MARKET INSIGHTS

Positively Negative:

Stock-Bond Correlation and Its Implications for Investors

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D E Shaw & Co

Introduction

One of the most important shifts in the investment landscape over the past two decades has been the emergence of a negative correlation between stock and bond returns. This shift has transformed the basic hedging properties of bonds, giving them a more substantial role in the construction of efficient, diversified portfolios for investors.

This change contributed to a sizable repricing of fixed income instruments over this period. As investors increasingly recognized that government bonds had become an effective hedge for the equity assets held in their portfolios, the term premium on bonds gradually declined, even reaching negative levels in recent years. This decline in the term premium created trillions of dollars of wealth for the holders of fixed income assets.

Yet, despite the fundamental importance of the stock-bond correlation for bond pricing and for investors' portfolios generally, its underlying drivers are not well understood, leaving considerable uncertainty about what to expect going forward. Many observers simply assume that the dynamics observed over the past two decades will persist. Others have suggested that the correlation is on the cusp of shifting back to a positive regime—a development that would have substantial consequences for financial markets.[1] In either case, it is hard to have confidence in the view without first determining what developments have pushed the correlation to its current levels.

In this paper, we argue that the negative correlation regime observed in recent decades has been driven to a large extent by the success of the U.S. Federal Reserve and other developed-economy central banks in reducing inflation and keeping inflation expectations relatively anchored. This success, in turn, has resulted in asset price fluctuations generally being driven by perceived changes in the strength of economic activity or shifts in risk sentiment—developments that generally induce a negative correlation.

Under this explanation, the path forward would hinge on how well central banks manage to achieve ongoing success on that front. If they can continue to control inflation and inflation expectations to the same extent that they have in recent years, government bonds should continue to offer attractive hedging properties, and the downward adjustment of the term premium observed to date could persist or even run further at longer maturities. If, instead, central banks falter and inflation again becomes unmoored, markets could snap back to a regime of positive correlations, potentially pushing the term premium much higher.

In our view, the former outcome is much more likely. The fundamental driver of the negative correlation—central banks' success in managing inflation—will likely remain in place, with the consequence that the term premium will likely remain low relative to its historical average. Nevertheless, given the significant portfolio implications of those different outcomes, it is important to understand the range of potential future scenarios and the factors that might tip the scale between them.

[1] See, *e.g.*, "Two-Decade Rupture in Stock-Bond Link Flashes Global Market Pain," Bloomberg, October 10, 2018.

Stock-Bond Correlation and Its Drivers

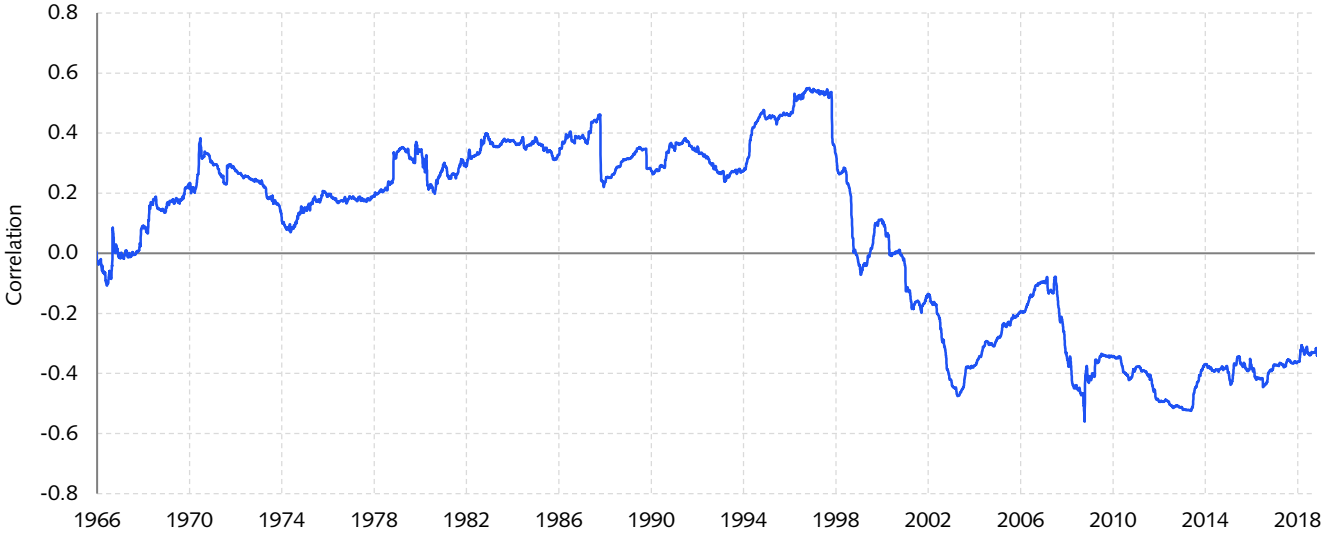
The meaningful shift in the relationship between government bonds and stocks is readily observable in a time series plot of the correlation between their daily returns. As shown in Figure 1, a negative correlation regime in U.S. markets began at some point around the late 1990s, following the period of positive correlation that had prevailed over the previous three decades.

We believe a major ingredient in this shift was the success of the Federal Reserve in bringing realized inflation rates to low levels and stabilizing inflation expectations at those levels, as well as the greater clarity the Fed offered concerning the policy framework for maintaining that outcome.[2]

To understand this argument, it is important to recognize that the connection between equity and bond prices depends on the factors that drive their respective fluctuations. For both bonds and stocks, the values of future cash flows are determined using discount rates that reflect the time value of money, making both assets sensitive to that variable. However, the relative responses of these assets to a shift in discount rates are not uniform, but rather depend on what factors are driving that shift. The following four scenarios offer a simple framework for understanding the factors that drive changes in stock and bond prices:

1) Suppose yields rise because the central bank is expected to tighten policy in response to an unexpected rise in inflation or inflation expectations. In that case, one might expect stock prices to fall along with bond prices. The negative response of stock prices reflects the belief that nominal interest rates will typically move by more than inflation, that economic activity will decline in response, and that the equity risk premium might rise in a more volatile inflation environment.[3]
2) A similar dynamic arises if investors revise their view of the policy inclinations of the relevant central bank for a given set of economic conditions (that is, there is a shift in what is often called the central bank's "policy rule"). If yields rise because the central bank is suddenly seen as taking a more hawkish approach, equity prices would likely fall due to higher discount rates, as in the previous scenario. In fact, the situation for equities is somewhat worse, in that there is no positive effect on nominal dividends from higher inflation.

