Invesco Fixed Income White Paper Series
How macro factors can aid asset allocation

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In brief
In this paper, we establish our set of macro factors – growth, inflation and financial conditions – which display quite stable correlations to the returns of various asset classes, irrespective of their country of issuance. Furthermore, we analyze how asset class volatility moves with the macro factors. We believe that, by looking at the sensitivities of asset class returns and volatilities to changes in the macro factors, allocation within global multi-asset portfolios can be improved.

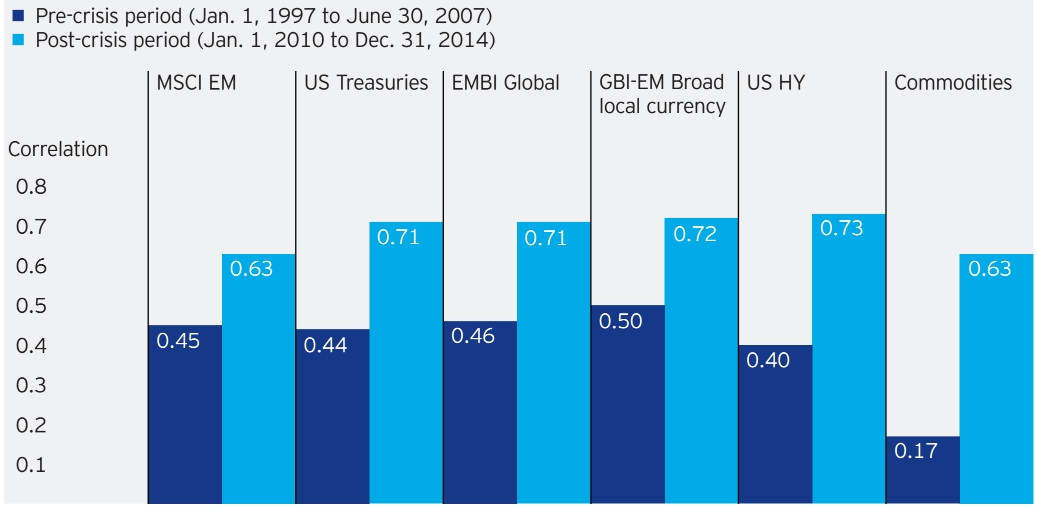
Key takeaways
- Cross-asset class correlations have risen significantly since the global financial crisis, making traditional portfolio diversification strategies more challenging.
- As an alternative, we offer an approach to portfolio allocation built around the correlations of asset classes to three key macro factors: growth, inflation and financial conditions.
- We provide an analysis of the historical, risk-adjusted returns of a wide range of asset classes based on their co-movements with the three macro factors.
- Along with stocks and bonds, we include currencies as a key asset class, extending our macro factor framework to inform asset allocation to global portfolios.
- Our analysis also incorporates the influence of the macro factors on the implied volatilities of equities, interest rates and currencies. We believe it is important to understand the reaction of volatility to macro factors when sizing risk in portfolio allocation.
- Our analysis shows that assets around the world have tended to move according to their asset classification - not their geographic location. This finding helps to establish that the three macro factors we have identified explain the main correlations of asset classes to macro drivers.
- Applying our macro factor framework to the portfolio allocation problem of investing in a rising inflation environment, we would expect global bonds and equities to underperform, while commodities, inflation-linked bonds and developed market currencies and volatilities would likely outperform.

Often, portfolios are built around the correlations between asset classes. But, such an approach is not without its shortcomings – especially since the familiar correlations of the past changed during the financial crisis. In this paper, we present an alternative approach to portfolio construction, one that is based on correlations: but here the focus is on co-movements of asset classes with various macro factors.

A primary aim of portfolio allocation is to balance returns versus risk by adjusting an investment's size within an overall portfolio. Typically, an investor must take into account his or her own risk tolerance, investment goals and investment timeframe when making allocation decisions. This makes correctly measuring risk a central problem for the asset allocator.

Traditionally, risk has been measured by examining asset class volatilities and correlations between asset classes. Investors typically examine the long-run return, correlation and volatility of each asset class to determine its size in the portfolio.

Figure 1: Correlations between major asset classes
Each bar represents the average correlation between one and remaining asset classes

