INSTITUTIONAL ADVISORY & SOLUTIONS

STOCK-BOND CORRELATION

A Global Perspective

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The PGIM Institutional Advisory & Solutions (IAS) group provides objective, data-informed analysis to help Chief Investment Officers and Investment Committees manage their portfolios.

Stock-bond correlation is considered an important input for multi-asset portfolio construction. While there has been much research on US stock-bond correlation, less work has focused on stock-bond correlations in other countries, their relationship to each other, and their common macroeconomic drivers (if any).

For the last 20 years, Developed Market (DM) local stock-bond correlations have, by and large, been negative, matching the US experience. Negative stock-bond correlation provides an implicit hedge of one asset to the other, dampening overall portfolio risk. A shift in local stock-bond correlation regime from negative to positive would alter the expected risk-reward characteristics of a portfolio of local assets.

Changes in local stock-bond correlations will likely be driven by economic and policy settings both in the US and in the local market. A shift to positive stock-bond correlation would likely manifest itself widely across DMs, making it difficult to find low-risk, fixed income assets with equity hedging properties.

CIOs and asset allocators need to monitor both US and local macroeconomic and policy developments when assessing the likelihood of a stock-bond correlation regime change.

Stock-bond correlation is considered an important input for the construction of a multi-asset portfolio. While there has been much research on US stock-bond correlation, less work has focused on stock-bond correlations in other countries, their relationship to each other, and their common macroeconomic drivers (if any).[1]

Examining stock-bond correlation across countries allows for a more precise evaluation of the macroeconomic determinants of stock-bond correlation and the relative importance of country-specific versus global factors. A global perspective can also be valuable in understanding what other hedges may be available should local stock-bond correlation turn positive.

We offer five takeaways:

(1) DM stock-bond correlations are highly synchronized. DM local currency stock-bond correlations tend to move together, switching regimes (*i.e.*, sustained periods of positive or negative correlation) as a group. Emerging Market (EM) local currency stock-bond correlations are less cohesive and tend to be positive.

(2) Macroeconomic conditions and policy settings determine stock-bond correlation. The volatility of risk-free rates, the co-movement of economic growth and risk-free rates, and the co-movement of equity and bond risk premia determine stock-bond correlation. These conditions themselves relate to *fiscal policy sustainability, monetary policy cyclicality, investor risk preferences, and the balance between supply- and demand-driven growth.* Sustainable fiscal policy, rules-based and countercyclical monetary policy, and demand-side shifts support *negative* stock-bond correlation. Unsustainable fiscal policy, non-rules-based and procyclical monetary policy, and supply-side shifts support *positive* stock-bond correlation.

(3) Both global and local macroeconomic conditions determine local stock-bond correlation. US macroeconomic conditions – a proxy for *common global macroeconomic factors* – play a prominent role in determining DM local currency stock-bond correlations and help explain the synchronicity of DM stock-bond correlations. Local conditions net of US effects, particularly local risk premia, are also important.

(4) A shift in US stock-bond correlation regime from negative to positive would likely be matched by a correlation regime change in other DMs too. Should US economic and policy forces increase the likelihood of a switch in US stock-bond correlation regime, the risk of a similar switch in stock-bond correlation regime in other DMs would rise too.

(5) In a positive US stock-bond correlation regime, when US bonds are a weaker hedge to US stocks, other DM bonds do not provide a better hedge. When US stock-bond correlation is positive, the correlations between US stock returns and DM (hedged USD) bond returns are also positive, meaning that DM sovereign bonds are also not a reliable US equity hedge. Other potential hedging assets, particularly commodities, are more reliably negatively correlated with US stocks and could be a hedge, but at the cost of significantly higher portfolio volatility.

Given these observations, our main message is:

CIOs and asset allocators need to monitor both US and local macroeconomic and policy developments when assessing the risks of a stock-bond correlation regime change. A shift to a positive stock-bond correlation regime will likely be widespread across developed markets, with the loss of sovereign fixed income as a strong equity hedge in a multi-asset portfolio.

1. See J. Shen and N. Weisberger, *US Stock-Bond Correlation: What Are the Macroeconomic Drivers?* PGIM IAS, May 2021.

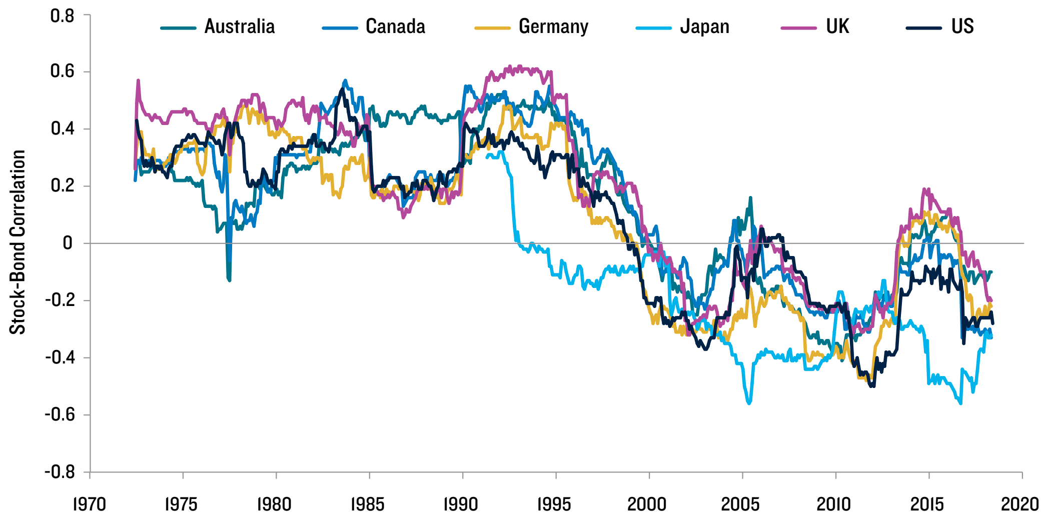
Stock-Bond Correlation Synchronicity

Looking across six DMs (Australia, Canada, Germany, Japan, UK, and US), we observe that changes in local currency stock-bond correlations are synchronized (Figure 1).[2] Indeed, the correlation of DM local currency stock-bond correlations with US stock-bond correlation ranges from a high of 0.92 for Canada to 0.58 for Japan (Figure 2).

Stock-bond correlation regimes (*i.e.*, positive or negative correlation) are also consistent across DMs. As Figure 2 illustrates, nearly 90% of the time stock-bond correlation in other DMs has the same sign as US stock-bond correlation.

One-third of the time (36%) other DMs and the US share negative stock-bond correlation (Quadrant 3) and 51% of the time, other DMs and the US share positive stock-bond correlation (Quadrant 1). Only about 5% of the time does a DM experience negative stock-bond correlation when US stock-bond correlation is positive (Quadrant 4). Japan is responsible for most non-synchronous instances.

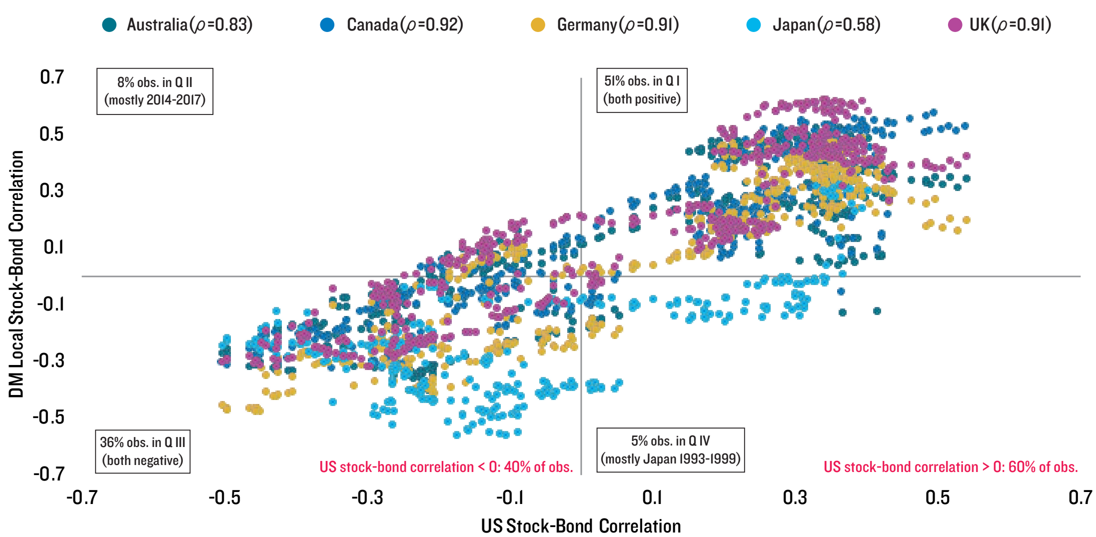
Figure 1: DM Local Stock-Bond Correlations



Note: MSCI Country Equity Local Currency Total Return Indices; Country Benchmark Long-Term Sovereign Bond Local Currency Total Return Indices; 1m returns; 5y, centered, rolling correlation; Australia, Canada, Germany, Japan, UK, US; 1970-2021 (varies by country).

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

Figure 2: US Stock-Bond Correlation (x-axis) and DM Local Stock-Bond Correlations (y-axis)



Note: MSCI Country Equity Local Currency Total Return Indices; Country Benchmark Long-Term Sovereign Bond Local Currency Total Return Indices; 1m returns; 5y, centered, rolling correlation; Australia, Canada, Germany, Japan, UK, US; 1970-2021 (varies by country).