Figure 1: Correlation Between S&P 500® and 10-year U.S. Treasury Returns



Correlations based on daily returns using exponential weighting with a 2-year half-life. Source: Bloomberg.

[2] The role of central banks and economic factors in influencing the correlation and associated risk premia are explored through use of a formal asset-pricing model in a National Bureau of Economic Research working paper by John Campbell, Carolin Pflueger, and Luis Viceira, "Macroeconomic Drivers of Bond and Equity Risks," © April 2014, revised August 2018.

[3] Because equities are a real asset, it is tempting to assume that shifts in inflation prospects would have no effect on their value. However, that is not the case if the central bank is adjusting the real interest rate and affecting real activity in response to an inflation shock. It is also not the case if perceived risk, and hence the equity premium, is responsive to a change in the inflation environment.

3) The situation is very different, though, if an increase in yields comes in response to improving prospects for economic growth, perhaps as the economy emerges from a recession and investors gain confidence in the recovery. While this increase in yields again reflects a higher expected interest rate policy path by the central bank, investors also would expect higher earnings growth in this case, potentially outweighing the drag of higher interest rates and boosting equity prices.

4) Lastly, it is worth considering the scenario in which asset price movements are driven by a shift in the risk appetite of investors. If investors become more willing to hold risky assets, whether because they perceive less overall risk or simply become more tolerant of risk, they will tend to push equity prices higher and bond prices lower.

As summarized in Table 1, the first two scenarios tend to create a positive correlation, while the last two create a negative correlation. (Table 1 is expressed in terms of developments pushing bond prices down, but the relationships hold if the factors move in the other direction.)

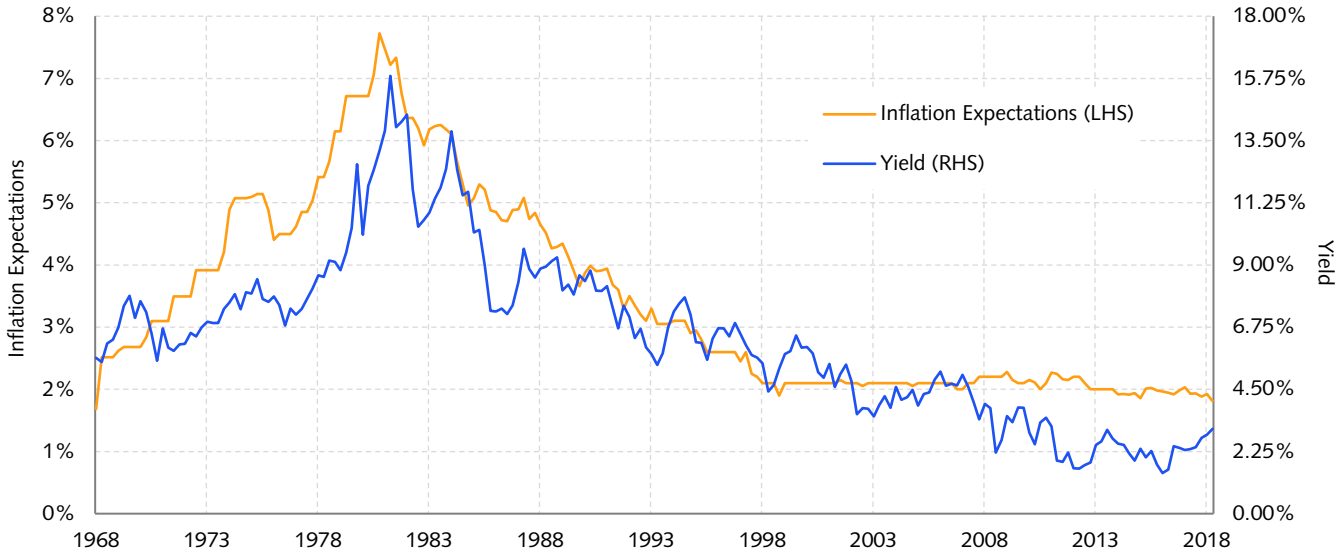
Table 1: Four Scenarios for Equity and Bond Returns

Asset Price Response	(1) Higher Inflation Expectations	(2) Hawkish Policy Surprise	(3) Stronger Expected Growth	(4) Higher Risk Appetite
Equities	Neg	Neg	Pos	Pos
Bonds	Neg	Neg	Neg	Neg

This simple framework can go a long way towards explaining the shift in correlation in U.S. markets described earlier. As shown in Figure 2, longer-term inflation expectations were high and variable over a sizable portion of the past 50 years, reflecting the poor credibility of the Fed in delivering low inflation and considerable market uncertainty regarding the Fed's policy approach. Under those circumstances, the factors reflected in the first two columns of Table 1 were critical drivers of market fluctuations, inducing a positive correlation between stocks and bonds.

However, the situation appears quite different since the late 1990s, as the Fed has managed to stabilize inflation expectations at around two percent. Over this period, the Fed has also become clearer about its policy framework for maintaining that outcome, boosting its

Figure 2: Long-Term Inflation Expectations and 10-year U.S. Treasury Yield



Long-term inflation expectations refer to the 10-year expected PCE (personal consumption expenditure) inflation measure from the Federal Reserve Board's FRB/US model, which we splice (beginning in 2014) to 5- to 10-year inflation expectations from the Consensus Economics survey. Source: Bloomberg; Consensus Economics.