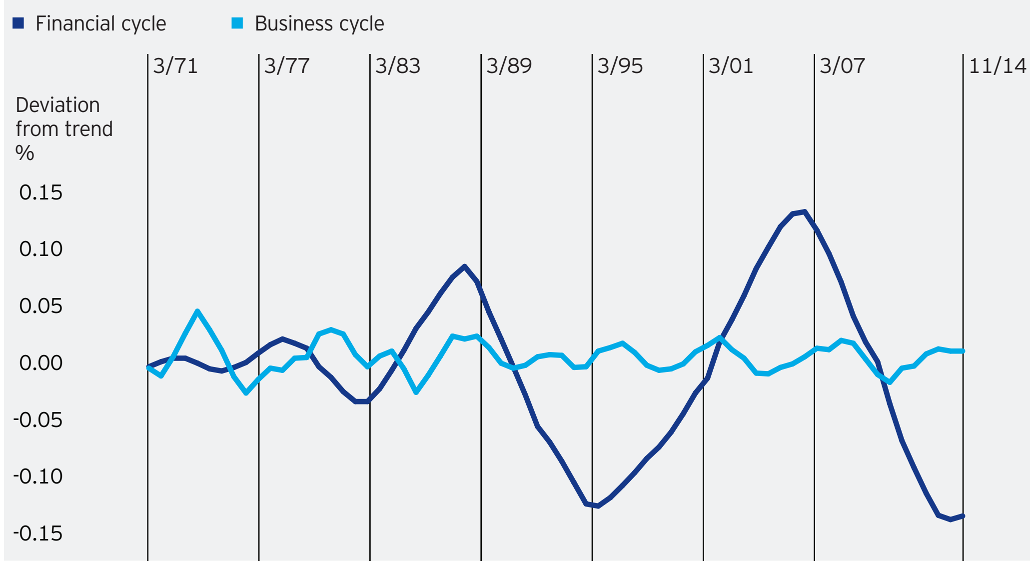


Source: International Monetary Fund, "Global Financial Stability Report," April 2015. Figure 1.20, p. 34. Data as at Dec. 31, 2014. Cross-asset correlation is measured as the median of the absolute values of pair-wise correlations between the daily Sharpe ratios of the asset classes (i.e. of all correlations between the daily Sharpe ratios of any two of the six asset classes, which is 15 correlation coefficients altogether) in the chart over a 60-day window. Asset classes are represented by MSCI EM = MSCI Emerging Markets Equity Index; US Treasuries = 7–10-year US Treasury Index; EMBI Global = JPMorgan Emerging Markets Bond Index Global; GBI-EM Broad local currency = JPMorgan Government Bond Index-Emerging Markets in local currency; US HY = US High-Yield Index; Commodities = Credit Suisse Index. Except for the GBI-EM Broad Local Currency Index, all indices are in US dollars.

Cross-asset class correlations have risen ...

The global financial crisis and subsequent response of policy makers to stabilize asset prices through quantitative easing upended the traditional asset allocation model by changing historical correlations and volatilities, making them less meaningful in allocation decisions. Simply put, post-crisis diversification across assets no longer provided investors with their intended risk diversification. This is because cross-asset class correlations have risen significantly since 2008, making traditional diversification strategies more challenging (Figure 1).

Figure 2: Macro cycles in the United States



Source: Borio, Claudio. "The financial cycle, the debt trap and secular stagnation." Presentation at the 84th Annual General Meeting, Bank of International Settlements, June 29, 2014. Data as at June 29, 2014. According to Borio, the financial cycle comprises the medium-term cycles in the total non-financial debt-to-GDP ratio and real house prices. The business cycle is the fluctuation in real GDP.

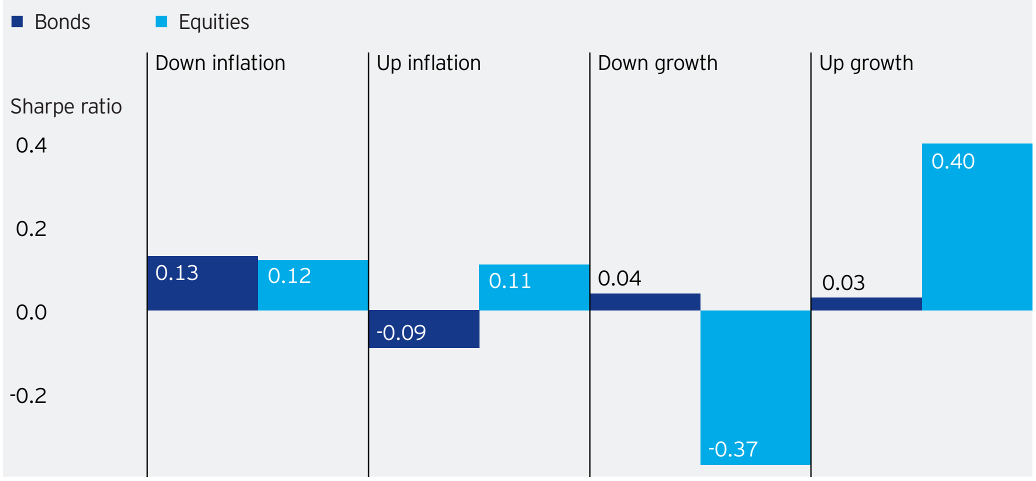
... and asset class time series may be too short

Another problem with traditional asset allocation is its dependence on historical data, which may not encompass a full macroeconomic cycle. For example, most data samples used in asset allocation only include periods of declining interest rates, moderate inflation and benign business cycle fluctuations. This is because most financial indices were created over the past few decades, whereas macroeconomic cycles may have long preceded them.[1]

From growth and inflation to risk and return

Seeking an alternative to overcome some of these challenges, many investors have turned to macroeconomic factors to better explain the risks and returns in their portfolios. Although conventional wisdom would suggest that growth and inflation have the largest effects on investment returns, they are not directly investable. Therefore, it is difficult to draw a concrete link between macroeconomic factors and returns. As a result, many investors have turned to a scenario-based framework, where they examine the performance of asset returns in varying economic environments.

