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TRADING & QUANTITATIVE RESEARCH REPORT

Regime-Dependent Macro Exposures in Emerging Market Bond ETFs

A Rolling Factor Model Comparison: Hard Currency vs. Local Currency

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Introduction & Theory

Introduction

Institutional investors use emerging market debt to diversify income streams. Two main segments are sovereign and quasi-sovereign bonds issued in US dollars, and domestic-currency government bonds. These are commonly accessed via the ETFs studied in this report: EMB (USD-denominated debt) and EMLC (local-currency exposure).

This report compares EMB and EMLC returns using a rolling linear factor model with global proxies for equity conditions, US dollar strength, interest rates, credit sentiment, commodities, and volatility. Results are evaluated through time-varying betas, a decomposition into systematic and residual returns, and Shapley-based factor importance.

The objective is to assess whether exposures are stable or regime-dependent, and whether local- and hard-currency debt respond differently to shifts in global financial conditions. These distinctions are relevant for risk management, as diversification benefits may vary across regimes.

Theory

Exchange traded funds (ETFs) are portfolios of underlying assets that trade as a single security on exchanges. While ETF prices are linked to the value of their underlying holdings (net asset value, NAV), deviations can arise due to trading frictions [1]. For bond ETFs, such deviations may be more persistent than for equity ETFs, reflecting the lower liquidity and infrequent trading of the underlying bonds [2]. As a result, ETF returns may contain components that are not fully explained by observable market factors.

EMB and EMLC are bond ETFs providing exposure to emerging market (EM) sovereign debt, either denominated in US dollars (EMB) or in local currencies (EMLC). Their returns are influenced by global macroeconomic conditions. EM assets are sensitive to shifts in global risk sentiment, capital flows, and external financing conditions. Changes in US interest rates, global equity markets, and credit conditions affect EM bond valuations through discount rates and risk premia [3].

Currency dynamics are central in differentiating the two ETFs. EMB, being US dollar-denominated, primarily reflects global rate and credit conditions. In contrast, EMLC includes exposure to local currencies, making it directly sensitive to exchange rate movements. Fluctuations in US dollar strength can therefore have asymmetric effects on EMB and EMLC, contributing to differences in both return behavior and factor sensitivities.

To quantify these relationships, returns are modeled using a linear factor framework, where asset returns are expressed as a function of observable macro factors. The coefficients represent sensitivities (betas) to each factor.

However, these relationships are not stable over time. Financial markets exhibit regime-dependent behavior, where factor sensitivities vary across different economic and financial conditions. To capture this, exposures are allowed to change over time using a rolling estimation approach.

Rolling least squares estimates the same linear model on a moving time window of fixed length T. At each time t, the coefficients are calculated based on the most recent observations at $\{t-T+1, t-T+2, \ldots, t\}$, resulting in a time series of coefficient estimates $\hat{\beta}_t$ rather than a constant vector $\hat{\beta}$.

Formally, the parameters in the linear model

$$y_t = \alpha + x_t^\top \beta_t + \varepsilon_t, \qquad (1)$$

are approximated for each time window by solving:

$$(\hat{\alpha}_t,\ \hat{\beta}_t) = \arg\min_{\alpha,\ \beta} \sum_{i=t-T+1}^{t} \left(y_i - \alpha - x_i^\top \beta\right)^2. \qquad (2)$$

This rolling procedure produces local estimates of factor exposures that evolve over time. The choice of window length T introduces a bias–variance trade-off: shorter windows adapt more quickly to changes in market conditions but are more sensitive to noise, while longer windows provide smoother estimates at the cost of slower adjustment to regime shifts.

The residual component ε_t captures variation not explained by the included macro factors. In the context of EM bond ETFs, this may reflect idiosyncratic drivers such as local market conditions, liquidity effects, and changes in index composition. The relative magnitude of the systematic and residual components provides insight into how well global macro factors explain return dynamics.

Data & Method

Data Overview

We use a set of macro-factors commonly used to characterize the market environment for emerging market bond ETF dynamics. Global market conditions are proxied by the price of the S&P 500 index. Currency conditions, relevant for USD versus local currency exposure, are included through the US Dollar Index (DXY). Current monetary policy is captured through the US Treasury yield curve. Initially, both the 2-year and 10-year Treasury yields were included, after which the 2-year yield was replaced by the 10-year/2-year yield spread in the final specification. US high yield spread was added to capture prevailing credit sentiment. To account for commodity-market dynamics, the Bloomberg Commodity Index (BCOM) was used. Finally, to proxy market uncertainty the VIX (CBOE Volatility Index) is used. All proxies, together with price series for both EMB and EMLC, were sourced from Bloomberg for a 10-year time period, starting in 2015-11-04 and ending in 2025-11-04.