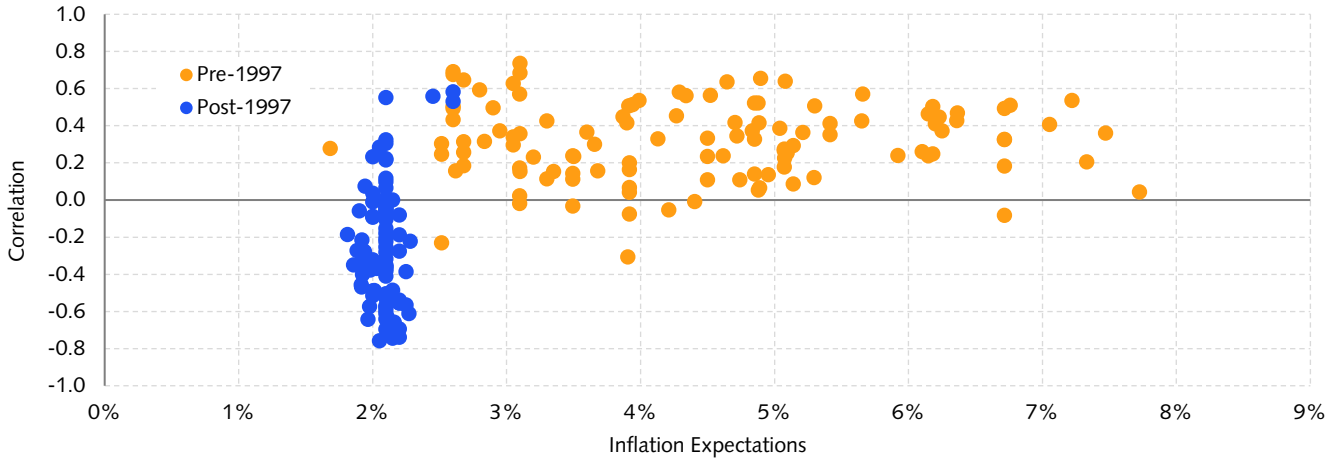
credibility among investors and making its policy decisions more predictable. This policy success has diminished the importance of the factors in the first two scenarios of Table 1, leaving the market to be driven more substantially by shifts in growth prospects and risk preferences, inducing a negative correlation.[4]

The relationship of the realized stock-bond correlation to inflation expectations is notable, as shown in Figure 3a.

The relationship also appears strong when measured against the 10-year Treasury yield, as that yield incorporates the broad patterns in inflation expectations (see Figure 3b).

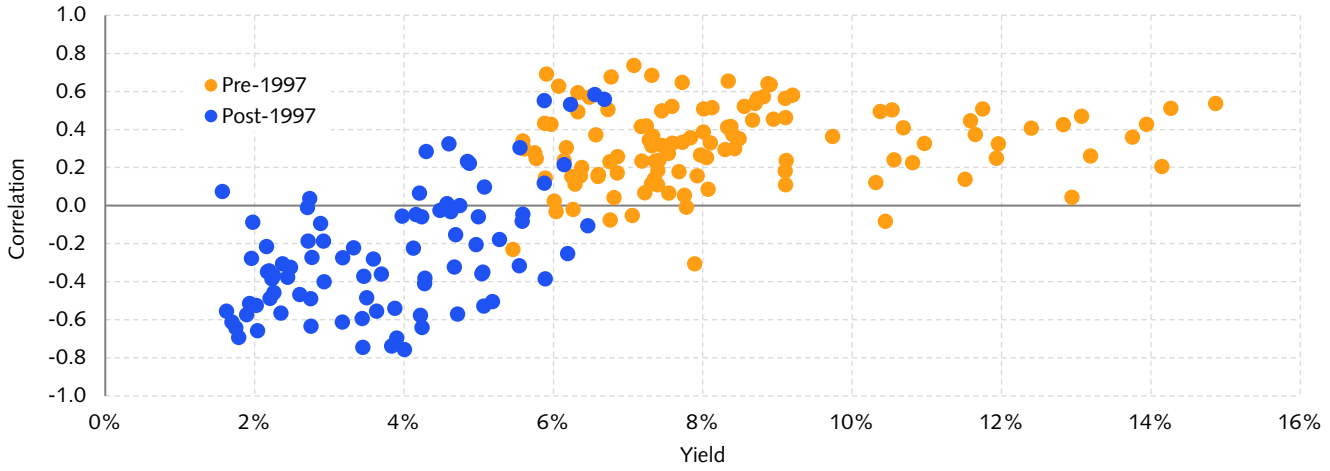
Because we know that the correlation shifted downward so strongly in the 1990s, it would be easy to find an apparent relationship with any variable that was also trending over this period. So why do we believe that the

Figure 3a: Stock-Bond Correlation Versus Inflation Expectations



Quarterly correlations based on daily returns of the S&P 500® and 10-year U.S. Treasury note. Inflation expectations refer to the 10-year expected PCE inflation measure from the Federal Reserve Board's FRB/US model, which we splice (beginning in 2014) to 5- to 10-year inflation expectations from the Consensus Economics survey. Source: Bloomberg; Consensus Economics.

Figure 3b: Stock-Bond Correlation Versus 10-year U.S. Treasury Yield



Quarterly correlations based on daily returns of the S&P 500® and 10-year U.S. Treasury note. Treasury yield computed as quarterly average. Source: Bloomberg.

[4] In addition to the empirical results reflected in Figure 2, this shift can also be seen in simple macroeconomic models that describe the economy with a few simple equations (see, for example, the structure of the model used in the Federal Reserve Board working paper "Short Takes on Monetary Policy Strategy: An Introduction to Some Basic Concepts" by James A. Clouse, FEDS#2018-089). According to those models, it appears that shocks related to inflation (as determined by a "Phillips curve") and short-term interest rates (as determined by the Fed's policy rule) have diminished significantly over the past two decades.

shift has to do with inflation? One reason is that the economic developments underlying this explanation were notable and also generated meaningful shifts in the behavior of other key variables. For example, researchers have found that the stability of inflation expectations since the late 1990s in the United States significantly reduced the persistence of inflation itself.[5]

There is also support for our hypothesis from patterns observed across other countries. The shift in the stock-bond correlation has occurred in almost all advanced economies, and it generally lines up with inflation expectations reaching low levels in those cases. A particularly informative example is Japan, where the correlation turned negative earlier than observed in other countries, coinciding with an earlier decline in inflation expectations in that country. (Please see the Appendix for further discussion of this international evidence.)