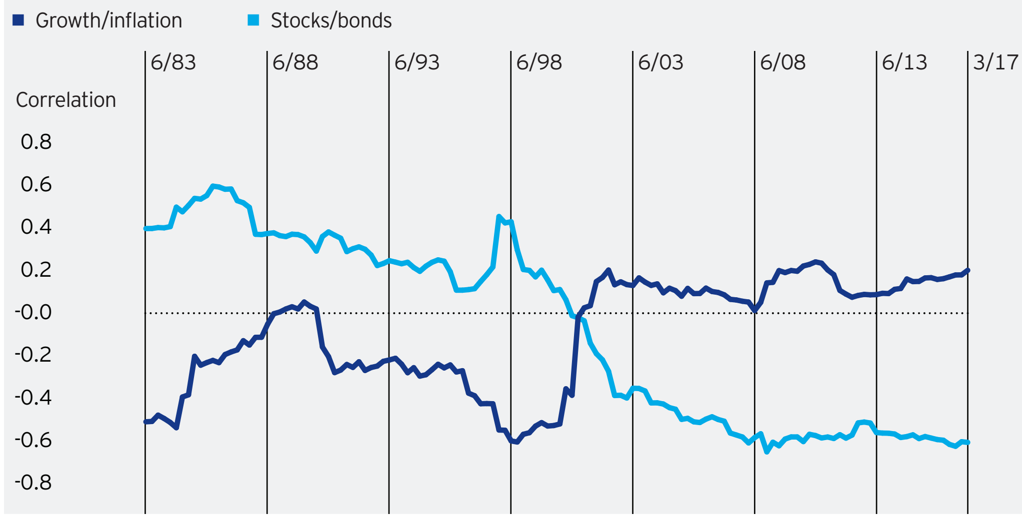
Figure 3: Scenario analysis of US risk-adjusted returns



Sources: Bloomberg L.P., Invesco. Data from Jan. 1, 1973 to March 31, 2017. Sharpe ratios are calculated on the excess returns of the Standard and Poor's 500 equity price index (equities) and the Bloomberg Barclays US Treasury Index (bonds). Growth and inflation are measured using the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters. Up and down scenarios represent the average Sharpe ratios during periods of rising and falling growth and inflation, respectively.

For example, the risk-adjusted returns of US equities show a strong positive correlation to changes in economic growth, irrespective of the inflation backdrop (Figure 3). Conversely, US bonds (and commodities, not shown) seem to be more affected by changes in the inflation rate.

Figure 4: Macro versus asset correlation in the United States



Sources: Bloomberg L.P., Invesco. Correlations beginning in 1983 are based on 10-year rolling data from Jan. 1, 1973 to March 31, 2017. Growth and inflation are measured using the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters. The correlation is between the quarterly change in one-year-ahead real GDP growth and the growth in the GDP deflator (measure of the level of prices of all new, domestically produced, final goods and services). The correlation between stocks and bonds is measured by the correlation between excess price returns in the Standard and Poor's 500 Index and the Bloomberg Barclays US Treasury Index.

The scenario analysis approach provides us with the first clues toward understanding at least one dimension of risk — correlation between asset classes. When we look at the correlation between bonds and equities (Figure 4, light blue line), two different regimes can be clearly seen over the past four decades. In the period 1973–1998, bonds and equities had a slightly positive correlation. Since then, however, the correlation has become much more negative.

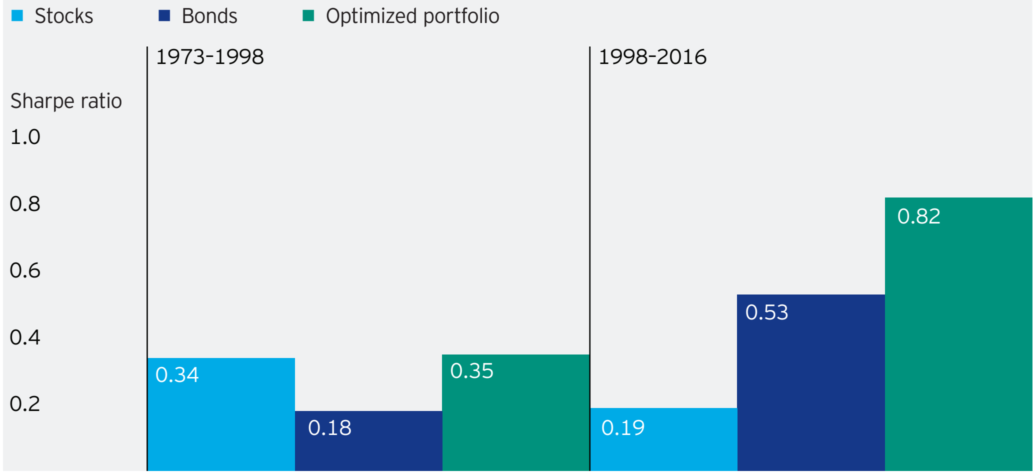
As for the correlation between the macro factors, growth and inflation, there are also two clearly different regimes (Figure 4, dark blue line). In the period 1973–1998, growth and inflation were negatively correlated, while they have been positively correlated since then.

And this is the point: the analysis indicates that asset class (bond and equity) correlations are driven by macro factors (growth and inflation). For example, in periods when inflation is on the rise, intuition would suggest that a fixed return asset (such as a bond) would have an inferior return relative to a flexible return asset (such as a stock).

Putting macro factors to work in portfolio allocation

The above analysis can be used to examine the portfolio allocation problem through a macroeconomic lens. For instance, to answer the question of how an investor should consider allocating between stocks and bonds, we first develop a forward-looking view of growth and inflation. These forecasts allow us to construct a "macro factor framework" to predict how various asset classes will likely behave in each environment.

Figure 5: Macro environment affects diversification benefits



Sources: Bloomberg L.P., Invesco. Data from Jan. 1, 1973 to March 31, 2017. The stock and bond returns are derived from the Standard and Poor's 500 Index and the Bloomberg Barclays US Treasury Index. The optimized portfolios are the stock and bond weights that generate the largest Sharpe ratios in each of the two periods.

