31, 2017. Assuming no changes to the yield curve, a year from now, the maturity of the bond would have decreased to nine years, which corresponds to a yield (on the current yield curve, which has not changed/moved) of 2.45%. Given the inverse relationship between the price and yield on bonds, in order for the yield on the bond we purchased to fall from 2.51% to 2.45%, the price of the bond needs to increase – which represents the capital appreciation.

Figure 11: Roll return reflects the impact on yield and price as a bond is held over time



Sources: FactSet, Federal Reserve of Philadelphia as of Jan. 31, 2017

Example 3: Forecasting roll return

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

$$\text{Roll return} = -(t - 1) \times \Delta y$$
$$\Delta y = \text{Interest rate}_{t-1} - \text{Interest rate}_t$$

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 forecasted 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 = 2.04%	6-year maturity = 2.72%
5-year maturity = 1.91%	5-year maturity = 2.62%

Current roll return = $-5 \times (1.91\% - 2.04\%) = 0.65\%$

Future roll return = $-5 \times (2.62\% - 2.72\%) = 0.50\%$

Roll return = $(0.65\% + 0.50\%) / 2 = 0.58\%$

For illustrative purposes only. Data as of Jan. 31, 2017.

3. Valuation change

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. As discussed above in the context of returns from yield, this comprises movement due to changes in interest rates and credit spreads, respectively.

Example 4: Forecasting valuation change

We forecast the impact of this change as follows:

For Maturity = t

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

From the *total yield* calculation (Example 2) 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:

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

Maturity = 6 years
Starting yield = 2.61%
Expected yield = 3.56%

Valuation change = $[1 - 6 \times (3.56\% - 2.61\%)]^{1/10} - 1 = -0.59\%$

For illustrative purposes only.

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

The expected impact on return from:

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

4. Credit loss

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. If, for example, an investment grade security has been downgraded below investment grade (BB or lower), a portfolio manager might have to replace the security in order to maintain the investment grade rating of the portfolio (as an investment rule), requiring the selling of the security – most likely at a loss. The expected 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.
- **Expected 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 expected default loss is a function of the expected 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.

Forecasted fixed income returns

Figure 12: 10-year expected fixed income market total returns (USD)

Asset class	Index	Expected return (%)	Yield (%)	Roll return (%)	Valuation change (%)	Credit loss (%)
US Treasury	BBG BARC US Treasury (10Y)	2.40	2.45	0.67	-0.71	
US Treasury (long)	BBG BARC US Treasury Long	1.95	3.48	0.77	-2.30	
US Treasury (short)	BBG BARC US Treasury Short	1.64	1.64	0.00	0.00	
US TIPS	BBG BARC US TIPS	2.65	2.90	0.68	-0.94	
US aggregate	BBG BARC US Aggregate	2.88	3.29	0.67	-0.90	-0.17
US universe	BBG BARC US Universe	3.05	3.66	0.67	-0.96	-0.32
US aggregate 1 to 3	BBG BARC US Corporate and Government (1Y-3Y)	2.14	2.31	0.27	-0.36	-0.08
US aggregate credit	BBG BARC US Aggregate Credit	3.02	4.05	0.70	-1.29	-0.44
US IG corporates	BBG BARC US Investment Grade	3.05	4.18	0.70	-1.37	-0.46
US IG corporates (long)	BBG BARC US Long Credit	2.84	5.22	0.73	-2.45	-0.66
US HY corporates	BBG BARC US High Yield	4.87	7.31	0.48	-1.48	-1.44
US MBS	BBG BARC US MBS	3.41	3.61	0.59	-0.78	
US municipals	BOA ML US Taxable Municipal	3.66	3.95	0.70	-0.99	
US intermediate municipals	BOA ML US Taxable Muni (3Y-15Y)	3.34	3.50	0.67	-0.82	
US bank loans	CSFB Leverage Loan Index	4.43	6.09	0.00	-0.21	-1.44
US preferred stocks	BOA ML Fixed Rate Pref Securities	4.51	6.51	0.59	-1.15	-1.44
Global aggregate	BBG BARC Global Aggregate	1.80	2.23	0.70	-0.94	-0.18
Global Treasury	BBG BARC Global Treasuries	1.32	1.57	0.68	-0.94	
Global sovereign	BBG BARC Global Sovereign	3.21	3.53	0.70	-1.03	
Global corporate	BBG BARC Global Corporate	2.40	3.46	0.70	-1.29	-0.48
Global IG	BBG BARC Global Corporate Inv Grd	2.45	3.58	0.70	-1.36	-0.48
Canada aggregate	FTSE TMX Universe Bond	2.24	2.65	0.70	-0.86	-0.26
Canada Treasury	BOA Merrill Lynch Canada Government	1.75	1.86	0.70	-0.81	
Canada corporate	BOA Merrill Lynch Canada Corporate	2.64	3.38	0.67	-0.91	-0.48
Global aggregate ex-US	BBG BARC Global Aggregate- Ex US	0.83	1.35	0.68	-1.03	-0.18
Global Treasury ex-US	BBG BARC Global Treasuries- Ex US	0.98	1.23	0.68	-0.94	
Global corporate ex-US	BBG BARC Global Corporate- Ex US	0.82	1.50	0.67	-0.92	-0.42
EM aggregate	BBG BARC EM Aggregate	3.98	5.72	0.67	-1.33	-1.07
EM aggregate sovereign	BBG BARC EM Sovereign	4.33	5.80	0.70	-1.02	-1.16
EM aggregate corporate	BBG BARC EM Corporate	4.06	5.87	0.59	-1.34	-1.06
EM corporate IG	BBG BARC Emerging Markets USD Aggregate - Corporate -IG	3.37	4.62	0.67	-1.27	-0.63
EM corporate HY	BBG BARC Emerging Markets USD Aggregate - Corporate -IG	5.34	7.52	0.59	-1.31	-1.46
Asian dollar IG	BOA Merrill Lynch ACIG	3.26	4.34	0.59	-1.11	-0.55
Asian dollar HY	BOA Merrill Lynch ACHY	5.63	8.13	0.36	-1.39	-1.46