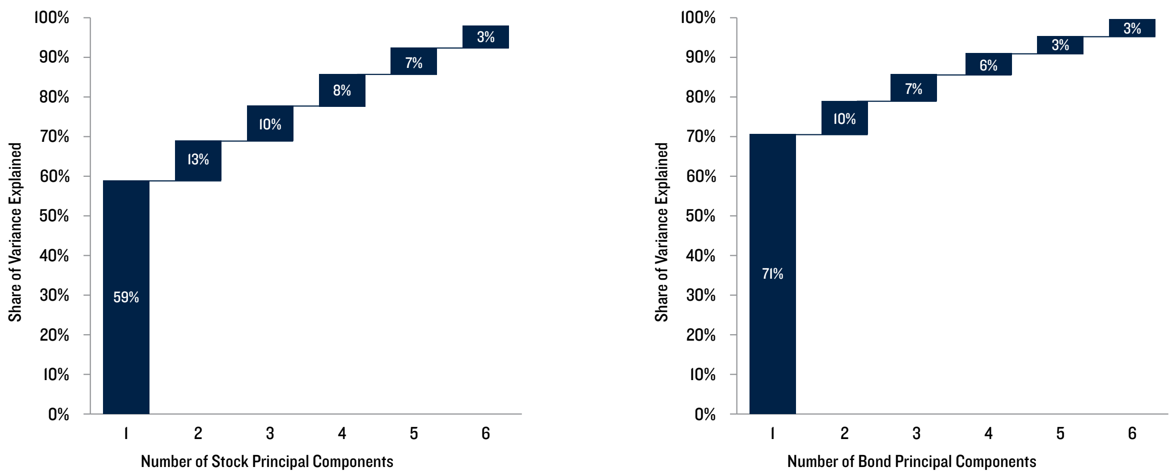
Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

2. See Appendix 1 for details on the construction of country-specific long-term benchmark sovereign bond local currency total return indices. See Appendix 2 for data description and summary statistics for stock and bond returns and stock-bond correlation.

Stock-Bond Correlation: A Global Phenomena

DM stock-bond correlation synchronicity suggests that common global factors or highly correlated local factors drive stock returns, bond returns and, hence, stock-bond correlation. Principal component analysis (PCA) supports this view as the largest common component of DM stock returns explains about 60% of the total variation (Figure 3, left panel), with loadings that are nearly equal across countries (Figure 4). Similarly, the largest DM bond return component explains about 70% of the total variation (Figure 3, right panel), with nearly equal country loadings, too (Figure 4).

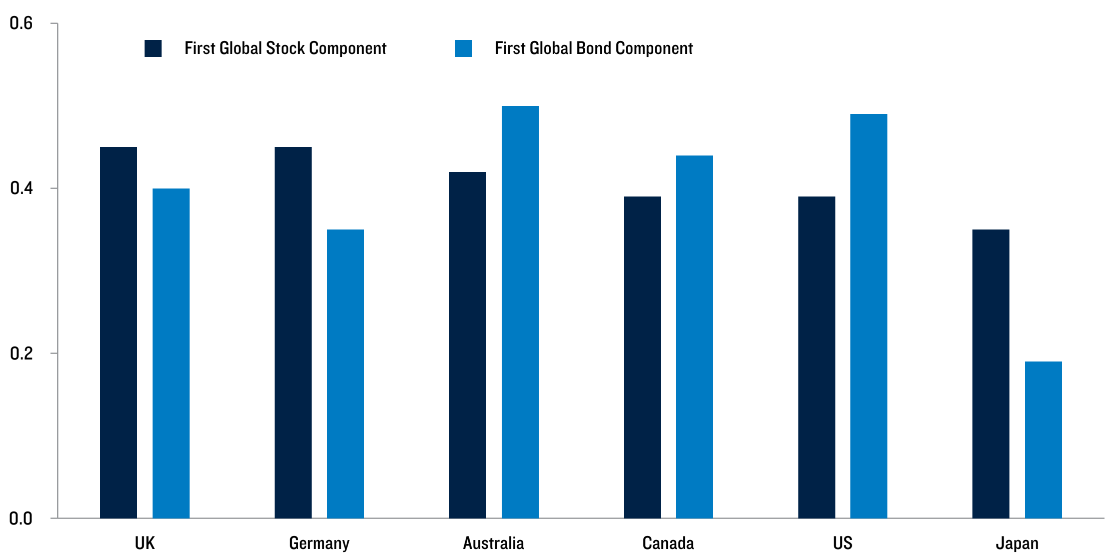
Figure 3: Principal Component Analysis of DM Stock and Bond Returns: Share of Total Variance Explained (Number of principal components, x-axis; % of total variance explained, y-axis)



Note: PCA of 1m local currency returns of six MSCI Country Equity Local Currency Total Return Indices, 1970-2021; PCA of 1m local currency returns of six Country Benchmark Long-Term Sovereign Bond Local Currency Total Return Indices, 1953-2021 (varies by country).

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

Figure 4: Country Loadings on the First Global Stock and Bond Principal Components



Note: PCA of 1m local currency returns of six MSCI Country Equity Local Currency Total Return Indices, 1970-2021; PCA of 1m local currency returns of six Country Benchmark Long-Term Sovereign Bond Local Currency Total Return Indices, 1953-2021 (varies by country).

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

In other words, country-specific DM stock returns share a common component to which they contribute equally, likewise for DM bond returns. Since DM stock and bond returns are, in part, globally determined, DM stock-bond correlations are likely global, too. In fact, the correlation between the first global stock and bond components looks remarkably like US stock-bond correlation (Figure 5). But the US is not alone as all DM local stock-bond correlations are highly *contemporaneously* correlated with the first global stock and bond component correlation (Figure 6), suggesting that all DM local stock-bond correlations are determined *jointly and contemporaneously*.[3]

Figure 5: First Global Stock & Bond Principal Component Correlation and US Stock-Bond Correlation

(1m returns, 5y centered rolling correlation)

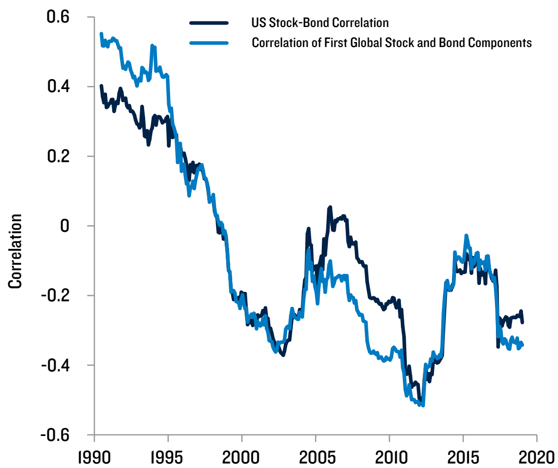
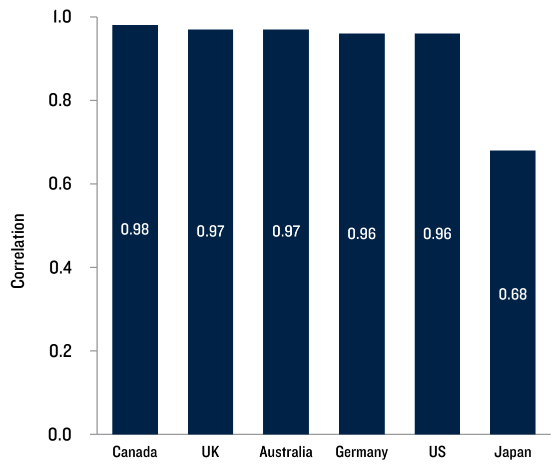


Figure 6: Correlation of Correlations: First Global Stock & Bond Principal Component Correlation and DM Stock-Bond Correlations

(1990-2021)



Note: PCA of 1m local currency returns of six MSCI Country Equity Local Currency Total Return Indices, 1970-2021; PCA of 1m local currency returns of six Country Benchmark Long-Term Sovereign Bond Local Currency Total Return Indices, 1953-2021(varies by country). MSCI US Equity Local Currency Total Return Index; US Benchmark Long-Term Sovereign Bond Local Currency Total Return Index.

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

The Macroeconomic Determinants of Stock-Bond Correlation

The synchronicity of DM stock-bond correlations suggests that common global factors drive stock-bond correlation. Earlier work provides a framework for thinking about the forces that could be at play.[4]

We first express stock and bond prices as discounted cash flows (Equation 1):

$$\boldsymbol{Bond\ Price_t} = \frac{\boldsymbol{FV}}{(\boldsymbol{1} + \boldsymbol{BRP_t} + \boldsymbol{i_t})^{\boldsymbol{t}}} \qquad \boldsymbol{Stock\ Price_t} = \sum_{t=1}^{\infty} \frac{\boldsymbol{CF_t}}{(\boldsymbol{1} + \boldsymbol{ERP_t} + \boldsymbol{i_t})^{\boldsymbol{t}}} \tag{1}$$

We then decompose the correlation of stock and bond returns, $\boldsymbol{\rho_t(\%\Delta s, \%\Delta b)}$, into three macroeconomic components that reflect the prevailing economic and policy environment (Equation 2):

$$\boldsymbol{\rho_t}(\%\Delta \boldsymbol{s}, \%\Delta \boldsymbol{b}) \approx \boldsymbol{\gamma_1} \times \boldsymbol{\sigma_t}(\Delta \boldsymbol{i}) - \boldsymbol{\gamma_2} \times \boldsymbol{\rho_t}(\%\Delta \boldsymbol{CF}, \Delta \boldsymbol{i}) + \boldsymbol{\gamma_3} \times \boldsymbol{\rho_t}(\Delta \boldsymbol{ERP}, \Delta \boldsymbol{BRP}) + \boldsymbol{\varepsilon_t} \tag{2}$$

3 No single DM statistically "causes" stock-bond correlation in any other DM. Appendix 3 reports Granger causality test results.

4 See *US Stock-Bond Correlation: What Are the Macroeconomic Drivers?* for details of this decomposition and a discussion of US policy drivers of US stock-bond correlation. Due to data limitations, we proxy for cash flow growth (*%ΔCF*) with real GDP growth (*%Δy*). Long histories of quarterly index-level cash flow data are not readily available for most DMs, unlike real GDP data. In the US, where quarterly cash flow data have longer histories, from 1993 to 2021 S&P 500 revenue growth and dividend growth have correlations with real GDP growth of 0.62 and 0.47, respectively. Over 1965-2021, dividend growth and real GDP growth have a correlation of 0.33.