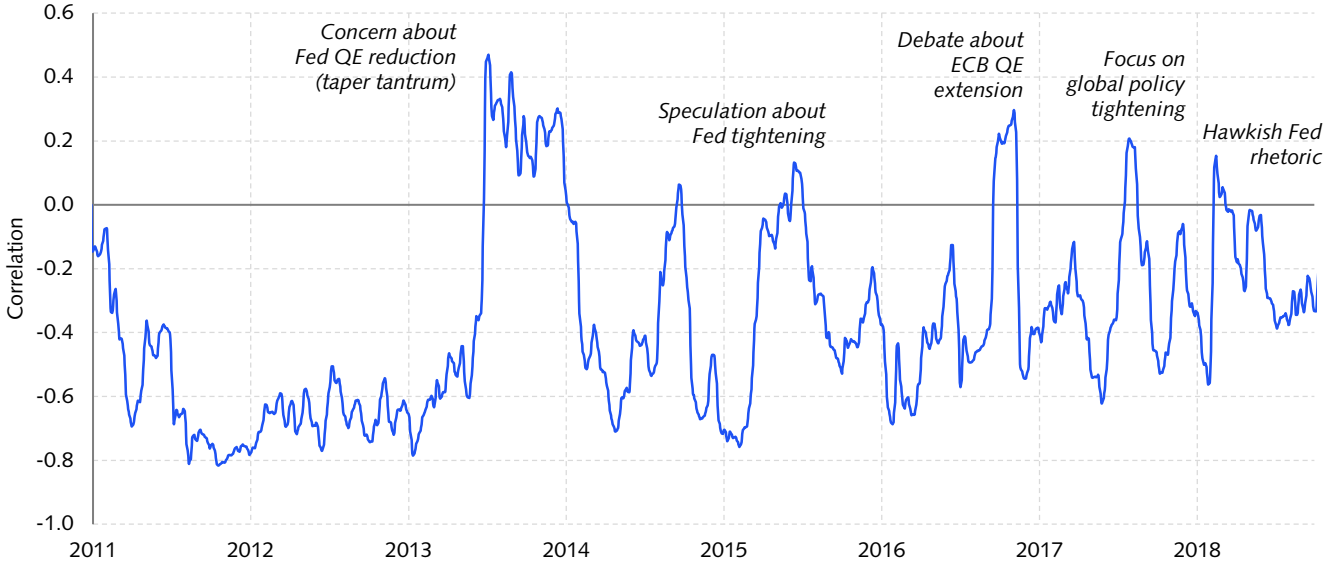
Zooming In on the Correlation

Our hypothesis relies on the changing importance that market participants assign to different types of information. Under this explanation, the move to a regime of greater inflation stability and more predictable monetary policy has been the primary driver of the broad shift to a negative stock-bond correlation shown in Figure 1. However, even within this recent regime, one might still expect to find predictable variation in this correlation when measured over periods in which market participants perceive the arrival of different types of information.

To investigate that possibility, we find it useful first to zoom in the lens and examine the stock-bond correlation in the United States using the same methodology as in Figure 1 above, but with a shorter half-life (40 days instead of two years). As shown in Figure 4, the negative correlation that appeared relatively steady when measured over a longer half-life now appears to be more variable. Moreover, there have been five periods since 2011 when the correlation has become markedly positive. Each of these spikes corresponds, in our view, to periods of disproportionate concern over the Fed's policy approach (scenario 2 from Table 1).

That narrative is useful, but it is somewhat ambiguous to claim that these episodes were driven by changing perceptions of the policy approach. To be more careful about the categorization, we can zoom the lens in one step further and investigate whether the correlation looks different on days when market participants receive more

Figure 4: Correlation Between S&P 500® and 10-year U.S. Treasury Returns



Correlations based on daily returns using exponential weighting with a 40-day half-life over a 1-year rolling window.
Source: Bloomberg; U.S. Treasury.

[5] See, e.g., "Inflation Persistence in an Era of Well-Anchored Inflation Expectations" (a Federal Reserve Bank of San Francisco Economic Letter), John C. Williams, October 2006.

information about the Fed's policy approach—specifically, days on which the Federal Open Market Committee (FOMC), the policymaking body of the Fed, releases either a policy statement or the minutes from its meeting. Relative to the correlation measure shown in Figure 1, we can see in Figure 5 that the correlation on FOMC release days shifts notably higher, with strong statistical significance. This pattern suggests, as expected, that FOMC days contain a larger amount of policy news (scenario 2 in Table 1) relative to the regular set of information about the economy and risk attitude (scenarios 3 and 4).[6]

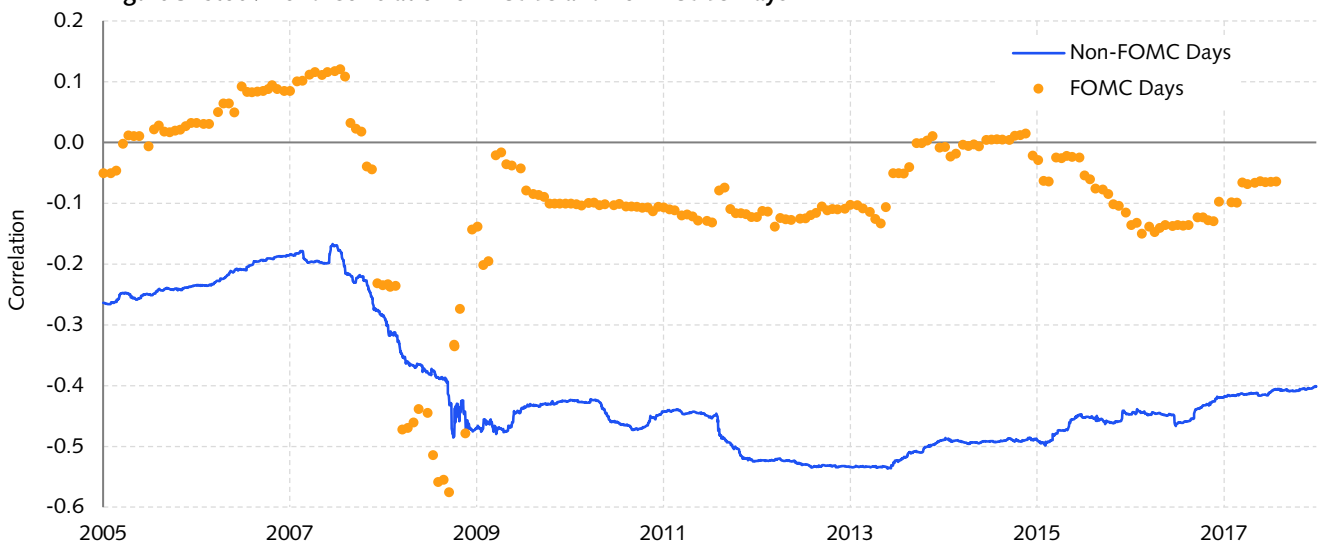
Finally, to zoom the lens in one final step, we can look at the intraday timing of correlation shifts on those FOMC days. We do so by measuring the correlation between equity and bond returns over 5-minute windows during the applicable day, allowing us to plot the difference in the mean intraday correlations that occur on FOMC days relative to the mean intraday correlations observed on non-FOMC days. Figure 6 shows that the window of time surrounding the 2:00 p.m. (Eastern) release of the Fed's policy statement is associated with a substantially higher correlation than observed during the same window on non-policy days.