Source: Invesco, estimates as of Feb. 28, 2017. All total returns data is annual.

Commodities

Exposure to commodities within an asset allocation framework is sometimes achieved through investment in futures contracts, which represent an agreement to buy or sell a predetermined amount of a commodity at a specific price on a specific date in the future. We use the futures curve, which is a graphical representation of commodity contracts that expire at different maturities, to help us understand the drivers of commodity returns. As with other asset classes, we apply the building block approach to identify yield (collateral return and roll return) and appreciation (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: agriculture, energy, industrial metals, livestock and precious metals (Figure 13). In order to forecast commodity returns, as represented by these indices, we begin by forecasting the returns of the individual commodity groups and then aggregating these forecasts, based on the weights below.

Figure 13: 10-year composition of commodity indices (USD)

2017 weights	S&P GSCI (%)	Bloomberg Commodity Index (%)
Agriculture	19.88	30.68
Energy	56.24	30.57
Industrial metals	9.71	17.39
Livestock	9.23	6.07
Precious metals	4.93	15.29

Sources: Standard & Poor's and Bloomberg. Data as of Feb. 28, 2017

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 – primarily 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, which we model through the *difference between historical excess returns, which include 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 forecasting the real spot return, *we use the long-term historical average, dating backing to 1970, of real spot monthly returns.*

Forecasted commodity returns

Figure 14: 10-year expected commodity market total returns (USD)

Asset class	Index	Expected return (%)	Collateral return (%)	Roll return (%)	Spot return (%)
Agriculture	S&P GSCI Agriculture	0.90	1.58	-2.85	2.17
Energy	S&P GSCI Energy	7.61	1.58	2.73	3.30
Industrial metals	S&P GSCI Industrial Metals	5.35	1.58	-0.22	3.99
Livestock	S&P GSCI Livestock	2.87	1.58	-0.33	1.61
Precious metals	S&P GSCI Precious Metals	2.87	1.58	-4.25	5.55
Commodities	S&P GSCI	5.39	1.58	0.70	3.10
BB commodities	Bloomberg Commodity Index	4.15	1.58	-0.75	3.32

Source: Invesco, estimates as of Feb. 28, 2017. All total returns data is annual.

Constructing a multi-asset portfolio: Forecasting volatility and correlation

In order to construct multi-asset, goal-oriented portfolios that seek diversification and focus on specific investment outcomes, in addition to returns, we 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 forecasted using rolling historical quarterly returns that are normalized for shorter-lived benchmarks.