The three macroeconomic components are:

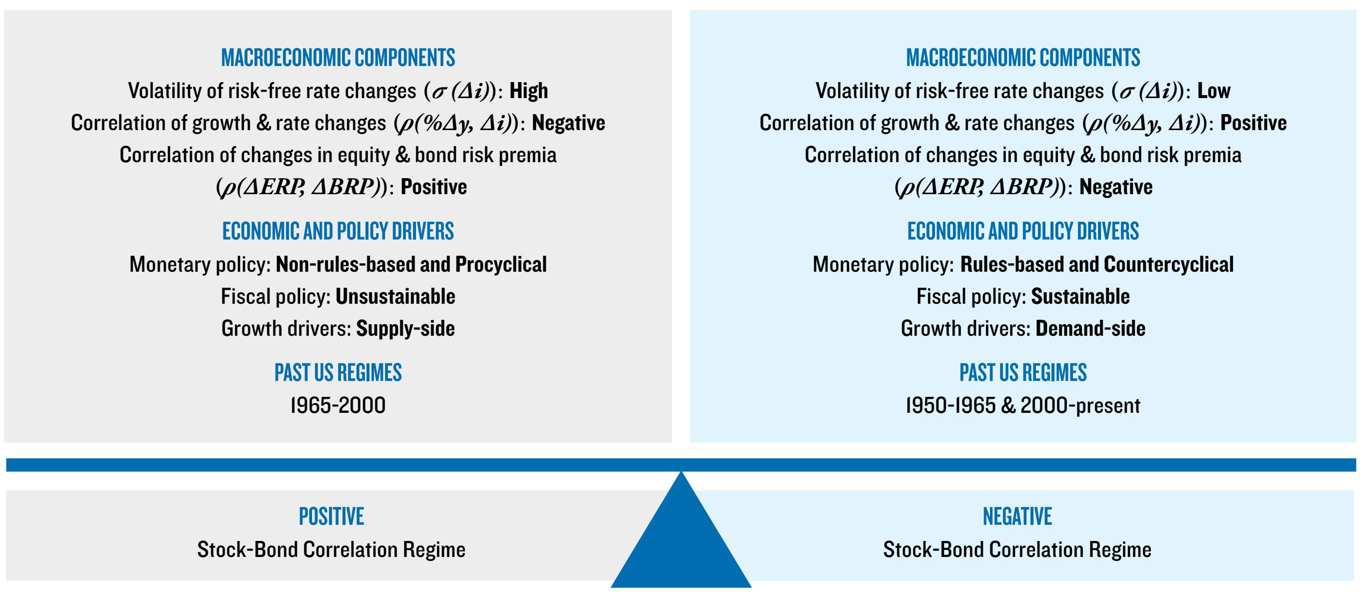
(1) The volatility of changes in risk-free rates ($\sigma_t(\Delta i)$): This component has a *positive* effect on stock-bond correlation because risk-free rates are part of the discount factor of both stocks and bonds. Unsustainable fiscal policy and procyclical monetary policy will likely lead to large swings in policy rates, greater rate volatility and *positive* stock-bond correlation. Sustainable fiscal policy and countercyclical monetary policy (with monetary authorities *predictably* raising rates in response to strong growth and cutting rates in the face of weak growth) support *negative* stock-bond correlation.

(2) The correlation of economic growth and changes in risk-free rates ($\rho_t(\%\Delta y, \Delta i)$): This component is *negatively* related to stock-bond correlation. Economic growth influences stock prices, while risk-free rates are part of both the stock and bond discount factors. When economic growth and risk-free rates move in the same direction (*i.e.*, *positive* growth-rates correlation), stock and bond prices move in opposite directions. Rules-based and countercyclical monetary policy supports positive growth-rates correlation as monetary authorities predictably raise rates in response to strong growth to control inflation and cut rates in the face of weak growth. In contrast, non-rules-based and procyclical monetary policy leads to negative growth-rates correlation and positive stock-bond correlation.[5]

(3) The correlation of changes in the Equity Risk Premium and the Bond Risk Premium ($\rho_t(\Delta ERP, \Delta BRP)$): This component is *positively* related to stock-bond correlation because ERP and BRP are part of the stock and bond discount factors, respectively. Positive (negative) ERP-BRP correlation leads to positive (negative) stock-bond correlation. Negative ERP-BPR correlation can arise from "risk-on/risk-off" market dynamics that push stock and bond premia in opposite directions, as investor preferences favor one asset over the other. In contrast, a fundamental change in a country's economic environment – say, sovereign credit worries – may cause a broad risk repricing across both stocks and bonds, leading to positive stock-bond correlation.

Figure 7 summarizes the macroeconomic and policy determinants of stock-bond correlation regimes:

Figure 7: Stock-Bond Correlation, Macroeconomic Components and Economic Policy Drivers



Source: PGIM IAS. For illustrative purposes only.

5 Supply shifts and demand shifts also impact growth-rates correlation and, hence, stock-bond correlation. A demand shock – say, a tax cut that shifts the demand curve up and to the right – raises both output and prices and produces a positive correlation between growth and rates and negative stock-bond correlation. A supply shock – say, an oil shortage that shifts the supply curve up and to the left, which lowers output and raises prices – leads to negative growth-rate correlation and positive stock-bond correlation.

The Relative Importance of Local vs. Global Drivers of Stock-Bond Correlation

Focusing on the three macroeconomic drivers of correlation discussed above (rate volatility, growth-rates correlation and the correlation of equity and bond risk premia), we use regression analysis to disentangle the effects of common global versions of the three drivers, *proxied using US macroeconomic variables*, from local versions of the drivers and quantify their relative importance in determining domestic stock-bond correlation.[6]

We estimate three sets of models:[7]

MODEL 1: LOCAL MACROECONOMIC COMPONENTS ALONE	• Benchmarks how well local macroeconomic components alone can explain stock-bond correlation. • Local macro components are: $\sigma_t(\Delta i_j)$, $\rho_t(\%\Delta y_j, \Delta i_j)$ and $\rho_t(\Delta ERP_j, \Delta BRP_j)$	***Local Stock-Bond Correlation =*** $\alpha + \beta \times$ ***Local Macro Components + Error***
MODEL 2: US MACROECONOMIC COMPONENTS ALONE	• Captures how well US macroeconomic components alone can explain stock-bond correlation. • US macro components, as a proxy for global factors, are: $\sigma_t(\Delta i_{US})$, $\rho_t(\%\Delta y_{US}, \Delta i_{US})$ and $\rho_t(\Delta ERP_{US}, \Delta BRP_{US})$	***Local Stock-Bond Correlation =*** $\alpha + \beta \times$ ***US Macro Components + Error***
MODEL 3: BOTH US AND RESIDUAL LOCAL MACROECONOMIC COMPONENTS	• US variables capture the direct effect of the US on local stock-bond correlation and the indirect effect through their influence on local economic conditions. • US variables are: $\sigma_t(\Delta i_{US})$, $\rho_t(\%\Delta y_{US}, \Delta i_{US})$ and $\rho_t(\Delta ERP_{US}, \Delta BRP_{US})$ • Residual local variables capture the purely local impact on local stock-bond correlation independent of US effects. US effects are netted out in a first stage regression. • Residual local variables are: $\tilde{\sigma}_t(\Delta i_j)$, $\tilde{\rho}_t(\%\Delta y_j, \Delta i_j)$ and $\tilde{\rho}_t(\Delta ERP_j, \Delta BRP_j)$	***Local Stock-Bond Correlation =*** $\alpha + \beta_{US} \times$ ***US Macro Components*** $+ \beta_{Local} \times$ ***Residual Local Macro Components*** ***+ Error***

All models are estimated on a country-by-country basis, meaning that parameters are country specific (Figure 8), with *standardized* coefficients reported to allow for the comparison of estimates across countries and variables.[8]

Some observations:

- Local variables alone (Model 1) and US variables alone (Model 2) explain about the same amount of variation in local stock-bond correlation; adjusted R^2's are in the 0.4-0.5 range for both models (Figure 8, column 2, rows 1-7, and 8-14 respectively).
- The combination of both US variables and residual local variables (Model 3) pushes adjusted R^2's to the 0.7 range (Figure 8, column 2, rows 15-20); 1/2 to 2/3 of that is from common US factors and the rest is due to purely local effects (Figure 9).

6 US variables (a proxy for *common global factors*) can affect stock-bond correlation both directly, and indirectly, by first influencing local factors. Therefore, local variables may appear *correlated* with local stock-bond correlation, but true causation is due to the US. To net out US effects, we regress local variables on US variables and use the regression residuals as local macroeconomic variables independent of US influence. We then use both US and these residual local variables as regressors to explain stock-bond correlation (Model 3). Coefficients on the US variables capture direct and indirect US effects and coefficients on residual local coefficients capture purely local effects. The US proxy is justified by the size of the US economy relative to the rest of the DM complex, with any (size- or market-weighted) global aggregate heavily influenced by the US. Moreover, anecdotally, US policy risks tend to be a major focus in investor conversations, even for global investors, further justifying "overweighting" the causal role of the US in determining DM local currency stock-bond correlations. See Appendix 5 for details.

7 By looking first at local explanatory variables alone and then at US variables alone, both Models 1 and 2 are, in some sense, mis-specified. However, these two models provide a baseline for how much each set of variables can explain on their own (the R^2). Model 3 then combines both sources of variation in local stock-bond correlation and apportions explanatory power to US variables (as the global proxy) and to local effects (net of US influence).

8 See Appendix 4 for data definitions and summary statistics. Estimation is done using ordinary least squares on country-by-country quarterly data. Correlations and volatilities are 5-year rolling calculations, and standard errors are adjusted accordingly.

- Estimated coefficients on local variables alone (Model 1) and on US variables alone (Model 2) are nearly all significant with the expected signs (Figure 8, columns 3-5, rows 1-14). This means that across DMs stock-bond correlation is related to macroeconomic conditions, as expected: *rising* when risk-free rate volatility *rises*, *rising* when growth-rates correlation *declines*, and *rising* when the equity-bond risk premium correlation *rises*.
- To disentangle global vs. local drivers, we use both *US* explanatory variables and *residual* local explanatory variables in Model 3. While nearly all *US* coefficients remain significant, fewer *residual* local coefficients are significant. Specifically, coefficients on residual local risk-free rates volatility and residual local growth-rates correlation are less likely to be significant (Figure 8, columns 3-8, rows 15-20).
- In contrast, residual local stock and bond risk premia correlation ($(\tilde{\rho}_t(\Delta ERP_j, \Delta BRP_j)$) remains significant for 4 out of 5 countries (Figure 8, column 8, rows 15-20). In fact, given the size of the standardized coefficients, the correlation of residual local equity-bond risk premia, which captures purely local risk appetite, is the most important factor in determining local stock-bond correlation (Figure 10).
- The volatility of US risk-free rates ($\sigma_t(\Delta i_{US})$) and the correlation of US growth and rates ($\rho_t(\%\Delta y_{US}, \Delta i_{US})$) both have a larger impact than local versions of these components (Figure 10), capturing the large role of *US* fiscal policy sustainability and the degree of *US* monetary policy cyclicality for local stock-bond correlation.