The localized dynamics highlighted in this section are similar in nature to what we believe drove the more generally positive correlation before the late 1990s—when movements in asset prices were heavily influenced by changes in discount rates that were disproportionately associated with inflation or policy-related uncertainty. That dynamic dominated markets in the decades leading up to the shift in correlation. Now, with low inflation well-established and the Fed's policy approach better understood, those types of dynamics take place only on a much smaller scale, and we have to look much more closely to find them.

Implications for the Term Premium

We believe that the regime shift in correlation has meaningful implications for asset prices. From the perspective of a CAPM-type approach, if investors were convinced that bonds offered a negative correlation with equity returns, then they would expect the risk premium on bonds (the "term premium") to be negative.[7] That is, investors may be willing to accept a negative expected excess return, in

Figure 5: Stock-Bond Correlation on FOMC and non-FOMC Days



Correlations based on a regression of S&P 500® returns on 10-year U.S. Treasury note returns, with a dummy variable included for days with the release of FOMC statements or minutes. The regression uses exponential weighting with a 2-year half-life. Source: Bloomberg; Federal Reserve Board.

[6] The only exception over the sample was in 2008; we believe this exception is attributable to the breakdown in a significant number of market relationships during this period.

[7] The Capital Asset Pricing Model (CAPM) relates the expected return of an asset to the systematic risk embedded in that asset, where the systematic risk is measured by the sensitivity of its returns to those of the overall market.

effect paying for the hedging services offered by bonds. If those bonds had particularly good payouts during periods of financial crisis or at other times when "insurance-like" payouts are highly valued, that would further support a negative sign on the term premium.

Of course, risk premia are more complicated than suggested by CAPM and are a function of a number of other factors, including the supply of an asset, captive demand for an asset generated by regulatory requirements or liability structures, and changes in the risk tolerance of investors. But even with these generalizations, it follows that the shift in the correlation should have contributed to a notable decline in the term premium in recent decades.

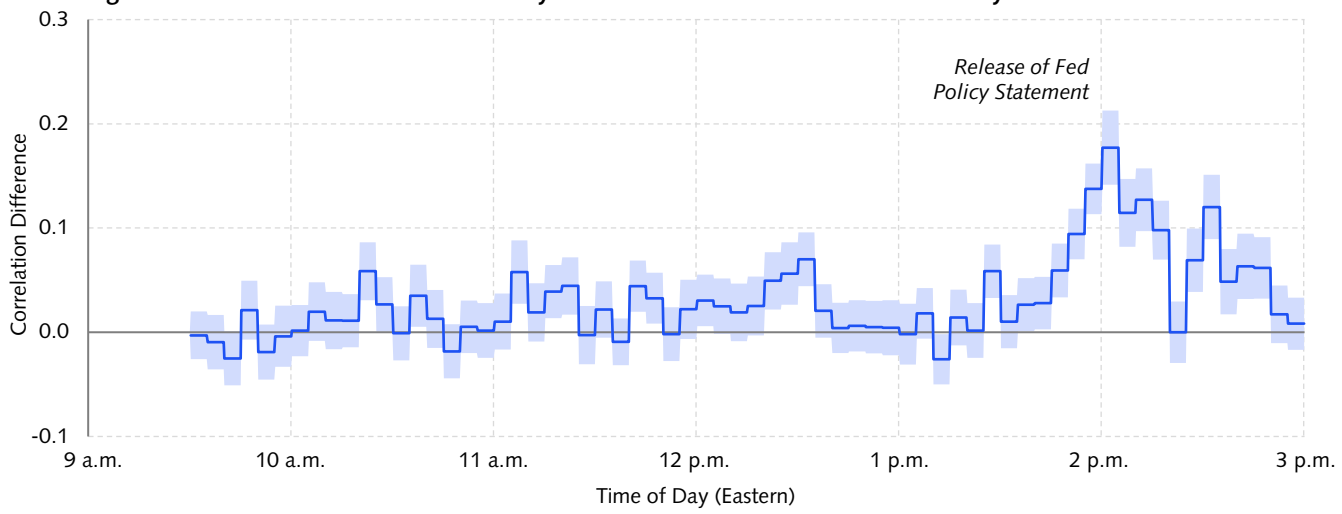
Measuring the risk premium on bonds is challenging, just as it is for any other asset. Market participants have increasingly gravitated towards two models of the term premium estimated by Federal Reserve staff members: the Adrian-Crump-Moench (ACM) model and the Kim-Wright (KW) model.[8] We rely on those models in our discussion.

Figures 7a and 7b show the history of these estimated term premium measures for 2-year and 10-year U.S. Treasury securities, respectively. These measures represent the annualized expected excess return that an investor would earn by holding a long position in the applicable Treasury security on a held-to-maturity basis, relative to the path of rolling over an investment earning the short-term interest rate (such as the repo rate or a bill yield). As we can see, the term premia on these instruments have decreased meaningfully over the sample period, reaching negative levels in recent years.

One interesting observation is that the decline in the term premium has been a gradual process, whereas the shift in correlations took place relatively quickly in the late 1990s. This pattern may reflect that market participants needed a period of time to become convinced that the correlation between equity and bond returns had become negative in an enduring manner.

Even if one accepts the shift in the correlation as a primary driver of the decline in term premia over the sample period, at least one anomaly remains unexplained: the fact that the expected excess return of holding instruments with longer maturities has held its ground to a much greater extent. That pattern can be seen by investigating the shape of the yield curve in more detail at maturities beyond ten years.