To forecast 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, by designating one benchmark to represent the full history for an asset class (Figure 15). The sub-asset classes with shorter histories are then adjusted based on their relationship to the representative benchmark. For example, to forecast 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 15: 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

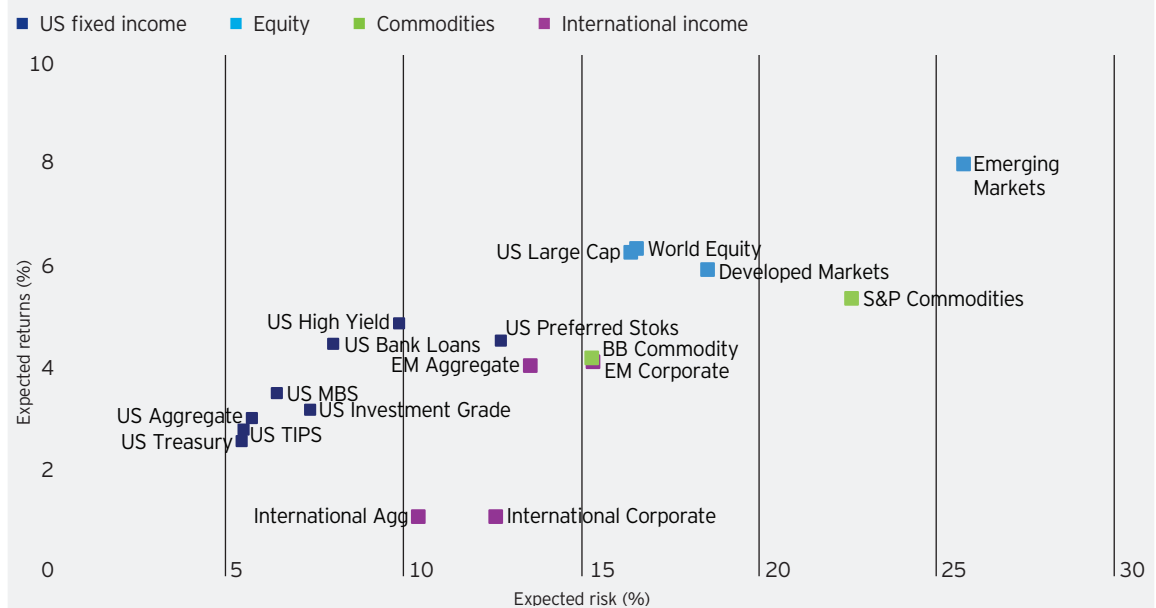
Correlation

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.

Figure 16: 10-year asset class expected risk/return (USD)



Source: Invesco, estimates as of Feb. 28, 2017. Proxies listed in figure 17, page 16. For illustrative purposes only.

Forecasted asset class returns

Figure 17: 10-year asset class expected total returns and standard deviations (USD)