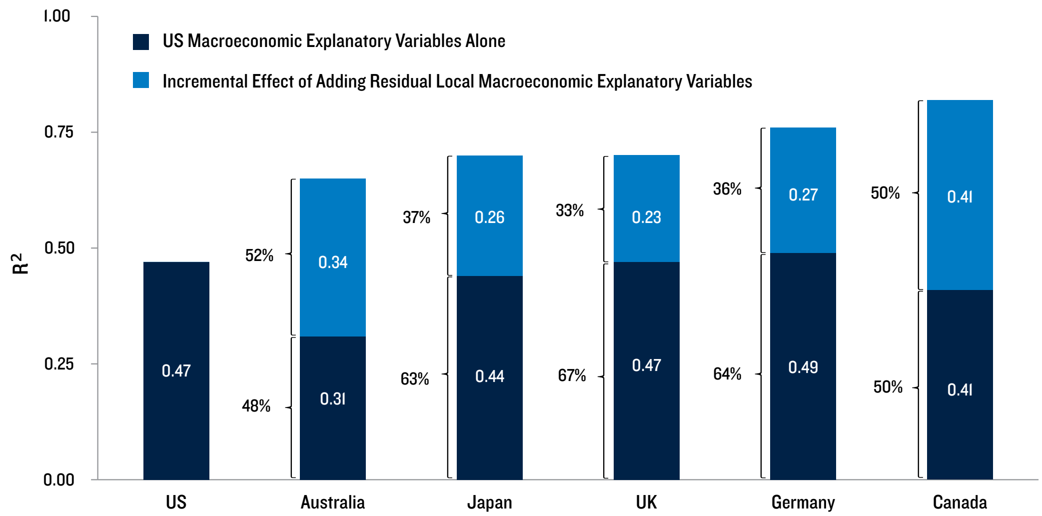
Figure 8: Local Stock-Bond Correlation Regressed on Local, US and Residual Local Macroeconomic Variables (Australia, Canada, Germany, Japan, UK, US; quarterly observations; 1972-2019)

				Standardized Coefficients: Change in Stock-Bond Correlation per 1SD Change in Explanatory Variable					
				Local/US Macroeconomic Components			Residual Local Macroeconomic Components		
	Model	Country j	Adjusted R^2	$\sigma_t(\Delta i_j)$	$\rho_t(\%\Delta y_j, \Delta i_j)$	$\rho_t(\Delta ERP_j, \Delta BRP_j)$	$\tilde{\sigma}_t(\Delta i_j)$	$\tilde{\rho}_t(\%\Delta y_j, \Delta i_j)$	$\tilde{\rho}_t(\Delta ERP_j, \Delta BRP_j)$
			Expected Sign→	+	–	+	+	–	+
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				LOCAL MACROECONOMIC COMPONENTS					
(1)	1	Australia	0.49	-0.10***	-0.02	**0.25*** **	N/A		
(2)	1	Canada	0.67	**0.09*** **	-0.02	**0.13*** **			
(3)	1	Germany	0.34	**0.15*** **	**-0.19*** **	**0.08*** **			
(4)	1	Japan	0.47	0.00	0.04***	**0.11*** **			
(5)	1	UK	0.67	-0.01	**-0.08*** **	**0.22*** **			
(6)	1	US	0.47	**0.13*** **	**-0.08*** **	**0.08*** **			
(7)	1	Average	0.52	0.05	-0.06	0.14			
				US MACROECONOMIC COMPONENTS					
(8)	2	Australia	0.31	0.03	**-0.11*** **	**0.10*** **	N/A		
(9)	2	Canada	0.41	**0.08*** **	**-0.11*** **	**0.09*** **			
(10)	2	Germany	0.49	**0.16*** **	**-0.13*** **	**0.04***			
(11)	2	Japan	0.44	**0.31*** **	**-0.19*** **	-0.21***			
(12)	2	UK	0.47	**0.15*** **	**-0.12*** **	**0.06*** **			
(13)	2	US	0.47	**0.13*** **	**-0.08*** **	**0.08*** **			
(14)	2	Average	0.43	0.14	-0.12	0.03			
				US MACROECONOMIC COMPONENTS			RESIDUAL LOCAL MACROECONOMIC COMPONENTS		
(15)	3	Australia	0.64	-0.05	**-0.10*** **	**0.16*** **	0.02	0.02	**0.14*** **
(16)	3	Canada	0.82	**0.07*** **	**-0.04*** **	**0.05*** **	**0.13*** **	0.01	**0.06*** **
(17)	3	Germany	0.76	**0.07***	**-0.23*** **	**0.11*** **	**0.10*** **	**-0.15*** **	0.03
(18)	3	Japan	0.70	**0.09****	0.02	-0.06**	**0.04****	0.03*	**0.11*** **
(19)	3	UK	0.70	**0.05*** **	**-0.04***	**0.08*** **	-0.10***	**-0.06*** **	**0.25*** **
(20)	3	Average	0.73	0.05	-0.08	0.07	0.04	-0.03	0.12

* / ** / *** indicates significance at the 10% / 5% / 1% level, respectively.

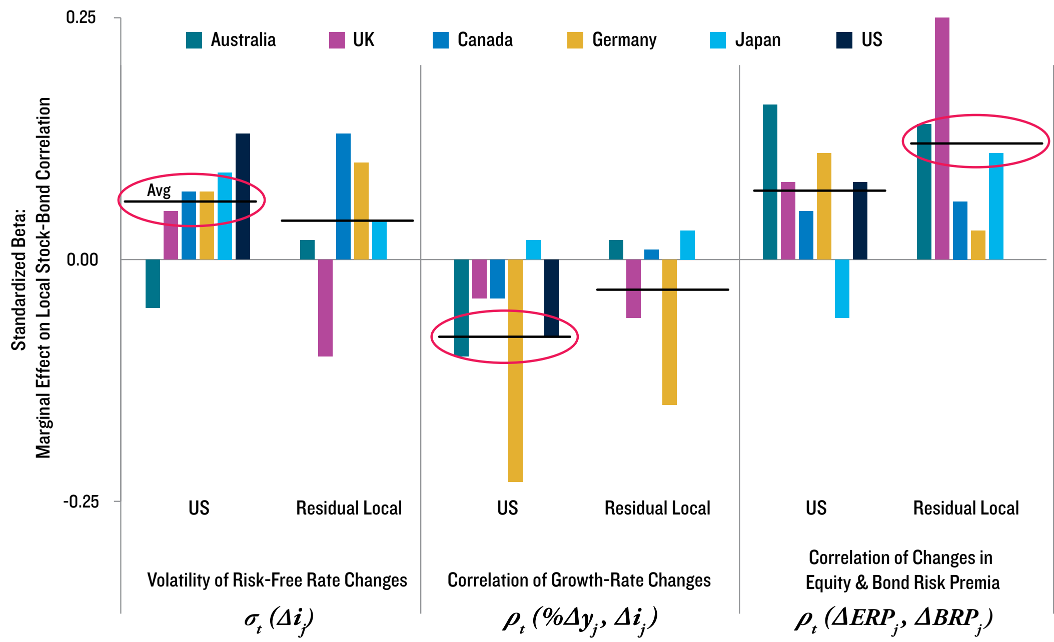
Source: DataStream, Federal Reserve Bank of St. Louis, FRED, Haver Analytics, MSCI, OECD and PGIM IAS. For illustrative purposes only.

Figure 9: R^2 Decomposition: US Variables and Residual Local Variables



Source: DataStream, Federal Reserve Bank of St. Louis, FRED, Haver Analytics, MSCI, OECD and PGIM IAS. For illustrative purposes only.

Figure 10: Standardized Coefficient Estimates



Source: DataStream, Federal Reserve Bank of St. Louis, FRED, Haver Analytics, MSCI, OECD and PGIM IAS. For illustrative purposes only.

Summing up, both global and local macroeconomic components are important in determining DM local stock-bond correlations. US risk-free rate volatility and US growth-rates correlation are the most important determinants of DM local stock-bond correlations and are closely related to US fiscal policy sustainability and monetary policy cyclicality. As US fiscal policy is less (more) sustainable, and as US monetary policy is less (more) rules-based and more procyclical (countercyclical), the likelihood that local stock-bond correlations switch to positive (remain negative) rises. Local drivers contribute, too, particularly the correlation of residual local risk premia, which is a function of local investor risk appetite.

For CIOs, the broadest takeaway is that debates about the stance of fiscal and monetary policy are neither theoretical nor esoteric. *Policy settings influence key economic aggregates, which in turn are directly relevant for stock-bond correlation.* Secondarily, there is a balance between global and local forces. For those who tend to focus exclusively on US risks, local dynamics ought to be considered too; and for those who focus on domestic determinants of local market dynamics, common global factors also need to be assessed. *In short, CIOs need to think both globally and locally when assessing the likelihood of stock-bond correlation regime change and, as such, both US and local macroeconomic conditions warrant careful monitoring.*

Seeking a US Equity Hedge When US Stock-Bond Correlation is Positive

From the perspective of a US investor, if US stock-US bond correlation turns positive, would there be another DM sovereign bond market that can be used to better hedge US equities? Given the large common principal component that drives DM bond returns, unsurprisingly the correlation of US stock returns and *US bond* returns is quite similar to the correlation of US stock returns and *DM (hedged USD) bond returns* (Figure 11).[9] Indeed, 94% of the time the US stock-bond correlation regime (positive or negative) is matched by the US stock-DM (hedged USD) bond correlation regimes (Figure 12). In short, when US bonds are not a good hedge for US stocks, neither are DM bonds.

Beyond DM sovereign fixed income, when US stock-bond correlation is positive, Oil, Gold and Energy total returns are negatively correlated with US stock returns. However, even in these cases, negative correlations are quite modest in magnitude, ranging from -0.09 to -0.05 (Figure 13, column 4, rows 1-4) and the odds of US stock and commodity returns being negatively correlated, *conditional* on positive US stock-bond correlation, are only slightly better than 50-50, with a high of 63% for GSCI crude oil total returns. Moreover, any hedging benefit comes at the cost of much higher volatility, ranging from 19% to 36% (Figure 13, column 2, rows 1-4).