Figure 6: Difference Between Mean Intraday Correlation on FOMC and non-FOMC Days



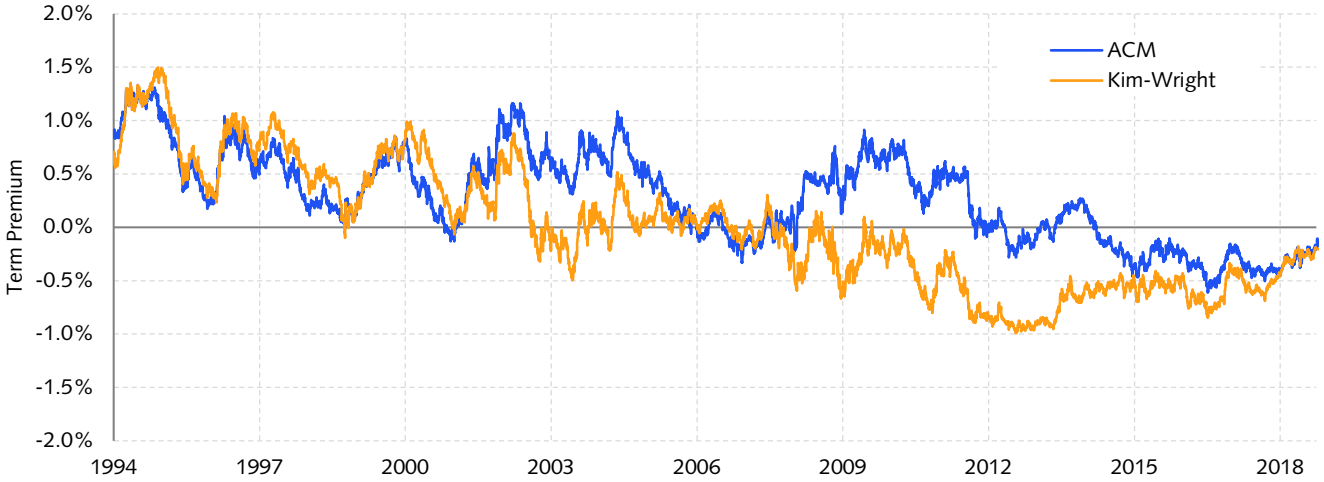
Correlations based on returns in each 5-minute interval of futures contracts on the S&P 500® and 10-year U.S. Treasury note. The figure shows the difference, and standard error of the difference, in mean correlation on FOMC days (days of FOMC statements) and non-FOMC days since January 2011. The sample includes 68 FOMC days and 1,852 non-FOMC days. Source: CME Group; Chicago Board of Trade (CBOT); the D. E. Shaw Group.

[8] See https://www.newyorkfed.org/research/data_indicators/term_premia.html for a description of the ACM model, and https://www.federalreserve.gov/pubs/feds/2005/200533/200533abs.html for a description of the KW model.

In particular, at horizons beyond those at which monetary policy might change, we can look at the slope of the forward rate curve as an approximation of the expected return on that instrument. For example, the difference between the 15y5y forward rate (*i.e.*, the 5-year rate for a period starting 15 years from now) and the 10y5y forward rate will approximate the expected return from holding (receiving) the 15y5y rate for five years, once we make a technical adjustment for convexity effects.[9]

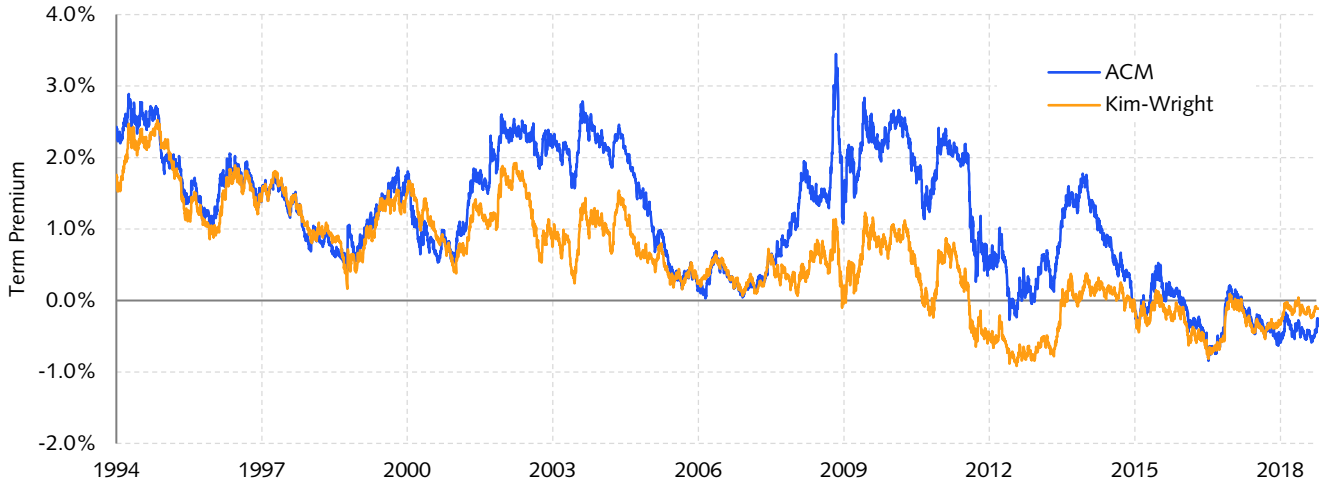
As we can see in Figure 8, the forward rate curve at these longer horizons has exhibited a positive slope, typically of about ten basis points per year. Moreover, this measure does not exhibit the persistent decline that was evident in the shorter-end term premium measures from Figure 7.[10]

Figure 7a: Estimate of 2-year Term Premium



Source: Bloomberg.

Figure 7b: Estimate of 10-year Term Premium



Source: Bloomberg.

[9] Note that we have switched to looking at the returns on forward rates rather than bonds. One can think of holding a longer-term bond as roughly equivalent to holding a shorter-maturity bond and a forward rate that spans the difference in maturities. (For example, holding a 15-year bond conceptually involves holding a 10-year bond and receiving a 10y5y forward rate.) By focusing on the forward rate, we are able to consider the portion of the expected return on the bond that is not associated with that of the shorter-maturity bond.

[10] Here we are considering the expected excess return to holding the forward rate over a particular period, such as five years. The term premium measures shown earlier are the expected excess returns to holding securities to maturity. It is possible for the forward rate to have positive expected excess return over the near term and yet a negative held-to-maturity term premium, if the average returns of the security are expected to turn negative as the starting point of the forward rate approaches.

Figure 8: Rolldown for Longer-Term Forward Rate

Annualized rolldown over 5 years for the 15y5y forward rate based on interest rate swaps and adjusted for convexity effects. Source: Bloomberg; the D. E. Shaw Group.

So what might explain this anomaly? It seems reasonable that shorter and intermediate maturities would embed the most negative levels of the term premium. After all, those are the maturities at which interest rates are most strongly influenced by the expected reaction of monetary policy to shifting economic growth prospects, and they may also benefit disproportionately from the "flight-to-quality" dynamic that manifests during periods of market stress. By contrast, at longer maturities, there may be greater scope for rates to be driven by other factors that might not induce the same negative correlation with stock prices. Nevertheless, given the increased stability of long-term inflation expectations since the 1990s, the correlation properties of distant forward rates have also become more favorable, and hence one might expect their risk premium to have declined to some degree.

What Lies Ahead?

It is difficult to fathom how great an impact the shift to a negative stock-bond correlation has had on global financial markets over the past 20 years.