	Asset class	Index	Expected return (%)	Standard deviation	Return/risk
Equity	US large-cap	S&P 500	6.35	16.56	0.38
	US small-cap	Russell 2000	5.73	22.38	0.26
	US mid-cap	Russell Midcap	6.12	19.16	0.32
	US top 200	Russell Top 200	6.38	16.45	0.39
	US small-mid	Russell 2500	6.06	20.89	0.29
	US broad market	Russell 3000	6.25	17.29	0.36
	International	MSCI World Ex-US	6.02	18.70	0.32
	Developed	MSCI EAFE	5.99	18.68	0.32
	Europe	MSCI Europe	5.96	18.67	0.32
	Canada	S&P TSX	6.34	20.07	0.32
	UK	MSCI UK	5.65	21.47	0.26
	Eurozone	MSCI Euro Ex-UK	6.08	19.76	0.31
	Japan	MSCI JP	4.85	23.09	0.21
	Pacific ex-Japan	MSCI Pacific Ex-JP	8.39	25.35	0.33
	Asia Pacific ex-Japan	MSCI APXJ	8.37	26.14	0.32
	Emerging markets (EM)	MSCI EM	8.21	25.76	0.32
	World equity ex-US	MSCI ACWI Ex-US	6.54	18.88	0.35
	World equity	MSCI ACWI	6.43	16.73	0.38
	US bonds	US Treasury	BBG BARC US Treasury (10Y)	2.40	5.83
US Treasury (long)		BBG BARC US Treasury Long	1.95	11.57	0.17
US Treasury (short)		BBG BARC US Treasury Short	1.64	1.56	1.05
US TIPS		BBG BARC US TIPS	2.65	5.88	0.45
US aggregate		BBG BARC US Aggregate	2.88	6.11	0.47
US universe		BBG BARC US Universe	3.05	5.81	0.53
US aggregate 1 to 3		BBG BARC US Corporate and Government (1Y-3Y)	2.14	3.33	0.64
US aggregate credit		BBG BARC US Aggregate Credit	3.02	7.62	0.40
US IG corporates		BBG BARC US Investment Grade	3.05	7.72	0.40
US IG corporates (long)		BBG BARC US Long Credit	2.84	9.84	0.29
US HY corporates		BBG BARC US High Yield	4.87	10.18	0.48
US MBS		BBG BARC US MBS	3.41	6.80	0.50
US municipals		BofA ML US Taxable Municipal	3.66	8.23	0.44
US intermediate municipals		BofA ML US Taxable Muni (3Y-15Y)	3.34	6.26	0.53
US bank loans		CSFB Leverage Loan Index	4.43	8.36	0.53
US preferred stocks	BofA ML Fixed Rate Pref Securities	4.51	12.99	0.35	
Global bonds	Global aggregate	BBG BARC Global Aggregate	1.80	7.08	0.25
	Global Treasury	BBG BARC Global Treasuries	1.32	8.87	0.15
	Global sovereign	BBG BARC Global Sovereign	3.21	6.74	0.48
	Global corporate	BBG BARC Global Corporate	2.40	7.57	0.32
	Global IG	BBG BARC Global Corporate Inv Grd	2.45	7.76	0.32
	Canada aggregate	FTSE TMX Universe Bond	2.24	9.87	0.23
	Canada Treasury	BofA Merrill Lynch Canada Government	1.75	9.28	0.19
	Canada corporate	BofA Merrill Lynch Canada Corporate	2.64	10.89	0.24
	Global aggregate ex-US	BBG BARC Global Aggregate - Ex-US	0.83	10.71	0.08
	Global Treasury ex-US	BBG BARC Global Treasuries - Ex-US	0.98	10.80	0.09
	Global corporate ex-US	BBG BARC Global Corporate - Ex-US	0.82	12.85	0.06
EM bonds	EM aggregate	BBG BARC EM Aggregate	3.98	13.79	0.29
	EM aggregate sovereign	BBG BARC EM Sovereign	4.33	12.66	0.34
	EM aggregate corporate	BBG BARC EM Corporate	4.06	15.52	0.26
	EM corporate IG	BBG BARC EM USD Aggregate - Corp-IG	3.37	8.45	0.40
	EM corporate HY	BBG BARC EM USD Aggregate - Corp-HY	5.34	15.51	0.34
	Asian dollar IG	BOA Merrill Lynch ACIG	3.26	9.05	0.36
	Asian dollar HY	BOA Merrill Lynch ACHY	5.63	19.45	0.29
Commodity	Agriculture	S&P GSCI Agriculture	0.90	21.98	0.04
	Energy	S&P GSCI Energy	7.61	34.80	0.22
	Industrial metals	S&P GSCI Industrial Metals	5.35	24.73	0.22
	Livestock	S&P GSCI Livestock	2.87	17.10	0.17
	Precious metals	S&P GSCI Precious Metals	2.87	19.17	0.15
	Commodities	S&P GSCI	5.39	22.65	0.24
	BB commodities	Bloomberg Commodity Index	4.15	15.48	0.27

Source: Invesco, estimates as of Feb. 28, 2017. All total returns data is annual.

Appendix: Asset class correlation matrices

Note: For figures Figures 18 through 27 the index proxies are represented in Figure 17, located on page 16.