Figure 5 shows the "optimized portfolio" in each regime – in other words, the allocation of stocks and bonds that produced the maximum risk-adjusted returns in each time period. It is possible to see that the diversification benefits of holding stocks and bonds is highly dependent upon the correlation between growth and inflation. For example, during the 1973–1998 regime, there was essentially no benefit to owning both stock and bonds – the optimized portfolio performed no better than either asset class. During this period, stocks and bonds were highly correlated, which we would expect since growth and inflation were negatively correlated. In contrast, during the 1998–2016 regime, when growth and inflation were positively correlated, diversification produced tremendous benefit – the optimized portfolio outperformed each asset class.

Data and methodology

To calculate risk-adjusted returns, we examined a large sample of global equity indices, credit spreads, 10-year government bond yields, currencies, commodities, inflation-linked bonds and implied volatilities (see the appendix for the indices used to represent each asset class). For bond yields, spreads and implied volatilities, we looked at monthly yield differences, and assumed a portfolio with a one-year duration for ease of computation. For the remaining assets, we simply took their monthly price changes. Finally, we converted all of the asset returns into Sharpe ratios by subtracting the risk-free return and dividing by the in-sample volatility.

To this set of time series, we applied principle components analysis (PCA), which allows us to decompose the drivers of returns into their "orthogonal", or principle factors. Although PCA does not directly identify the factors, it can be used to infer them. To solve the problem of time series with different data ranges, we used the "soft-impute" method to estimate the factors across the whole sample. Finally, to isolate only those factors that were stable during the sample period, we employed the "bootstrap" method.** For robustness, we applied this analysis at weekly, monthly and quarterly frequencies. Simply put: we looked for factors that explained returns in both random time samples and across random asset samples. We believe this helps to ensure the stability and applicability of the factors.*

* Mazumder, R., Hastie, T. and Tibshirani, R.: "Spectral Regularization Algorithms for Learning Large Incomplete Matrices". J Machine Learning Research, 11 (2010), p. 2287 – 2322.

** Efron, B.: Bootstrap Methods: "Another Look at the Jackknife". Annals of Statistics, vol. 7, no. 1, p. 1-26. All foreign currency equity, bond and volatility returns represent returns hedged into US dollars.

Going beyond growth and inflation, bonds and equities: volatility, currencies and a third macro factor — "financial conditions"

This growth and inflation analysis is very appealing, as it is simple, easy to visualize, intuitive and helps to explain past changes in bond/equity correlations. While this framework helps us better understand the distant past, it is not as useful in explaining the more recent (post-2008) world. Typically, periods around major shifts in monetary policy do not fit neatly within the growth and inflation factor framework. Moreover, while growth and inflation shed light on the correlation between asset classes, they are less helpful in predicting volatility — the other important dimension of risk. Additionally, much of the analysis done around the macro factor framework has been focused on US history and assets. In a globally integrated economy and capital markets, however, we consider currency risk to be an equally important dimension of risk. By including currencies in our study, we aim to extend the macro factor framework to inform asset allocation for global portfolios.

To address these shortcomings, we've reinvestigated correlation and volatility across a broader range of asset classes using a multivariate statistical study. We hope to show (1) that the global macroeconomic environment dominates risks in a global portfolio; (2) that global financial conditions are an important driver of risk and return; (3) that volatility is driven by macro factors.

The global dimension of asset returns

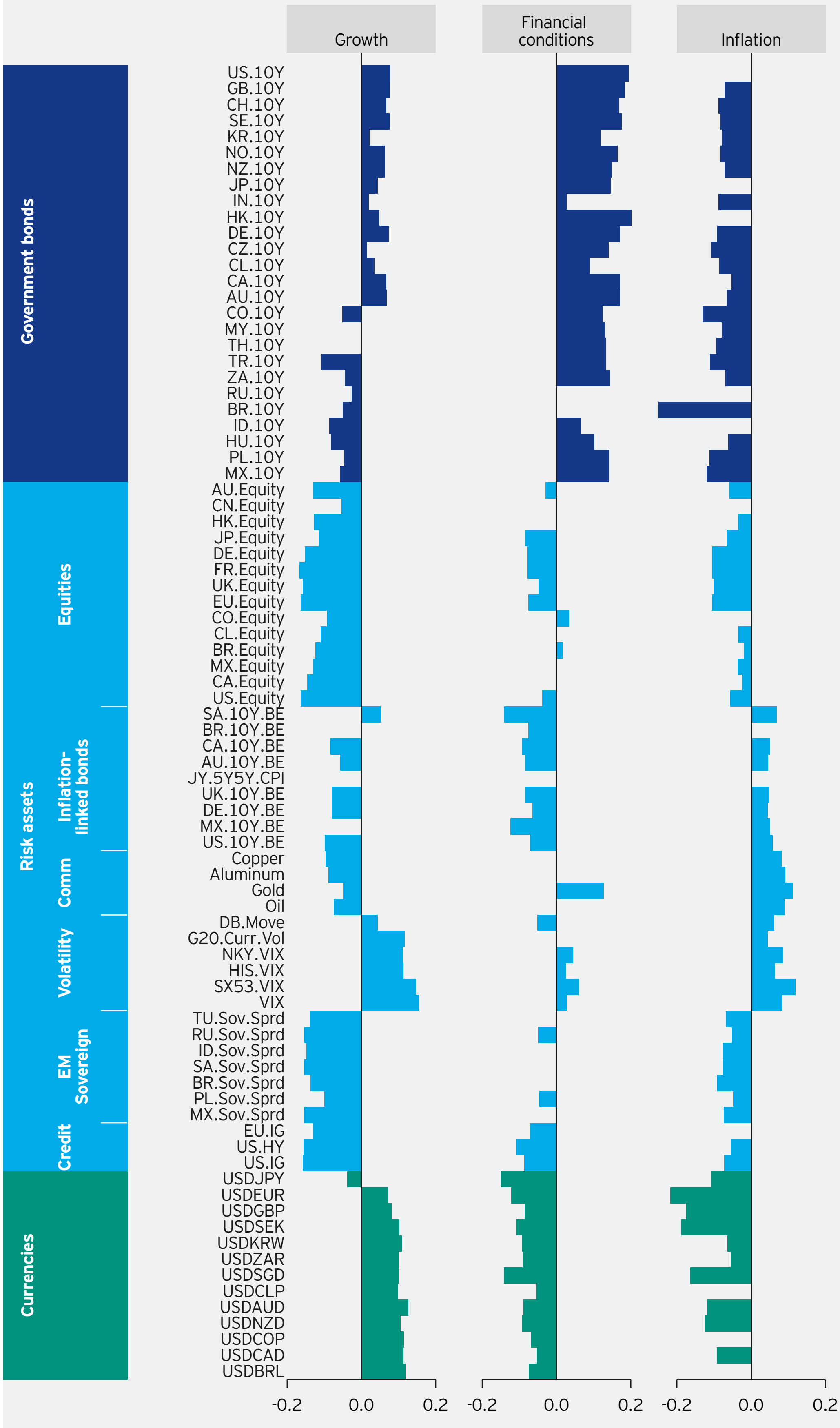
The first observation from this analysis is the consistency of returns among asset classes across different geographic regions and factors. By grouping those assets with similar signs under the three macro factors: growth, financial conditions and inflation, we identify three main asset clusters: government bonds, risk assets (equities, duration-hedged inflation-linked bonds, commodities, implied volatilities, duration-hedged emerging market US dollar-denominated sovereign debt, duration-hedged developed market credit) and currencies. Assets within these three clusters tended to behave similarly to each other in different macro environments, regardless of geographic location. We believe this consistency provides further support for the influence of macro factors on asset class behavior.