Figure 11: US Stock-DM (Hedged USD) Bond Correlations and US Stock-US Bond Correlation

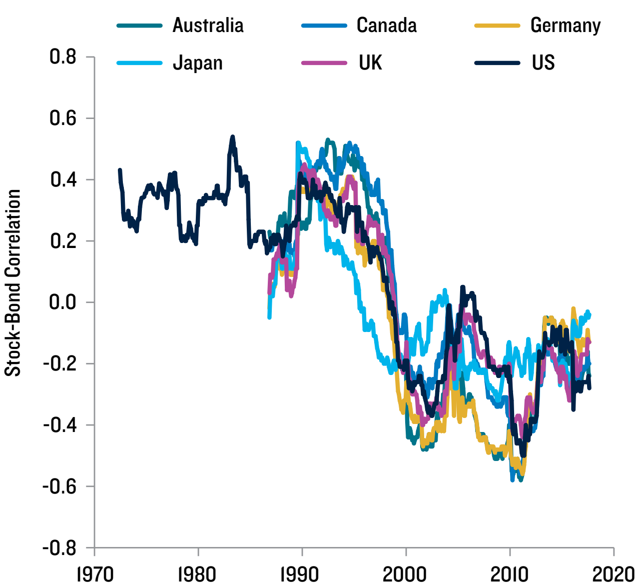
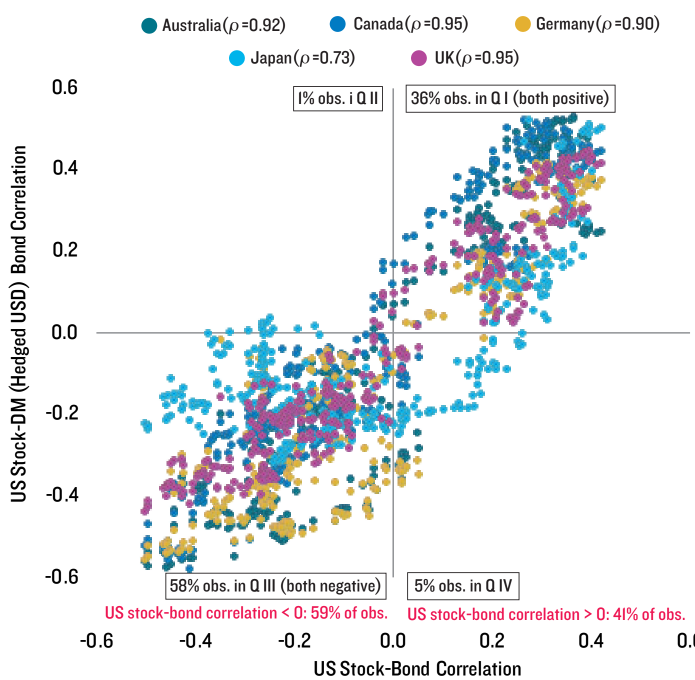


Figure 12: US Stock-US Bond Correlation (x-axis) and US Stock-DM (Hedged USD) Bond Correlations (y-axis)



Note: MSCI Country Equity Local Currency Total Return Indices; US Benchmark Long-Term Sovereign Bond Local Currency Total Return Index; FTSE World Government Bond Index (WGBI) Total Return Hedged USD for Australia, Canada, Germany, Japan, and UK; 1m returns; 5y, centered, rolling correlation; 1970-2021 (varies by country).

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, FTSE, MSCI and PGIM IAS. For illustrative purposes only.

9 For hedged USD bond returns we use FTSE Country Government Bond Index Total Return Hedged USD data that begin in 1984 for the five countries we consider.

Figure 13: Asset Returns and Volatilities and Correlations with US Stock Returns by Stock-Bond Correlation Regime

	Assets	Average Return (Annualized)	Volatility (Annualized)	Average Correlation with US Stock	Average Correlation with US Stock when US Stock-US Bond Correlation > 0	Probability of Correlation with US Stock < 0 Conditional on US Stock-US Bond Correlation > 0
		(1)	(2)	(3)	(4)	(5)
(1)	GSCI Crude Oil	11%	36%	0.12	-0.09	63%
(2)	GSCI Gold	7%	19%	-0.02	-0.05	62%
(3)	US Tbill 3M	5%	1%	-0.04	-0.05	52%
(4)	GSCI Energy	9%	32%	0.13	-0.05	49%
(5)	GSCI Commoditiy	9%	20%	0.13	0.02	41%
(6)	US Bond	6%	6%	0.08	0.28	0%
(7)	BB US Credit	8%	7%	0.31	0.44	0%
(8)	Russell 1000 Value	13%	15%	0.70	0.51	0%
(9)	MSCI EM	13%	22%	0.69	0.56	0%

Note: MSCI Country Equity Local Currency Total Return Indices; Country Benchmark Long-Term Sovereign Bond Local Currency Total Return Indices; 1m returns; 5y, centered, rolling correlation; 1953-2021 (varies by country).

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, Haver Analytics, MSCI and PGIM IAS. For illustrative purposes only.

EM Stock-Bond Correlations

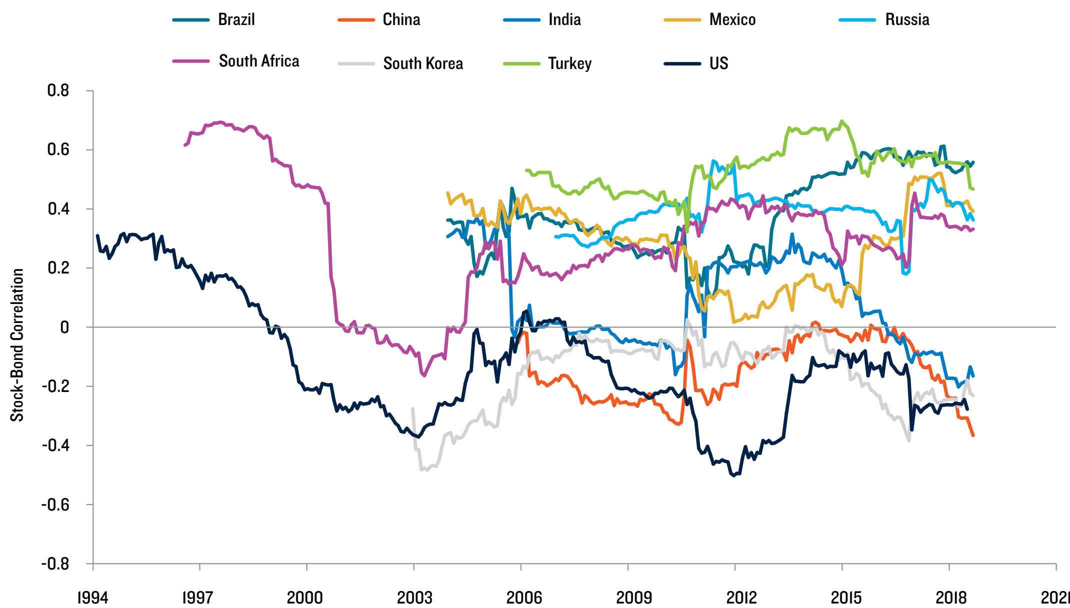
How do EM stock-bond correlations compare to DM stock-bond correlations? To the extent that fiscal sustainability and monetary policy independence issues loom larger in EMs, it stands to reason that negative stock-bond correlation may be less prevalent across EMs and positive stock-bond correlation more prevalent. Moreover, given that many non-domestic investors allocate their assets first to EM as an asset class and then, within the EM "sleeve," across EM stocks and bonds, there may be a greater tendency for investor risk sentiment to lead to positive co-movement between EM equity and bond risk premia, adding to positive EM stock-bond correlations.

A full analysis of the global and local macroeconomic factors that drive EM (local currency) stock-bond correlations is constrained by relatively short EM data histories (we look at eight EMs – Brazil, China, India, Mexico, Russia, South Africa, South Korea, and Turkey with data back to the early 2000s for most countries). However, unlike DMs where stock-bond correlation has been persistently negative for the last 20y+, EM (local currency) stock-bond correlations have been mostly *positive* since 2000, but not uniformly so (Figure 14).[10] In contrast to the synchronicity of DM stock-bond correlations, EM (local currency) stock-bond correlations are not synchronized with each other (Figure 15), nor are they particularly anchored to US stock-bond correlation (Figure 16).

Turning from the perspective of a local EM investor to a US investor, could EM (hedged USD) bond returns be a useful hedge to US stocks, particularly when US bonds are not? Given the limited history of EM bond returns, and the fact that US stock-bond correlation was last positive prior to 2000 (in fact, we dropped China from this analysis because of data limitations), there is little evidence for how EM (hedged USD) bond returns have behaved relative to US stock returns when US stock-bond correlation was positive. That said, EM (hedged USD) bond returns have generally been positively correlated with US stock returns, even when US stock-bond correlation was negative (Figure 17). There is little to suggest that EM bonds would be a better hedge for US stocks when US bonds are not.

10 MSCI Country Local Currency Total Return Indices are used for EM stock returns. J.P. Morgan GBI-EM Country Local Currency Indices are used for EM bond returns. J.P. Morgan index history is close to EM yield history, so there was no advantage in creating our own EM bond indices. See data description and summary statistics in Appendix 6. EM hedged USD bond returns are based on J.P. Morgan GBI-EM Country Hedged USD Total Return Indices.

Figure 14: EM Local Currency Stock-Bond Correlations and US Stock-Bond Correlation



Note: MSCI Country Equity Local Currency Total Return Indices; US Benchmark Long-Term Sovereign Bond Local Currency Total Return Index; J.P. Morgan GBI-EM Country Local Currency Indices; Brazil, China, India, Mexico, Russia, South Africa, South Korea, Turkey; 1m returns; 5y, centered, rolling correlation; 1994-2021 (varies by country).

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, J.P. Morgan, MSCI and PGIM IAS. For illustrative purposes only.