Figure 18: Correlation matrix for equities versus equities

■ 0.52 to 0.75 ■ 0.76 to 1.00

	US large-cap	US small cap	US mid-cap	US top 200	US small- to mid-cap	US broad market	MSCI World ex-US	MSCI EAFE	MSCI Europe	Canada	UK	Eurozone	Japan	Pacific ex-Japan	Asia Pacific ex-Japan	Emerging market	World ex-US equity	World equity
US large-cap	1.00	0.83	0.94	1.00	0.88	0.99	0.86	0.85	0.85	0.78	0.82	0.83	0.59	0.76	0.71	0.75	0.86	0.95
US small-cap	0.83	1.00	0.93	0.80	0.99	0.88	0.76	0.75	0.74	0.75	0.68	0.74	0.52	0.70	0.65	0.71	0.77	0.82
US mid-cap	0.94	0.93	1.00	0.91	0.97	0.96	0.86	0.85	0.84	0.82	0.80	0.83	0.58	0.78	0.72	0.78	0.86	0.92
US top 200	1.00	0.80	0.91	1.00	0.85	0.99	0.85	0.84	0.83	0.76	0.81	0.82	0.59	0.73	0.69	0.73	0.84	0.94
US small- to mid-cap	0.88	0.99	0.97	0.85	1.00	0.92	0.81	0.80	0.79	0.79	0.74	0.79	0.56	0.74	0.69	0.75	0.81	0.87
US broad market	0.99	0.88	0.96	0.99	0.92	1.00	0.87	0.86	0.85	0.80	0.82	0.84	0.60	0.77	0.72	0.76	0.86	0.95
MSCI World ex-US	0.86	0.76	0.86	0.85	0.81	0.87	1.00	1.00	0.97	0.84	0.93	0.96	0.75	0.86	0.79	0.85	0.99	0.97
MSCI EAFE	0.85	0.75	0.85	0.84	0.80	0.86	1.00	1.00	0.97	0.81	0.93	0.96	0.76	0.86	0.78	0.83	0.99	0.96
MSCI Europe	0.85	0.74	0.84	0.83	0.79	0.85	0.97	0.97	1.00	0.78	0.95	0.99	0.60	0.80	0.71	0.79	0.96	0.94
Canada	0.78	0.75	0.82	0.76	0.79	0.80	0.84	0.81	0.78	1.00	0.78	0.76	0.57	0.80	0.75	0.83	0.86	0.85
UK	0.82	0.68	0.80	0.81	0.74	0.82	0.93	0.93	0.95	0.78	1.00	0.90	0.59	0.79	0.69	0.75	0.92	0.91
Eurozone	0.83	0.74	0.83	0.82	0.79	0.84	0.96	0.96	0.99	0.76	0.90	1.00	0.59	0.77	0.70	0.78	0.95	0.93
Japan	0.59	0.52	0.58	0.59	0.56	0.60	0.75	0.76	0.60	0.57	0.59	0.59	1.00	0.63	0.61	0.62	0.74	0.70
Pacific ex-Japan	0.76	0.70	0.78	0.73	0.74	0.77	0.86	0.86	0.80	0.80	0.79	0.77	0.63	1.00	0.91	0.90	0.89	0.86
Asia Pacific ex-Japan	0.71	0.65	0.72	0.69	0.69	0.72	0.79	0.78	0.71	0.75	0.69	0.70	0.61	0.91	1.00	0.94	0.84	0.81
Emerging market	0.75	0.71	0.78	0.73	0.75	0.76	0.85	0.83	0.79	0.83	0.75	0.78	0.62	0.90	0.94	1.00	0.90	0.86
World ex-US equity	0.86	0.77	0.86	0.84	0.81	0.86	0.99	0.99	0.96	0.86	0.92	0.95	0.74	0.89	0.84	0.90	1.00	0.97
World equity	0.95	0.82	0.92	0.94	0.87	0.95	0.97	0.96	0.94	0.85	0.91	0.93	0.70	0.86	0.81	0.86	0.97	1.00

Source: Invesco, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 19: Correlation matrix for equities versus US bonds