Once we identified these three clusters, the asset class allocation problem was significantly reduced. Although the investment universe comprises numerous individual assets, by taking correlations into account, investable assets may be grouped into as few as eight categories: global equities and credit, global developed market government bonds, global emerging markets government bonds, global inflation-linked bonds, commodities, currencies and volatilities. The output from the PCA is shown in Figure 6.

Figure 6 shows the average risk-adjusted return (Sharpe ratio) of each asset in response to the macro factor over the time period. For example, a decrease in the growth factor (recession) led to positive Sharpe ratios for government bonds, implied volatilities and the US dollar against other currencies.

Part of our statistical approach was to avoid predetermining what factors might be at work in driving asset returns — for example, based on economic theory. Instead we looked for consistent relationships to emerge out of the data using PCA and then confirmed whether the relationships had an economic basis before we identified drivers as macro factors. We found three stable factors in our analysis: growth, inflation and financial conditions, which we discuss further below. Moreover, the relationships implied by our study matched the scenario results shown in Figure 3.

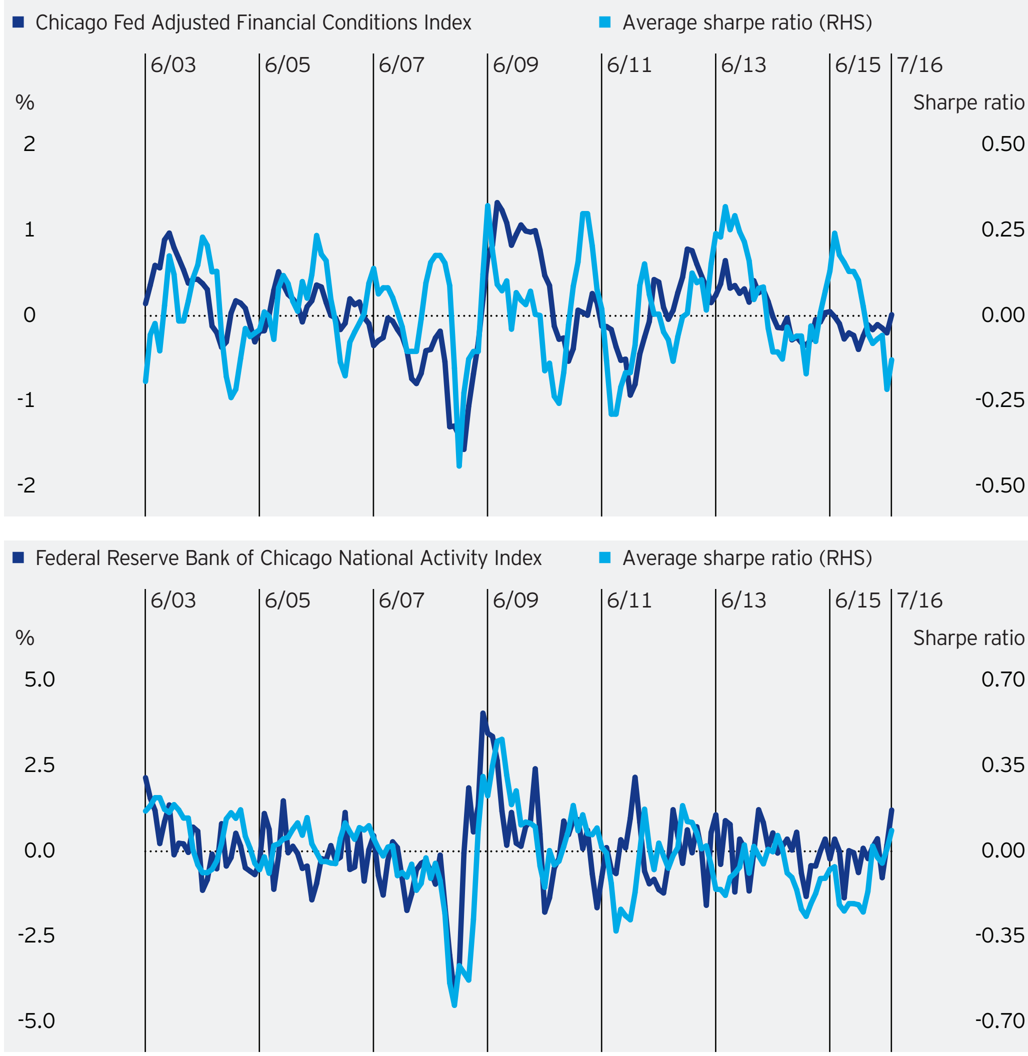
Figure 6: Risk-adjusted returns per incremental changes in macro factors (ie. decrease in growth, tightening of financial conditions and rising inflation)