Figure 15: Average Pairwise Correlation of EM Local Currency Stock-Bond Correlations (1994-2021)

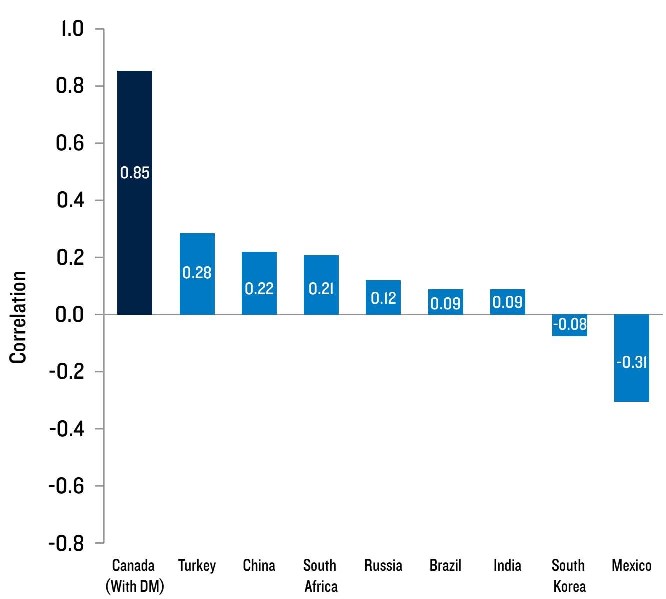
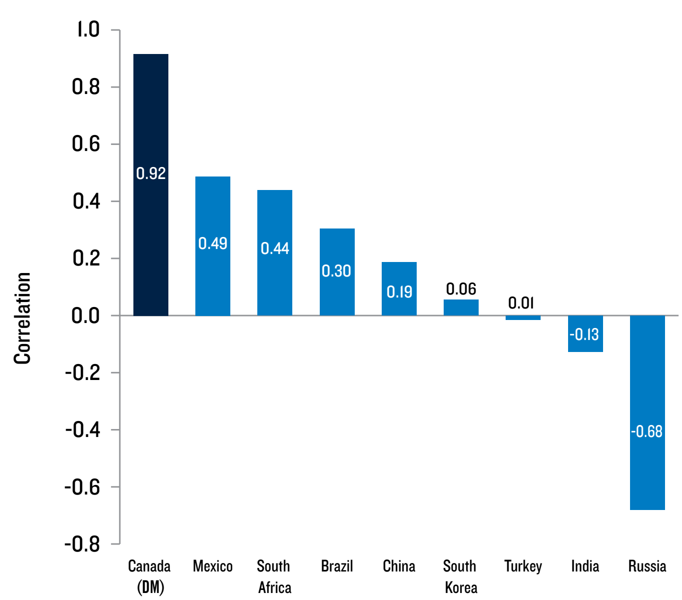


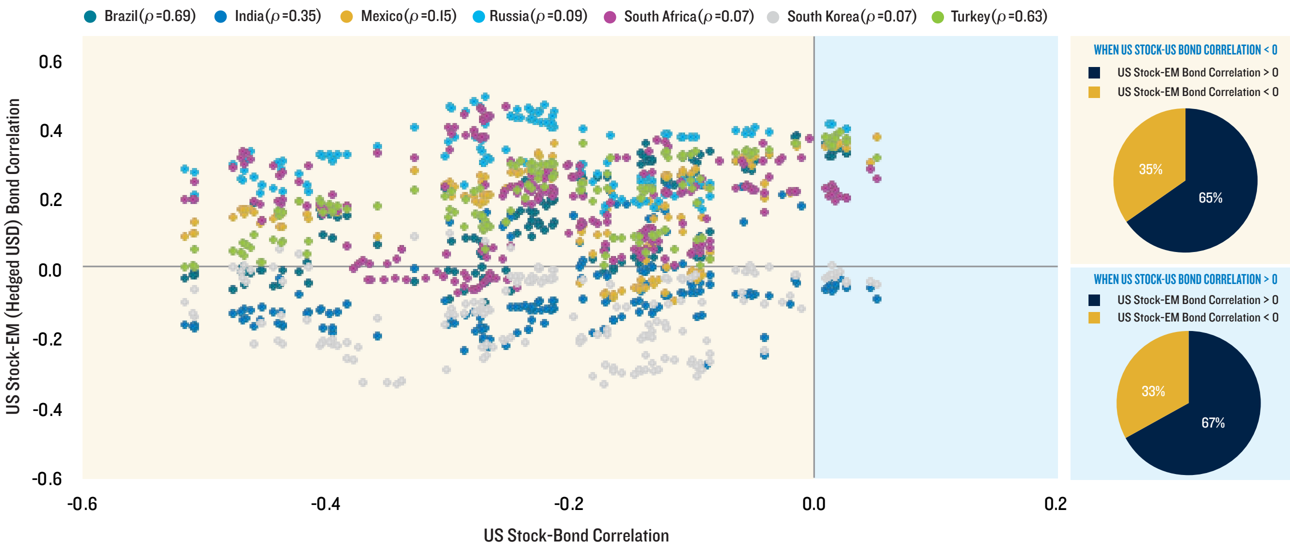
Figure 16: Correlation of EM Local Currency Stock-Bond Correlations with US Stock-Bond Correlation (1994-2021)



Note: Canada is included for comparison to DM results; MSCI Country Equity Local Currency Total Return Indices; US Benchmark Long-Term Sovereign Bond Local Currency Total Return Indices; J.P. Morgan GBI-EM Country Local Currency Unhedged Indices; 1m returns; 5y, centered, rolling correlation window; Brazil, China, India, Mexico, Russia, South Africa, South Korea, Turkey; 1994-2021 (varies by country).

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, J.P. Morgan, MSCI and PGIM IAS. For illustrative purposes only.

Figure 17: US Stock-Bond Correlation (x-axis) and US Stock-EM (Hedged USD) Bond Correlations (y-axis) (1997-2021)



Note: MSCI Country Equity Local Currency Total Return Indices; US Benchmark Long-Term Sovereign Bond Local Currency Total Return Index; J.P. Morgan GBI-EM Country Hedged USD Indices; Brazil, India, Mexico, Russia, South Africa, South Korea, Turkey (China is dropped due to insufficient history); 1m returns; 5y, centered, rolling correlation; 1997-2021 (varies by country).

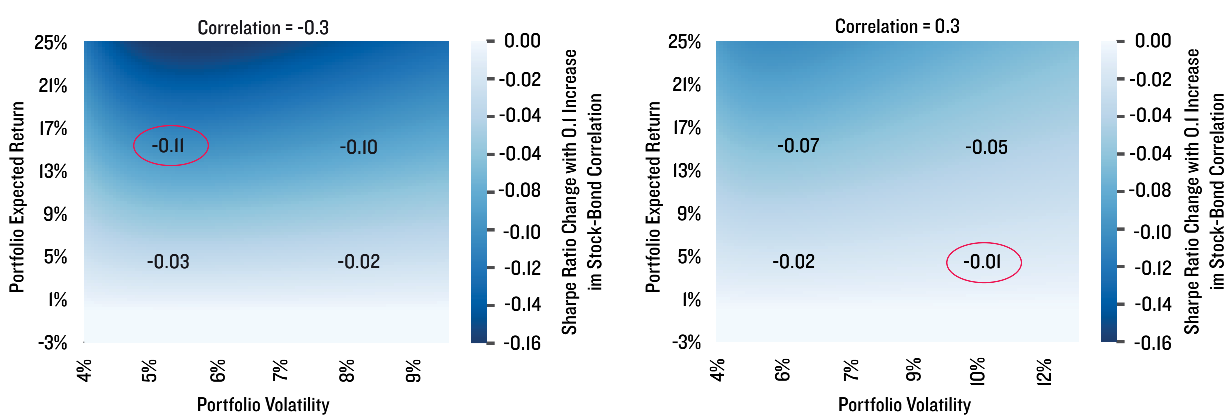
Source: DataStream, Federal Reserve Bank of St. Louis, FRED, J.P. Morgan, MSCI and PGIM IAS. For illustrative purposes only.

The next step is to focus on the *consequences* of stock-bond correlation for strategic portfolio construction. It will be informative to examine historical *ex-post* performance of multi-asset portfolios in different stock-bond correlation regimes and simulated *ex-ante* performance. Of interest will be how to incorporate uncertainty about future stock-bond correlation in the portfolio construction process. Clearly, portfolio performance is a function of stock-bond correlation along with other capital market assumptions. However, the relationship between correlation and performance is non-linear, and the effect of a change in correlation on portfolio performance depends on market conditions and asset weights.

For example, the impact of a change in correlation on a 60/40 portfolio of stocks and bonds depends on expected returns and volatility (Figure 18). When volatility is low and expected returns are high, a 0.1 unit *increase* in stock-bond correlation *reduces* portfolio Sharpe ratio by 0.11 points. In contrast, when volatility is high and expected returns are low, a 0.1 unit increase in correlation reduces portfolio Sharpe ratio by only 0.01 points.

These and related issues will be explored in a forthcoming paper.

Figure 18: Change in 60/40 Portfolio Sharpe Ratio from a 0.1 Unit Increase in Stock-Bond Correlation



Note: The change in Sharpe Ratio for a 0.1-unit change in stock-bond correlation, depicted in the heatmap, is based on the analytical performance of a 60/40 portfolio evaluated over a range of values for five parameters: expected stock and bond returns (-5% to 30% & -0.5% to 22%, respectively), expected stock return and bond return volatility (6.5% to 17.5% & 1.5% to 11.5%, respectively), and stock-bond return correlation (-1.0 to 1.0). Source: PGIM IAS. For illustrative purposes only.

Acknowledgments

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Appendices

Appendix 1: Construction of DM Long-Term Sovereign Bond Local Currency Total Return Indices

Even though there are readily available sovereign bond local currency total return indices for many DMs (*e.g.*, J.P. Morgan GBI indices), we choose to construct our own DM sovereign bond *local currency* total return indices for all six countries because there is often a longer history of yields and to be consistent across countries. For *hedged USD bond returns* we use FTSE World Government Bond Index (WGBI) Total Return Hedged USD series that begin in 1984 for all countries in our study.

We construct benchmark long-term sovereign bond local currency total return indices for six DMs (Australia, Canada, Germany, Japan, UK and US) using each country's benchmark long-term, fixed maturity, sovereign yield.

To do so we assume that:

1. A new 10y non-callable par bond is issued at month three and nine of each year;
2. The entire bond position is rolled into the fresh bond when issued; and
3. Coupons are paid semiannually, therefore the first coupon is due immediately before rebalancing.