■ -0.32 to -0.11 ■ -0.10 to 0.10 ■ 0.11 to 0.35 ■ 0.36 to 0.70

	US treasury	US treasury long	US treasury short	US TIPS	US aggregate	US universe	US aggregate 1 to 3	US aggregate credit	US inv grd corps	US inv grd corps long	US high yield corps	US MBS	US municipals	US intermediate municipals	US bank loans	US preferred stocks
US large-cap	-0.28	-0.26	-0.10	0.04	-0.05	0.11	-0.14	0.20	0.22	0.20	0.64	-0.11	0.00	-0.07	0.47	0.35
US small-cap	-0.32	-0.30	-0.11	-0.01	-0.10	0.05	-0.17	0.15	0.17	0.15	0.64	-0.18	-0.03	-0.09	0.48	0.29
US mid-cap	-0.29	-0.26	-0.12	0.08	-0.04	0.13	-0.14	0.24	0.26	0.23	0.70	-0.12	0.06	-0.03	0.55	0.36
US top 200	-0.28	-0.26	-0.10	0.02	-0.05	0.10	-0.14	0.19	0.21	0.19	0.61	-0.11	-0.01	-0.07	0.44	0.33
US small- to mid-cap	-0.31	-0.29	-0.11	0.03	-0.08	0.09	-0.15	0.19	0.21	0.19	0.67	-0.16	0.01	-0.06	0.51	0.32
US broad market	-0.29	-0.28	-0.11	0.04	-0.05	0.11	-0.15	0.21	0.23	0.20	0.66	-0.12	0.00	-0.07	0.49	0.35
MSCI World ex-US	-0.25	-0.25	-0.08	0.13	0.02	0.19	-0.05	0.30	0.32	0.28	0.69	-0.06	0.06	0.00	0.53	0.39
MSCI EAFE	-0.24	-0.24	-0.08	0.13	0.02	0.19	-0.05	0.30	0.32	0.28	0.68	-0.06	0.06	0.00	0.52	0.39
MSCI Europe	-0.25	-0.26	-0.06	0.09	0.01	0.17	-0.05	0.27	0.30	0.25	0.67	-0.07	0.06	0.00	0.51	0.37
Canada	-0.23	-0.23	-0.05	0.19	0.02	0.19	-0.04	0.29	0.31	0.26	0.66	-0.04	0.08	0.03	0.53	0.32
UK	-0.26	-0.28	-0.07	0.11	0.00	0.16	-0.05	0.28	0.30	0.24	0.65	-0.06	0.09	0.02	0.55	0.36
Eurozone	-0.24	-0.25	-0.05	0.08	0.01	0.16	-0.05	0.26	0.29	0.25	0.65	-0.07	0.04	-0.02	0.48	0.36
Japan	-0.16	-0.15	-0.11	0.13	0.02	0.14	-0.05	0.22	0.25	0.21	0.47	-0.04	0.02	-0.01	0.35	0.30
Pacific ex-Japan	-0.17	-0.16	-0.10	0.22	0.09	0.25	-0.01	0.34	0.36	0.33	0.65	0.00	0.11	0.05	0.47	0.36
Asia Pacific ex-Japan	-0.20	-0.19	-0.12	0.16	0.02	0.18	-0.05	0.28	0.30	0.27	0.61	-0.06	0.04	-0.01	0.43	0.33
Emerging market	-0.23	-0.21	-0.09	0.19	0.03	0.20	-0.05	0.30	0.32	0.28	0.68	-0.05	0.04	-0.01	0.48	0.34
World ex-US equity	-0.24	-0.24	-0.08	0.16	0.03	0.20	-0.05	0.31	0.34	0.29	0.70	-0.05	0.06	0.00	0.53	0.39
World equity	-0.27	-0.26	-0.10	0.10	-0.01	0.16	-0.09	0.27	0.30	0.26	0.70	-0.09	0.03	-0.03	0.53	0.38

Source: Invesco, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 20: Correlation matrix for equities versus global bonds