The negative correlation has sharply increased the hedging utility of bonds to investors in their efforts to construct diversified portfolios. Indeed, if investors were pursuing a simple mean-variance portfolio optimization with just stocks and 10-year bonds, a shift in the correlation from 0.4 to -0.4 would, with unchanged risk premia, cause them to more than double their target holdings of bonds.[11] The greater attractiveness of bonds contributed to a massive repricing of fixed income assets, with the 10-year term premium declining by around 100 basis points since the late 1990s. That decline created a remarkable amount of capital gains for investors in U.S. financial markets, and even more for global investors if we consider the similar patterns realized around the world.

Thus, we risk stating the obvious when we say that a lot rests on whether the regime persists.

Our view is that this meaningful shift in the behavior and pricing of these assets can largely be traced to one particular set of institutions: global central banks. The success of those institutions in anchoring longer-term inflation expectations and enhancing the predictability of monetary policy has, in our view, been a key factor leading to the shift.

Through that effect, central banks are largely responsible for bringing the term premium lower over the past several decades. While market observers have been fixated on the

[11] Similarly, the mean-variance optimization would want to boost equity holdings given that the aggregate risk of the portfolio has declined. However, we leave aside the implications for equity prices in this piece.

role of central banks' quantitative easing (QE) programs in driving down the term premium in the past few years, we believe that these other aspects of monetary policy have played a much more powerful role in producing this outcome over a longer horizon. Indeed, the decline in the term premium began well before QE was ever put into place (as can be seen in Figures 7a and 7b).

Under that view, the path of the term premium going forward rests on whether central banks continue to achieve success along these dimensions. If central banks were to lose their grip on inflation or allow policy to become more erratic, we would expect a significant and painful reversal of the favorable market dynamics that have characterized the past two decades. The term premium would likely shift higher, and investors would face a substantial increase in aggregate portfolio risk, as stocks and bonds would begin to move together.

However, we believe that a dramatic shift in this direction is unlikely. Our view is that developed economy central banks will continue to achieve success in keeping inflation expectations low and stable, allowing the negative correlations between stocks and bonds to persist for the foreseeable future.

As with any forecast, and especially ones about financial market behavior over long horizons, our prediction is subject to meaningful uncertainties and risks. These include several emerging factors that could pose challenges to central banks, such as potentially unstable fiscal dynamics in some advanced economies and growing pressure on the independence of central banks. Nevertheless, we believe that central banks have learned a number of lessons over the past several decades about the importance of maintaining stable inflation expectations, and we think it is highly unlikely that the developed world will return to an unmoored inflation regime similar to those of the 1970s and 1980s.[12]

If we are correct in that view, then we think that the term premium will remain low relative to its historical levels, and the decline in term premium could extend even more forcefully to longer maturities where the adjustment has been less pronounced. That outcome would represent the final chapter in the remarkable transition of fixed income pricing that has transpired over the past two decades.

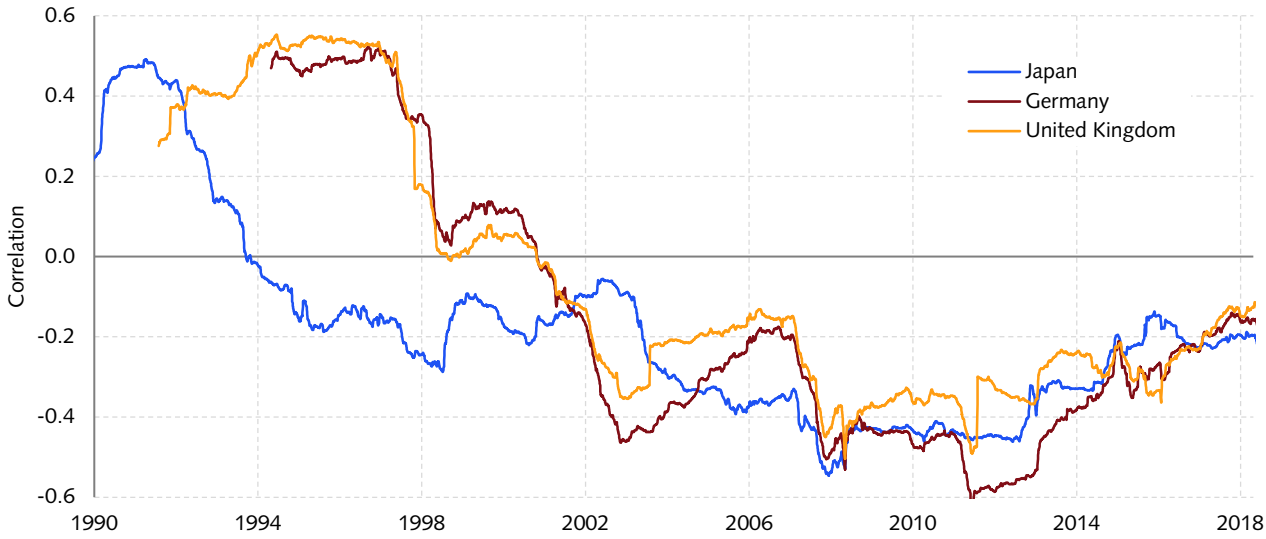
[12] See, e.g., Marco Vega and Diego Winkelried, "Inflation Targeting and Inflation Behavior: A Successful Story?", *International Journal of Central Banking*, December 2005.

Appendix

The shift in the stock-bond correlation has been a development not only in the United States, but in almost all advanced economies. As shown in Figure 9, the timing of the shifts in Germany and the United Kingdom corresponds closely to the shift in the United States (as seen earlier in Figure 1), but the correlation in Japan clearly turns negative well before the others.