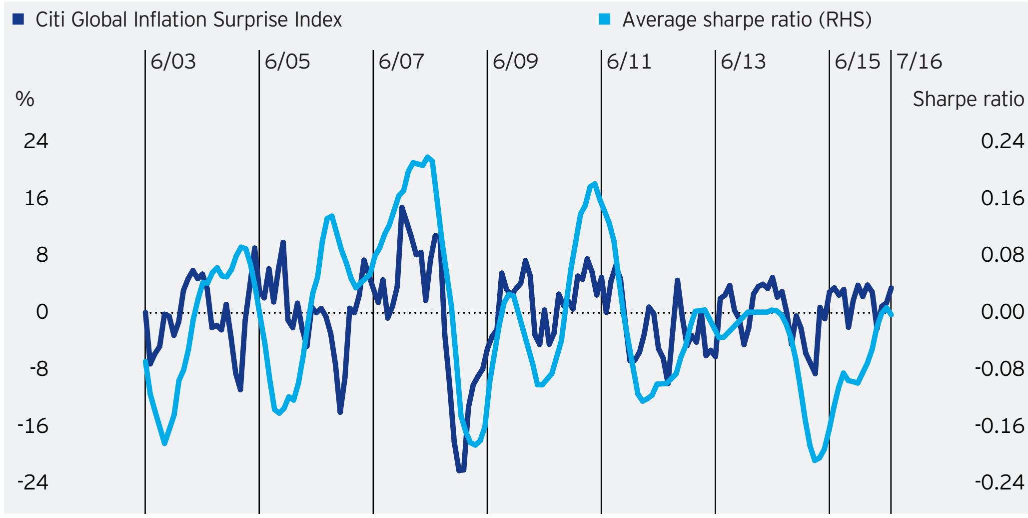


Sources: Bloomberg L.P., Invesco. Data from Jan. 1, 2003 to July 1, 2016. The sign and size of the bars indicate the direction and strength, respectively, of the relationship between the factor and the asset. Where assets tended to share similar signs across all three macro environments, they were grouped into clusters indicated by the boxes on the left.

Figures 7a–c show the Sharpe ratio of the "factor portfolio" at each point in time.[2] We construct the factor portfolio by going long or short for each individual asset according to the signs and strengths of the Sharpe ratio returns as shown in Figure 6. Figures 7a–c show that each factor portfolio demonstrates a close relationship with the underlying macro fundamental index. For example, the average Sharpe ratio of the portfolio in Figure 7a follows the Chicago Fed Adjusted Financial Conditions Index closely, suggesting that portfolio returns are sensitive to global financial conditions. Furthermore, Figures 7a–c reinforce our view that financial conditions have had an outsized impact on portfolio returns in the post-crisis period.

Figures 7a–c: Factor portfolios follow macro fundamentals





Source: Bloomberg L.P., Invesco. Data from Jan. 1, 2003 to July 1, 2016. The factor portfolios are graphed along with their corresponding macro factor. For financial conditions, the six-month change in the Federal Reserve Bank of Chicago Adjusted Financial Conditions Index is graphed alongside the six-month average Sharpe ratio for the financial conditions factor. Growth and inflation are measured using the three-month change in the Federal Reserve Bank of Chicago National Activity Index and the three-month change in the CITI Inflation Surprise Index.

As previously mentioned, an important outcome of our analysis was the identification of a third factor, distinct from the widely accepted factors of growth and inflation. This third factor seemed to be correlated with several proxies for financial conditions. We believe that this "financial conditions" factor, or this "policy factor", corresponds to the effect of monetary and fiscal policy on asset prices. Because financial conditions affect the discount rate that investors use to determine the net present value of any asset, any tightening of financial conditions should theoretically prove negative for all asset classes. We believe this factor provides the missing link in the post-2008 world, where equity and bond returns have been positive despite anemic growth and inflation. It would seem that unconventional monetary policy (loose financial conditions) can be considered the primary driver of returns.