■ 0.00 to 0.10 ■ 0.11 to 0.35 ■ 0.36 to 0.68 ■ 0.69 to 0.80

	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 large-cap	0.16	0.06	0.35	0.39	0.40	0.51	0.48	0.54	0.19	0.12	0.50	0.57	0.53	0.57	0.47	0.59	0.32	0.57
US small-cap	0.09	0.01	0.26	0.31	0.32	0.50	0.46	0.53	0.14	0.07	0.38	0.52	0.49	0.48	0.40	0.55	0.26	0.55
US mid-cap	0.16	0.07	0.37	0.42	0.43	0.56	0.52	0.59	0.20	0.12	0.48	0.60	0.56	0.60	0.50	0.62	0.34	0.63
US top 200	0.15	0.06	0.34	0.37	0.39	0.49	0.46	0.52	0.18	0.11	0.51	0.56	0.52	0.55	0.46	0.58	0.30	0.55
US small- to mid-cap	0.12	0.04	0.31	0.36	0.37	0.53	0.49	0.56	0.16	0.09	0.43	0.56	0.53	0.54	0.45	0.59	0.31	0.59
US broad MSCI world	0.15	0.06	0.34	0.39	0.40	0.53	0.49	0.55	0.19	0.12	0.50	0.58	0.54	0.57	0.48	0.61	0.32	0.59
Ex-US MSCI EAFE	0.35	0.27	0.54	0.60	0.60	0.63	0.59	0.66	0.40	0.32	0.69	0.62	0.57	0.67	0.56	0.65	0.39	0.64
MSCI Europe	0.35	0.27	0.54	0.60	0.60	0.61	0.57	0.64	0.40	0.32	0.69	0.61	0.57	0.66	0.56	0.64	0.38	0.63
Canada	0.34	0.26	0.52	0.58	0.59	0.59	0.55	0.62	0.39	0.30	0.70	0.57	0.53	0.63	0.53	0.61	0.34	0.59
UK	0.29	0.24	0.46	0.53	0.53	0.77	0.73	0.80	0.33	0.26	0.58	0.64	0.60	0.65	0.55	0.67	0.41	0.66
Eurozone	0.32	0.23	0.49	0.57	0.58	0.60	0.56	0.64	0.37	0.29	0.65	0.54	0.49	0.61	0.50	0.58	0.34	0.60
Japan	0.33	0.27	0.52	0.57	0.58	0.56	0.53	0.59	0.38	0.30	0.71	0.57	0.53	0.62	0.52	0.60	0.32	0.57
Pacific ex-Japan	0.23	0.17	0.36	0.42	0.42	0.42	0.39	0.44	0.26	0.22	0.44	0.46	0.43	0.51	0.40	0.48	0.33	0.47
Asia Pacific ex-Japan	0.36	0.31	0.59	0.63	0.63	0.65	0.62	0.67	0.40	0.33	0.68	0.66	0.63	0.68	0.61	0.67	0.47	0.69
Emerging market	0.26	0.22	0.49	0.53	0.54	0.58	0.54	0.60	0.30	0.23	0.61	0.61	0.59	0.65	0.54	0.62	0.44	0.67
World ex-US	0.28	0.26	0.52	0.56	0.56	0.64	0.61	0.67	0.32	0.25	0.64	0.71	0.68	0.68	0.61	0.72	0.45	0.71
Equity	0.35	0.28	0.55	0.61	0.61	0.66	0.62	0.69	0.40	0.32	0.70	0.65	0.60	0.69	0.59	0.67	0.41	0.67
World equity	0.27	0.19	0.48	0.53	0.54	0.61	0.57	0.64	0.32	0.24	0.64	0.63	0.59	0.66	0.56	0.66	0.38	0.65

Source: Invesco, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 21: Correlation matrix for equities versus commodities

■ 0.00 to 0.10 ■ 0.11 to 0.35 ■ 0.36 to 0.60

	Agriculture	Energy	Industrial metals	Livestock	Precious metals	Commodities	BB commodities
US large-cap	0.27	0.23	0.45	0.04	0.07	0.29	0.34
US small-cap	0.20	0.27	0.42	0.04	0.11	0.31	0.34
US mid-cap	0.27	0.29	0.49	0.07	0.13	0.35	0.40
US top 200	0.26	0.21	0.43	0.04	0.06	0.27	0.32
US small- to mid-cap	0.23	0.29	0.45	0.05	0.12	0.33	0.37
US broad market	0.27	0.25	0.46	0.04	0.09	0.30	0.35
MSCI World ex-US	0.33	0.35	0.55	0.03	0.22	0.42	0.49
MSCI EAFE	0.32	0.33	0.53	0.03	0.20	0.40	0.46
MSCI Europe	0.31	0.31	0.51	0.02	0.17	0.38	0.44
Canada	0.36	0.49	0.60	0.06	0.36	0.56	0.62
UK	0.32	0.37	0.55	0.03	0.19	0.44	0.49
Eurozone	0.30	0.28	0.48	0.01	0.16	0.35	0.41
Japan	0.19	0.27	0.34	0.06	0.15	0.30	0.32
Pacific ex-Japan	0.35	0.33	0.57	0.04	0.29	0.41	0.50
Asia Pacific ex-Japan	0.29	0.28	0.53	0.04	0.25	0.34	0.42
Emerging market	0.33	0.35	0.57	0.04	0.31	0.42	0.50
World ex-US equity	0.34	0.36	0.57	0.03	0.25	0.43	0.51
World equity	0.32	0.31	0.54	0.04	0.18	0.38	0.45