Mathematically, the resulting bond total return index is a function of the coupon rate $\boldsymbol{c}$, the yield $\boldsymbol{y}$, and maturity $\boldsymbol{T}$. Note that a bond that trades at par has a coupon rate equal to its yield.

$$\begin{aligned} \boldsymbol{Bond\ Price} &= \Big[\sum_{t=1}^{T} \frac{c_t}{(1+y_t/2)^{2t}} + \frac{1}{(1+y_t/2)^{2T}}\Big] \times 100 \\ &= \Big[\sum_{t=1}^{T} \frac{y_t}{(1+y_t/2)^{2t}} + \frac{1}{(1+y_t/2)^{2T}}\Big] \times 100 \end{aligned} \tag{A1}$$

Appendix 2: Stock & Bond Returns and Stock-Bond Correlation – Data and Summary Statistics

Stock return: Using the monthly MSCI Country Equity Local Currency Total Return Index, the non-overlapping, trailing 1-month stock total return is:

$$\%\Delta \boldsymbol{s}_t = \frac{\boldsymbol{Stock\ Index_t}}{\boldsymbol{Stock\ Index_{t-1}}} - 1 \tag{A2}$$

Bond return: Using the monthly Country Benchmark Long-Term Sovereign Bond Local Currency Total Return Index (as constructed in Appendix 1), bond total return is defined similarly:

$$\%\Delta \boldsymbol{b}_t = \frac{\boldsymbol{Bond\ Index_t}}{\boldsymbol{Bond\ Index_{t-1}}} - 1 \tag{A3}$$

Stock-bond correlation: We calculate the time-$\boldsymbol{t}$ centered rolling correlation of monthly stock and bond returns over an $\boldsymbol{H}$-period window:

$$\boldsymbol{\rho}_t^H(\%\Delta \boldsymbol{s}, \%\Delta \boldsymbol{b}) = \frac{\boldsymbol{cov}_t(\%\Delta \boldsymbol{s}, \%\Delta \boldsymbol{b})}{\boldsymbol{\sigma}_{\%\Delta s}\boldsymbol{\sigma}_{\%\Delta b}} = \frac{\sum_{h=-H/2}^{H/2}(\%\Delta \boldsymbol{s}_{t+h} - \overline{\%\Delta \boldsymbol{s}})(\%\Delta \boldsymbol{b}_{t+h} - \overline{\%\Delta \boldsymbol{b}})}{\sqrt{\sum_{h=-H/2}^{H/2}(\%\Delta \boldsymbol{s}_{t+h} - \overline{\%\Delta \boldsymbol{s}})^2 \sum_{h=-H/2}^{H/2}(\%\Delta \boldsymbol{b}_{t+h} - \overline{\%\Delta \boldsymbol{b}})^2}} \tag{A4}$$

where $\%\Delta s_t$ and $\%\Delta b_t$ are defined as time t stock and bond returns per above, $\overline{\%\Delta s}$ and $\overline{\%\Delta b}$ represent estimated mean returns over the $\boldsymbol{H}$-period horizon, $\sigma_{\%\Delta s}$ and $\sigma_{\%\Delta b}$ are the volatilities of stock and bond returns calculated on a centered rolling basis over the same horizon, $\boldsymbol{H}$, and time period, $\boldsymbol{t}$, and $cov_t(\%\Delta s, \%\Delta b)$ is the covariance of stock and bond returns calculated on a centered rolling basis over the same horizon, $\boldsymbol{H}$, and time period, $\boldsymbol{t}$.

We set $\boldsymbol{t}$ as monthly and $\boldsymbol{H}$ as a 60m (5y) window for most of the analysis above. When using quarterly macroeconomic data in the regression analysis, we set $\boldsymbol{t}$ as quarterly and $\boldsymbol{H}$ as a 20q (5y) window.

Figure A1 presents DM stock returns, bond returns, and stock-bond correlations summary statistics.

Figure A1: DM Stock Total Returns, Bond Total Returns and Stock-Bond Correlations Summary Statistics

Country	Stock Returns			Bond Returns			Stock-Bond Correlations		
	Period	Mean (Annualized)	Volatility (Annualized)	Period	Mean (Annualized)	Volatility (Annualized)	Period	Mean of 5y Centered Rolling	Full Sample Non-Rolling
Australia	1970-01 to 2021-12	12%	18%	1969-10 to 2021-10	8%	6%	1972-07 to 2019-05	0.13	0.21
Canada	1970-01 to 2021-12	11%	16%	1960-04 to 2021-10	7%	6%	1972-07 to 2019-05	0.14	0.17
Germany	1970-01 to 2021-12	10%	19%	1960-04 to 2021-10	6%	5%	1972-07 to 2019-05	0.07	0.05
Japan	1970-01 to 2021-12	8%	18%	1989-04 to 2021-10	3%	4%	1991-10 to 2019-05	-0.23	-0.05
UK	1970-01 to 2021-12	12%	19%	1960-04 to 2021-10	8%	6%	1972-07 to 2019-05	0.18	0.28
US	1970-01 to 2021-12	12%	15%	1953-10 to 2021-10	6%	6%	1972-07 to 2019-05	0.08	0.10

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

Appendix 3: DM Stock-Bond Correlations – Granger Causality Tests

We use Granger causality tests to explore if US stock-bond correlation has a causal role in determining stock-bond correlation in other DMs. Formally, US stock-bond correlation Granger causes local stock-bond correlation if past US stock-bond correlation influences current local stock-bond correlation, controlling for past values of local stock-bond correlation, as in Equation A5. Note that the model specification is in first differences and with one lag of the right-hand side variable to ensure stationarity, per the Augmented Dickey-Fuller test.

$$\Delta\boldsymbol{\rho_t}(\%\Delta\boldsymbol{s_j},\%\Delta\boldsymbol{b_j}) = \boldsymbol{\alpha} + \boldsymbol{\beta_1} \times \Delta\boldsymbol{\rho_{t-1}}(\%\Delta\boldsymbol{s_j},\%\Delta\boldsymbol{b_j}) + \boldsymbol{\beta_2} \times \Delta\boldsymbol{\rho_t}(\%\Delta\boldsymbol{s_{US}},\%\Delta\boldsymbol{b_{US}}) + \boldsymbol{\varepsilon_{jt}} \qquad \text{(A5)}$$

Said differently, US stock-bond correlation Granger causes country $\boldsymbol{j}$ stock-bond correlation if $\boldsymbol{\beta_2}$ (the coefficient on US stock-bond correlation) is, statistically, nonzero, after controlling for lags of the dependent variable. Assuming the null hypothesis of *no* causality, Figure A2 shows that there is little statistical evidence suggesting that US stock-bond correlation Granger causes stock-bond correlation in other DMs. We also run Granger causality tests of the stock-bond correlation of each country $\boldsymbol{i}$ (as the right-hand side variable) on the stock-bond correlation of another country $\boldsymbol{j}$ (as the left-hand side variable) and find that no country's stock-bond correlation causes another country's stock-bond correlation (Figure A3).

Figure A2: Granger Causality Tests: US Stock-Bond Correlation as Explanatory Variable, DM Stock-Bond Correlations as Dependent Variables (Monthly, 1970-2021)

Country j	P-Value: Null of No US Causality ($\beta_2 = 0$)	
Australia	0.08*	Reject null (at 10% level)
Canada	0.43	Fail to reject null
Germany	0.21	Fail to reject null
Japan	0.36	Fail to reject null
UK	0.74	Fail to reject null

Note: * / ** / *** indicates significance at the 10% / 5% / 1% level, respectively.

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

Figure A3: Pairwise Granger Causality Tests – DM Stock-Bond Correlations (Monthly, 1970-2021)

P-Value: Whether Country i Granger Causes Country j						
Country i / Country j	Australia	Canada	Germany	Japan	UK	US
Australia	1.00	0.13	0.01**	0.24	0.85	0.08*
Canada	0.00***	1.00	0.00***	0.09*	0.66	0.43
Germany	0.60	0.12	1.00	0.26	0.71	0.21
Japan	0.37	0.24	0.93	1.00	0.74	0.36
UK	0.48	0.43	0.19	0.48	1.00	0.74
US	0.05**	0.84	0.02**	0.29	0.64	1.00

Note: * / ** / *** indicates significance at the 10% / 5% / 1% level, respectively.

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, MSCI and PGIM IAS. For illustrative purposes only.

Appendix 4: Macroeconomic Components of Stock-Bond Correlation: Data and Summary Statistics

DM macroeconomic data are available quarterly through Haver Analytics and DataStream.

Country specific **risk-free rates** are either the overnight interbank rate or the 3m interbank rate, whichever has a longer history. The volatility of changes in the risk-free rate is calculated as the 20q, centered, rolling volatility of 1q changes in the risk-free rate.

For all countries, **real GDP growth** is quarter over quarter. The correlation of growth and changes in the risk-free rate is calculated as the 20q, centered, rolling correlation of 1q real GDP growth and 1q changes in the risk-free rate.

Equity risk premium (ERP) is defined as the difference between the (trailing 12m actual) earnings-to-price ratio, available through DataStream from as early as 1969 (varies by country), and the risk-free rate, as per above.

Bond risk premium (BRP) is defined as the term spread between the 10-year government bond yield, available through Haver from as early as 1953 (varies by country), and the risk-free rate as defined above.

Conceptually, the term spread is not the same as the BRP. For the US, there are several model-based bond premia available, and we compare the simple US 10y – risk-free rate term spread to one such estimate (the ACM 10y term premium estimated by the New York Fed based on a five-factor, no-arbitrage term structure model, available from the Federal Reserve Bank of New York through Haver Analytics). In quarterly levels, the ACM bond premium and the US 10y – risk-free rate spread are reasonably correlated (Figure A5, top panels) and in 12m changes that correlation is even higher (Figure A5, bottom panels). Because most countries do not have a readily available model-based BRP, we use the high correlation in the US to justify using the term spread as a measure of the BRP for DM countries.