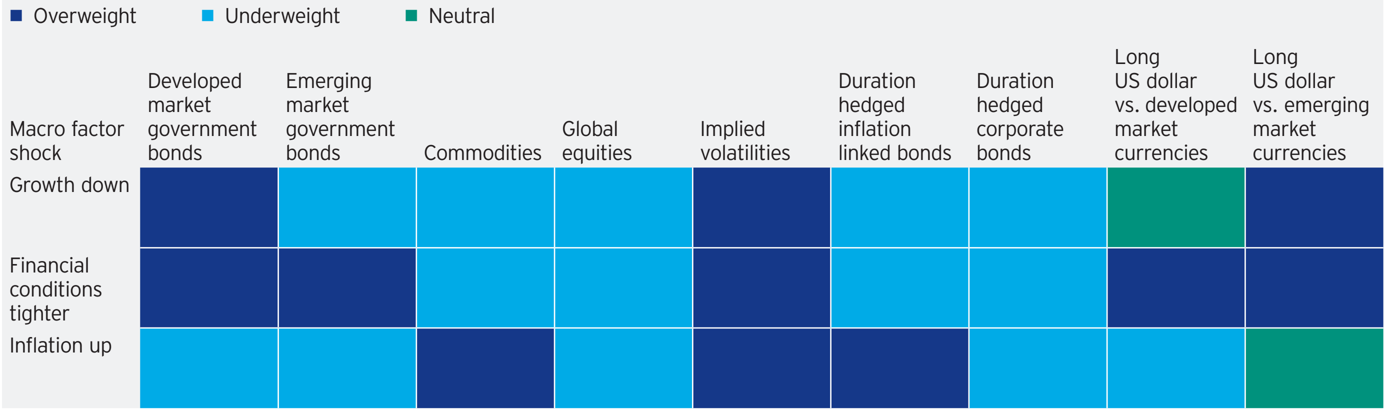
Volatility and macro factors

Finally, we incorporated implied volatilities in our study. As shown by Figure 6, volatilities of equities, interest rates and currencies all tended to respond similarly to the macro factors, i.e. they too acted as a cluster. Our study shows that volatility increased when growth fell, financial conditions tightened or inflation rose. We believe that it is important to understand this asymmetry in the reaction of volatility to macro factors when sizing risk in portfolio allocation. For example, the same bond allocation may pose different levels of risk in different macro environments due to different levels of bond market volatility.

Conclusion: building portfolios around macro factors

Our study indicates that assets around the world move according to their asset classification – and not their geographic location. This finding, along with the findings of our scenario and correlation analyses, has helped establish our set of macro factors. We believe the three macro factors identified here determine the main correlations of asset classes to macro drivers. Lastly, we addressed the matter of volatility, and how it moves with macro factors.

Figure 8: Asset class weights based on macro factor changes



Source: Invesco, as at April 12, 2017.

Together, we can use the sensitivities of asset class correlations and volatilities to better allocate within our global portfolios.

Applying our framework to the portfolio construction problem of investing in a rising inflation environment, we would expect global bonds and equities to underperform based on historical correlations to macro factors, while commodities, inflation-linked bonds and developed market currencies and volatilities should outperform. We would thus seek to position our global portfolio according to the weights illustrated in Figure 8.

In future papers, we will discuss how Invesco Fixed Income utilizes this macro factor framework to inform our investment process and aid portfolio construction.

1 M. Drehmann, C. Borio and K. Tsatsaronis (2012): Characterizing the financial cycle: don't lose sight of the medium term!, Bank for International Settlements Working Papers, no. 380, June 2012, graph 3, p.19.
2 All calculations are gross of possible fees that might apply to investors.