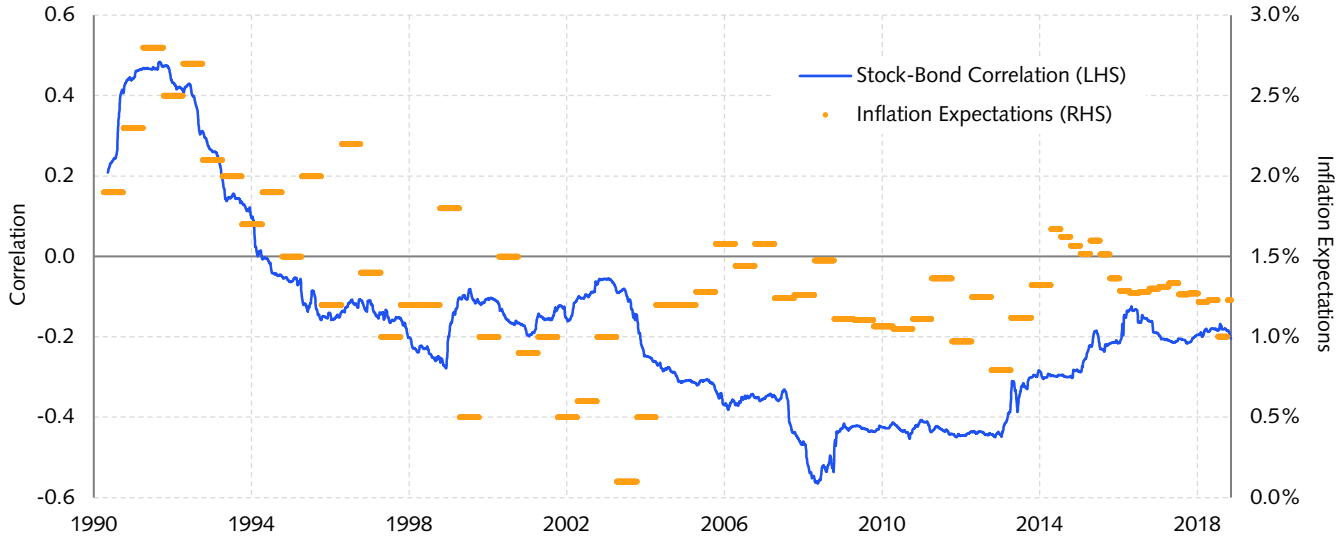
The earlier shift in the correlation in Japan may be particularly informative. Japan also reached low levels of inflation expectations ahead of other advanced economies, and it turns out that the shift in correlation lines up relatively well with the decline in inflation expectations, as shown in Figure 10.

Figure 9: Stock-Bond Correlation in Japan, Germany, and United Kingdom



Correlations based on daily futures returns using exponential weighting with a 2-year half-life. For Japan, data represents TOPIX and 10-year JGBs; for Germany, DAX and long-term bunds; for United Kingdom, FTSE 100 and long-term gilts. Source: Bloomberg.

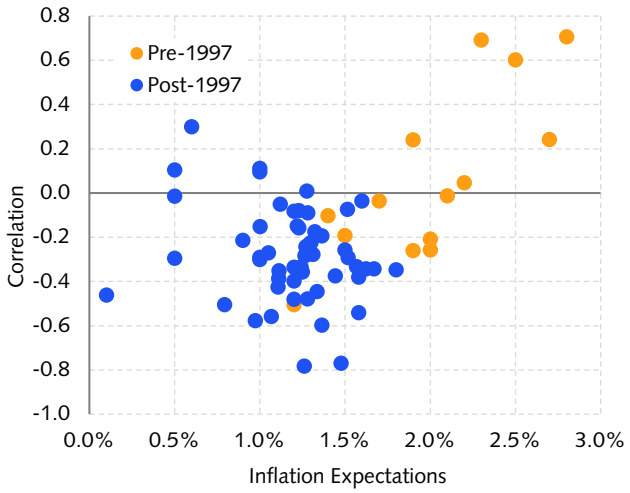
Figure 10: Stock-Bond Correlation and Long-Term Inflation Expectations in Japan



Long-term inflation expectations refer to 5y5y CPI expectations. Source: Bloomberg; Consensus Economics.

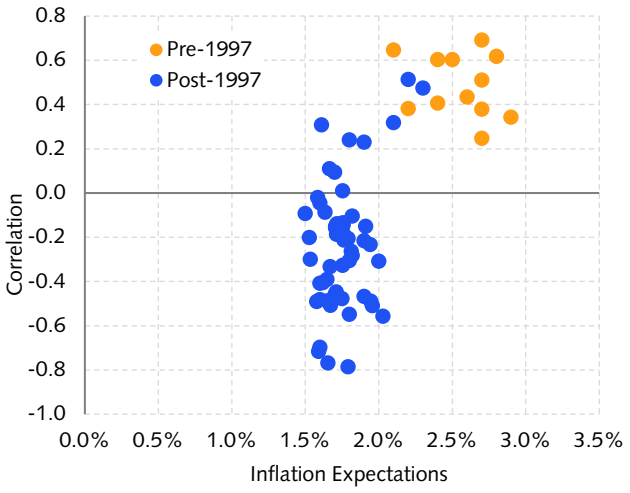
Across the three countries, the relationship between the correlation and the level of inflation expectations is somewhat harder to measure than it is for the United States, as the inflation survey data for the pre-1997 period is more limited. However, there appears to be some positive relationship across all three countries.

Figure 11a: Stock-Bond Correlation Versus Inflation Expectations in Japan



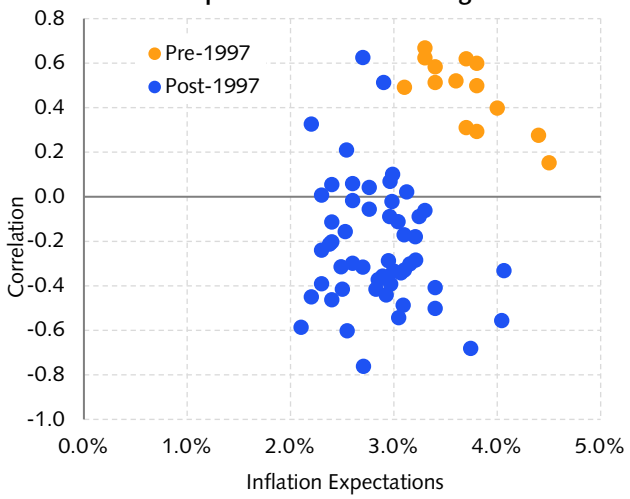
Correlations based on daily futures returns for the corresponding half-year or quarter, as applicable. Data for each country represents the same instruments used in Figure 9. Source: Bloomberg; Consensus Economics.

Figure 11b: Stock-Bond Correlation Versus Inflation Expectations in Germany



Correlations based on daily futures returns for the corresponding half-year or quarter, as applicable. Data for each country represents the same instruments used in Figure 9. Source: Bloomberg; Consensus Economics.

Figure 11c: Stock-Bond Correlation Versus Inflation Expectations in United Kingdom



Correlations based on daily futures returns for the corresponding half-year or quarter, as applicable. Data for each country represents the same instruments used in Figure 9. Source: Bloomberg; Consensus Economics.

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