Source: Invesco, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 22: 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	0.92	0.27	0.66	0.91	0.82	0.75	0.65	0.59	0.63	-0.17	0.83	0.55	0.65	-0.35	0.12
US Treasury (long)	0.92	1.00	0.12	0.60	0.85	0.76	0.52	0.63	0.59	0.70	-0.15	0.73	0.53	0.59	-0.31	0.12
US Treasury (short)	0.27	0.12	1.00	0.12	0.23	0.18	0.58	0.06	0.04	0.00	-0.15	0.31	0.06	0.11	-0.16	-0.02
US TIPS	0.66	0.60	0.12	1.00	0.77	0.79	0.60	0.72	0.70	0.68	0.30	0.64	0.54	0.58	0.17	0.27
US aggregate	0.91	0.85	0.23	0.77	1.00	0.98	0.79	0.88	0.85	0.85	0.18	0.90	0.69	0.74	-0.03	0.30
US universe	0.82	0.76	0.18	0.79	0.98	1.00	0.74	0.94	0.91	0.90	0.37	0.86	0.69	0.73	0.12	0.36
US aggregate 1 to 3	0.75	0.52	0.58	0.60	0.79	0.74	1.00	0.64	0.60	0.50	0.03	0.76	0.47	0.57	-0.12	0.27
US aggregate credit	0.65	0.63	0.06	0.72	0.88	0.94	0.64	1.00	1.00	0.96	0.51	0.69	0.67	0.69	0.28	0.48
US investment grade corps	0.59	0.59	0.04	0.70	0.85	0.91	0.60	1.00	1.00	0.96	0.55	0.64	0.65	0.66	0.32	0.50
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	0.49	0.63	0.62	0.63	0.22	0.42
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	0.04	0.27	0.20	0.78	0.42
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	0.57	0.64	-0.15	0.10
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	0.95	0.20	0.32
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	0.07	0.31
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	0.23
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, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 23: 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, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 24: 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, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 25: 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 inv. grd	Canada aggregate	Canada treasury	Canada corporate	Global aggregate ex-US	Global 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	0.98	0.89	0.88	0.85	0.61	0.63	0.56	0.97	0.97	0.84	0.38	0.38	0.55	0.58	0.34	0.51	0.28
Global treasury	0.98	1.00	0.81	0.79	0.74	0.55	0.59	0.49	0.97	0.99	0.74	0.42	0.45	0.41	0.53	0.33	0.52	0.23
Global sovereign	0.89	0.81	1.00	0.92	0.91	0.71	0.71	0.66	0.85	0.80	0.84	0.76	0.78	0.77	0.87	0.69	0.81	0.62
Global corporate	0.88	0.79	0.92	1.00	0.99	0.72	0.70	0.70	0.85	0.79	0.88	0.71	0.70	0.77	0.80	0.65	0.79	0.65
Global investment grade	0.85	0.74	0.91	0.99	1.00	0.70	0.68	0.69	0.81	0.74	0.87	0.72	0.70	0.78	0.81	0.65	0.81	0.66
Canada aggregate	0.61	0.55	0.71	0.72	0.70	1.00	0.99	0.99	0.60	0.55	0.66	0.61	0.59	0.68	0.66	0.61	0.56	0.60
Canada treasury	0.63	0.59	0.71	0.70	0.68	0.99	1.00	0.97	0.62	0.57	0.66	0.60	0.58	0.64	0.65	0.59	0.54	0.56
Canada corporate	0.56	0.49	0.66	0.70	0.69	0.99	0.97	1.00	0.56	0.49	0.64	0.61	0.58	0.68	0.64	0.63	0.54	0.64
Global aggregate ex-US	0.97	0.97	0.85	0.85	0.81	0.60	0.62	0.56	1.00	0.99	0.88	0.33	0.33	0.50	0.50	0.31	0.41	0.26
Global treasury ex-US	0.97	0.99	0.80	0.79	0.74	0.55	0.57	0.49	0.99	1.00	0.79	0.29	0.30	0.42	0.46	0.26	0.38	0.19
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	0.63	0.62	0.62	0.64	0.61	0.55	0.55
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	0.98	0.94	0.89	0.98	0.74	0.78
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	0.88	0.87	0.96	0.73	0.73
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	0.90	0.93	0.88	0.91
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	0.84	0.85	0.76
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	0.70	0.80
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	0.74
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, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

Figure 26: Correlations matrix for global bonds versus commodities

	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 inv grd	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 inv grd	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 inv grd	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

Figure 27: Correlation matrix for commodities versus commodities

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

Source: Invesco, estimates from Feb. 28, 1997 through Feb. 28, 2017. Past performance is not a guarantee of future performance. An investment cannot be made directly in an index.

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