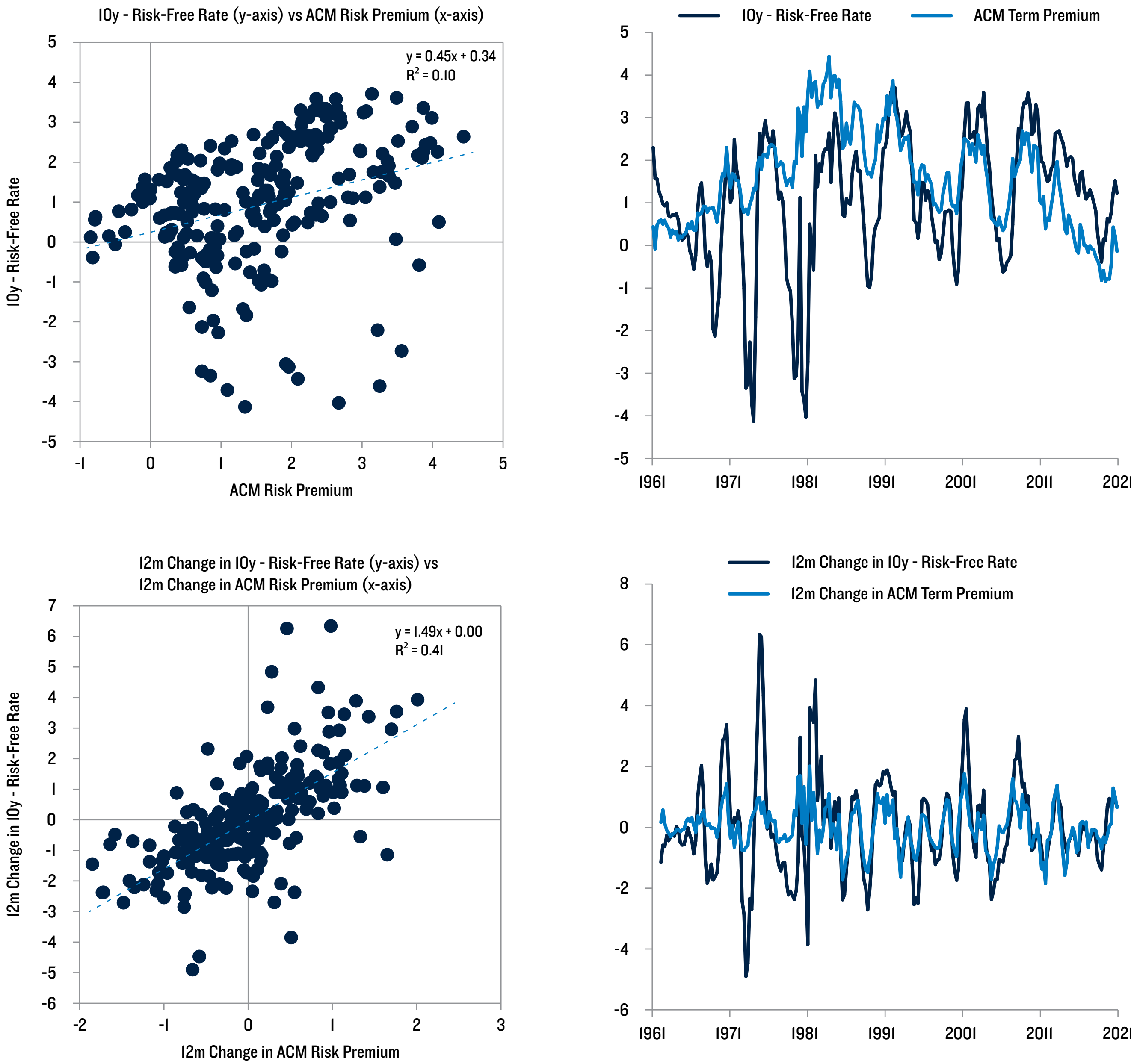
We then calculate the correlation of changes in ERP and changes in BRP as the 20q, centered, rolling correlation of 1q changes in ERP and 1q changes in BRP.

Figure A4: Macroeconomic Components of Stock-Bond Correlation: Summary Statistics

Country	Volatility of Change in Risk-Free Rates			Correlation of GDP Growth and Change in Risk-Free Rates			Correlation of Changes in ERP and BRP		
	Period	Mean of 5y Centered Rolling	Full Sample Non-Rolling	Period	Mean of 5y Centered Rolling	Full Sample Non-Rolling	Period	Mean of 5y Centered Rolling	Full Sample Non-Rolling
Australia	1970-12 to 2019-06	0.99%	1.20%	1970-12 to 2019-06	0.14	0.02	1972-09 to 2019-06	0.40	0.73
Canada	1958-12 to 2019-06	0.78%	0.87%	1963-12 to 2019-06	0.32	0.24	1972-09 to 2019-06	0.39	0.52
Germany	1962-12 to 2019-06	0.59%	0.73%	1993-12 to 2019-06	0.36	0.28	1972-09 to 2019-06	0.19	0.40
Japan	1988-06 to 2019-06	0.17%	0.38%	1996-12 to 2019-06	0.14	0.02	1991-12 to 2019-06	-0.04	0.09
UK	1980-12 to 2019-06	0.65%	0.86%	1980-12 to 2019-06	0.17	0.06	1980-12 to 2019-06	0.42	0.55
US	1957-06 to 2019-06	0.69%	0.85%	1957-06 to 2018-12	0.33	0.29	1972-09 to 2019-06	0.40	0.63

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, Haver Analytics, MSCI, OECD and PGIM IAS. For illustrative purposes only.

Figure A5: US 10y – Risk-Free Rate Bond Yield Spread vs. US ACM Risk Premium



Source: DataStream, Federal Reserve Bank of St. Louis, FRED, Haver Analytics and PGIM IAS. For illustrative purposes only.

Appendix 5: Residual Local Macroeconomic Variables – First Stage Regression Results

To address the possibility that local macroeconomic variables may be (in part) determined by the US, we remove the effects of the US on local variables in a first stage regression. As Figure A6 shows, we run univariate regression of each of the local variables ($\sigma_t(\Delta i_j)$, $\rho_t(\%\Delta y_j, \Delta i_j)$ and $\rho_t(\Delta ERP_j, \Delta BRP_j)$), as the dependent variable, on the corresponding US measure ($\sigma_t(\Delta i_{US})$, $\rho_t(\%\Delta y_{US}, \Delta i_{US})$ and $\rho_t(\Delta ERP_{US}, \Delta BRP_{US})$), respectively, as the independent variable to obtain a time series of regression residuals – one time series per variable, per country.

These residual series represent local variables that are uncorrelated with US macroeconomic variables but may still *influence* changes in local stock-bond correlation.

Regression coefficients on US variables will capture direct and indirect (*i.e.*, via their influence on local varaibles) effects on local stock bond correlation, while coefficients on residual local variables will capture purely local effects.

Using $\sigma_t(\Delta i_j)$ as an example, the first stage regressions take the form:

$$\sigma_t(\Delta i_j) = \gamma_j + \delta_j \times \sigma_t(\Delta i_{US}) + \vartheta_{jt}$$
$$\textit{we then define } \breve{\sigma}_t(\Delta i_j) = \sigma_t(\Delta i_j) - \hat{\gamma}_j - \hat{\delta}_j \times \sigma_t(\Delta i_{US}) \tag{A6}$$
$$\textit{such that } cov\left(\breve{\sigma}_t(\Delta i_j), \sigma_t(\Delta i_j)\right) \neq 0 \textit{ and } cov\left(\breve{\sigma}_t(\Delta i_j), \sigma_t(\Delta i_{US})\right) = 0 \textit{ by construction}$$

The R^2's from these first stage univariate regressions are reasonably high, averaging 0.25 - 0.52 across countries, and all coefficient estimates are positive and significant (Figure A6), suggesting the US macroeconomic variables influence local variables.

Figure A6: Univariate Regression Results – Local Variable Regressed on US Variable

	Country j (1)	Regress $\sigma_t(\Delta i_j)$ on $\sigma_t(\Delta i_{US})$ Adjusted R^2 (2)	Coefficient Estimate (3)	Regress $\rho_t(\%\Delta y_j, \Delta i_j)$ on $\rho_t(\%\Delta y_{US}, \Delta i_{US})$ Adjusted R^2 (4)	Coefficient Estimate (5)	Regress $\rho_t(\Delta ERP_j, \Delta BRP_j)$ on $\rho_t(\Delta ERP_{US}, \Delta BRP_{US})$ Adjusted R^2 (6)	Coefficient Estimate (7)
(1)	Australia	0.55	0.98***	0.09	0.28***	0.39	0.81***
(2)	Canada	0.76	0.73***	0.11	0.37***	0.58	0.89***
(3)	Germany	0.49	0.58***	0.25	0.49***	0.23	0.60***
(4)	Japan	0.17	0.45***	0.42	0.59***	0.06	0.27***
(5)	UK	0.63	0.77***	0.36	0.77***	0.37	0.60***
(6)	Average	0.52	0.70	0.25	0.50	0.33	0.67

Source: DataStream, Federal Reserve Bank of St. Louis, FRED, Haver Analytics, MSCI, OECD and PGIM IAS. For illustrative purposes only.

Appendix 6: EM Stock Returns, Bond Returns, and Stock-Bond Correlations – Data Construction and Summary Statistics

For our study of EM stock-bond correlations, we consider stock and bond returns for eight EMs: Brazil, China, India, Mexico, Russia, South Africa, South Korea, and Turkey.

EM stock returns are calculated using MSCI Country Equity Local Currency Total Return Indices.

EM bond returns are calculated using J.P. Morgan GBI-EM Country Local Currency Total Return Indices.

EM stock-bond correlations are also calculated as above (Appendix 2).

Summary statistics for EM stock and bond returns and stock-bond correlations are presented in Figure A7.

Figure A7: EM Stock Returns, Bond Returns, and Stock-Bond Correlations – Summary Statistics

Country	Stock Returns			Bond Returns			Stock-Bond Correlations		
	Period	Mean (Annualized)	Volatility (Annualized)	Period	Mean (Annualized)	Volatility (Annualized)	Period	Mean of 5y Centered Rolling	Full Sample Non-Rolling
Brazil	1988-01 to 2021-12	128%	62%	2002-01 to 2021-12	13%	6%	2004-07 to 2019-07	0.38	0.40
China	1993-01 to 2021-12	7%	32%	2004-01 to 2021-12	4%	3%	2006-07 to 2019-05	-0.15	-0.10
India	1993-01 to 2021-12	16%	25%	2002-01 to 2021-12	8%	6%	2004-07 to 2019-07	0.08	0.05
Mexico	1988-01 to 2021-12	26%	25%	2002-01 to 2021-12	9%	6%	2004-07 to 2019-07	0.28	0.33
Russia	1995-01 to 2021-12	26%	45%	2005-02 to 2021-12	8%	6%	2007-08 to 2019-07	0.39	0.32
South Africa	1993-01 to 2021-12	15%	18%	1994-07 to 2021-12	12%	9%	1997-01 to 2019-05	0.29	0.35
South Korea	1988-01 to 2021-12	13%	28%	2001-01 to 2021-12	5%	4%	2003-07 to 2019-07	-0.16	-0.16
Turkey	1988-01 to 2021-12	54%	48%	2004-04 to 2021-12	12%	11%	2006-10 to 2019-05	0.54	0.46

Source: DataStream, J.P. Morgan, MSCI and PGIM IAS. For illustrative purposes only.

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