Additional information

The below indices represent the range of asset classes used in the PCA analysis

Ticker	Name	Ticker	Name
USDAUD Curncy	USDAUD Spot Exchange Rate - Price of 1 USD in AUD	USDPLN Curncy	USDPLN Spot Exchange Rate - Price of 1 USD in PLN
USDBRL Curncy	USDBRL Spot Exchange Rate - Price of 1 USD in BRL	USDRUB Curncy	USDRUB Spot T+1 (TOM) Exchange Rate - Price of 1 USD in RUB
USDCAD Curncy	USDCAD Spot Exchange Rate - Price of 1 USD in CAD	USDSGD Curncy	USDSGD Spot Exchange Rate - Price of 1 USD in SGD
USDCLP Curncy	USDCLP Spot Exchange Rate - Price of 1 USD in CLP	USDZAR Curncy	USDZAR Spot Exchange Rate - Price of 1 USD in ZAR
USDCOP Curncy	USDCOP Spot Exchange Rate - Price of 1 USD in COP	USDKRW Curncy	USDKRW Spot Exchange Rate - Price of 1 USD in KRW
USDCZK Curncy	USDCZK Spot Exchange Rate - Price of 1 USD in CZK	USDSEK Curncy	USDSEK Spot Exchange Rate - Price of 1 USD in SEK
USDHUF Curncy	USDHUF Spot Exchange Rate - Price of 1 USD in HUF	USDTWD Curncy	USDTWD Spot Exchange Rate - Price of 1 USD in TWD
USDINR Curncy	USDINR Spot Exchange Rate - Price of 1 USD in INR	USDTHB Curncy	USDTHB Spot Exchange Rate - Price of 1 USD in THB
USDIDR Curncy	USDIDR Spot Exchange Rate - Price of 1 USD in IDR	USDTRY Curncy	USDTRY Spot Exchange Rate - Price of 1 USD in TRY
USDJPY Curncy	USDJPY Spot Exchange Rate - Price of 1 USD in JPY	USDGBP Curncy	USDGBP Spot Exchange Rate - Price of 1 USD in GBP
USDMYR Curncy	USDMYR Spot Exchange Rate - Price of 1 USD in MYR	USDEUR Curncy	USDEUR Spot Exchange Rate - Price of 1 USD in EUR
USDMXN Curncy	USDMXN Spot Exchange Rate - Price of 1 USD in MXN	LUCROAS Index	Bloomberg Barclays US Agg Credit Avg OAS
USDNZD Curncy	USDNZD Spot Exchange Rate - Price of 1 USD in NZD	LF98OAS Index	Bloomberg Barclays US Corporate High Yield Average OAS
USDNOK Curncy	USDNOK Spot Exchange Rate - Price of 1 USD in NOK	LECPOAS Index	Bloomberg Barclays EuroAgg Corporate
JPSSEMME Index	J.P. Morgan EMBI Plus Mexico Sovereign Spread	DAX Index	Deutsche Boerse AG German Stock Index DAX
JPSSGDPO Index	J.P. Morgan EMBIG Diversified Poland Sovereign Spread	NKY Index	Nikkei 225
JPSSEMBR Index	J.P. Morgan EMBI Plus Brazil Sovereign Spread	HSI Index	Hong Kong Hang Seng Index
JPSSEMSA Index	J.P. Morgan EMBI Plus South Africa Sovereign Spread	SHSZ300 Index	Shanghai Shenzhen CSI 300 Index
JPSSEMID Index	J.P. Morgan EMBI Plus Indonesia Sovereign Spread	AS51 Index	S&P/ASX 200
JPSSEMRU Index	J.P. Morgan EMBI Plus Russia Sovereign Spread	XAU Curncy	XAUUSD Spot Exchange Rate - Price of 1 XAU in USD
JPSSEMTU Index	J.P. Morgan EMBI Plus Turkey Sovereign Spread	LMAHDS03 LME Comdty	LME Aluminum 3 Month Rolling Forward
VIX Index	Chicago Board Options Exchange SPX Volatility Index	LMCADS03 LME Comdty	LME Copper 3 Month Rolling Forward
V2X Index	EURO STOXX 50 Volatility Index VSTOXX	GACGB10 Index	Australia Govt Bonds Generic Yield 10 Year
VHSI Index	HSI Volatility Index	GEBR10Y Index	Brazil Government Generic Bond 10 Year
VNKY Index	Nikkei Stock Average Volatility Index	GCAN10YR Index	Canadian Govt Bonds 10 Year Note
JPMVXYGL Index	J.P. Morgan Global FX Volatility Index	CHSWP10 CMPN Curncy	CLP SW PESO v CAMARA 10Y
USCRWTIC Index	Bloomberg West Texas Intermediate (WTI) Cushing Crude Oil Spot Price	COGR10Y Index	Colombia Government Generic Bond 10 Year Yield
BFCIUS Index	Bloomberg United States Financial Conditions Index	CZGB10YR Index	Czech Republic Governments Bonds 10 Year Note Generic Bid Yield
GSERMUS Index	Goldman Sachs MAP Economic Surprise Index - US	GDBR10 Index	Germany Generic Govt 10Y Yield
USGGBE10 Index	US Breakeven 10 Year	HKGG10Y Index	Hong Kong Generic 10 Year
MXGGBE10 Index	Mexico Breakeven 1 10 Year	GHGB10YR Index	GDMA Hungarian Govt Bond 10 Year
DEGGBE10 Index	Germany Breakeven 10 Year	GIND10YR Index	India Govt Bond Generic Bid Yield 10 Year

Ticker	Name	Ticker	Name
UKGGBE10 Index	UK Breakeven 10 Year	GIDN10YR Index	Indonesia Govt Bond Generic Bid Yield 10 Year
FWISJY55 Index	JPY Inflation Swap Forward 5Y5Y	GJGB10 Index	Japan Generic Govt 10Y Yield
ADGGBE10 Index	Australia Breakeven 10 Year	MAGY10YR Index	Malaysia Govt Bonds 10 Year Yield
CDGGBE10 Index	Canada Breakeven 10 Year	GMXN10YR Index	Mexico Generic 10 Year
BRGGBE10 Index	Brazil Breakeven 10 Year	NDSW10 Curncy	NZD SWAP 10YR
SAGGBE10 Index	South Africa Breakeven 10 Year	NKSW10 CMPN Curncy	NOK SWAP 10YR
MOVE Index	Merrill Lynch Option Volatility Estimate MOVE Index	POGB10YR Index	Poland Government 10 Year Note Generic Bid Yield
SPX Index	S&P 500 Index	RRSWM10 Curncy	RUB SWAP VS MOSPRIME 10Y
SPTSX Index	S&P/TSX Composite Index	GSAB10YR Index	South Africa Govt Bonds 10 Year Note Generic Bid Yield
MEXBOL Index	Mexican Stock Exchange Mexican Bolsa IPC Index	GVSK10YR Index	KCMP South Korea Treasury Bond 10 Year
IBOV Index	Ibovespa Brasil Sao Paulo Stock Exchange Index	GSGB10YR Index	SWEDISH GOVERNMENT BOND 10 YR NOTE
IPSA Index	Santiago Stock Exchange IPSA Index	GSWISS10 Index	Switzerland Govt Bonds 10 Year Note Generic Bid Yield
COLCAP Index	Colombia COLCAP Index	GVTL10YR Index	Thailand Govt Bond 10 Year Note
SX5E Index	EURO STOXX 50 Price EUR	GTRU10YR Index	USD Turkey Govt Bond Generic Bid Yield 10 Year
UKX Index	FTSE 100 Index	GUKG10 Index	UK Govt Bonds 10 Year Note Generic Bid Yield
CAC Index	CAC 40 Index	USGG10YR Index	US Generic Govt 10 Year Yield

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