Data Management

Some of the retrieved data did not have values for all days, such as during non-trading days. To ensure a consistent dataset, dates with missing values for any of the relevant variables were dropped. Missing-value days were limited (excluding non-trading days), and their removal has minimal impact on the dataset. The resulting dataset is consistent and suitable for modelling.

Because our objective is to model changes in price rather than price levels, we transformed the price series for EMB, EMLC, BCOM and S&P 500 into weekly returns. Weekly returns were used to reduce daily noise and strengthen the signal from the underlying drivers.

Other proxies can be persistent in levels, which may cause the model to separate "high-level" and "low-level" periods rather than identifying meaningful market regimes. To keep the specification consistent with the weekly return frequency, the macro proxies were transformed into weekly changes. Price-based proxies were converted to weekly log-returns, while yield-based proxies were converted to weekly differences. These transformations make the inputs closer to stationary and improve comparability over time.

Method

First, correlations between the macro factors were computed over the full sample. For factors exhibiting high correlation ($|\rho| > 0.7$), the more redundant factor was orthogonalized with respect to the S&P 500 proxy (SPY), which exhibited the strongest correlations, by regressing it on that proxy and using the residual as the cleaned factor. This step was applied to reduce multicollinearity and improve interpretability of factor exposures.

Rolling window least squares were then estimated using a 26-week window on the orthogonalized factor set. A 26-week specification was chosen as a balance between responsiveness to regime shifts and estimation stability. For each time t, the estimated beta for each factor $\hat{\beta}_{f,t}$ was plotted in a time series to illustrate changing factor exposures.

Finally, model behavior was summarized by decomposing returns into a fitted systematic component and a factor-neutral (residual) component, and plotting both alongside the raw return series. Variable importance was computed using Shapley percentages of R^2, obtained by attributing the model's explanatory power to each factor based on its marginal contribution across all possible subsets of the factor set.

In addition, relative performance between EMB and EMLC was analyzed using the spread (EMB minus EMLC), where an increase indicates relative outperformance of EMB. Regimes were identified using a 52-week moving-average rule applied to each the most explanatory factors, and spread changes together with their correlations with the factors were evaluated across regimes.

Results

Results
The model produces three sets of outputs: a cleaned factor set, time-varying exposures $\hat{\beta}_{f,t}$ and a decomposition of returns into a factor component and a factor-neutral residual component, which is complemented by Shapley-based importance of R^2.

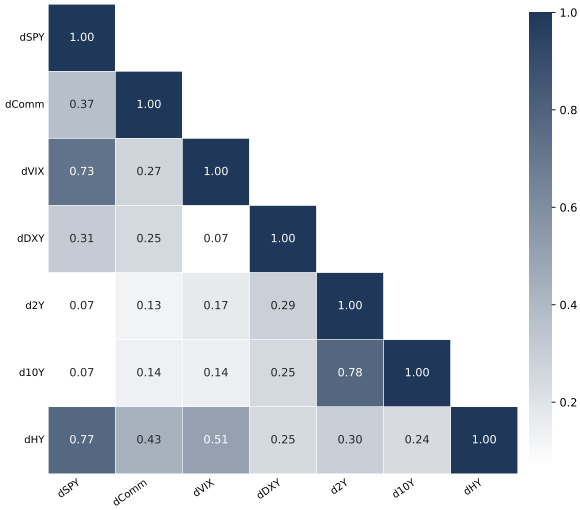

Figure 1: Factor correlation matrix.

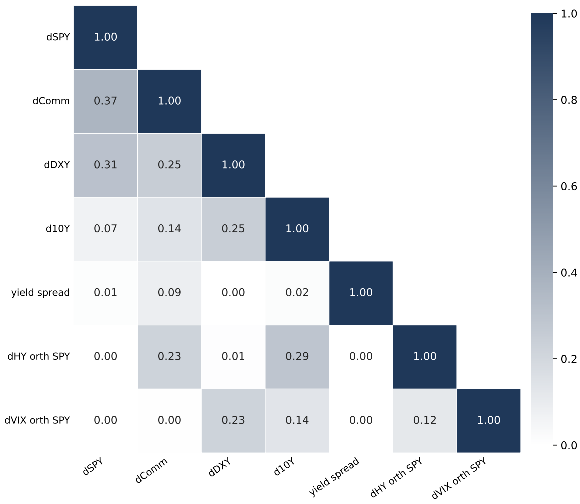

Figure 2: Factor correlation matrix after orthogonalization and replacement of the 2-year yield with the yield spread.

Correlations among the macro proxies showed high correlation between the S&P 500, the VIX, and the high yield spread, alongside high correlation between movements in the 2-year and 10-year yields (see Figure 1). After orthogonalization and replacing the 2-year yield with the yield spread, these large correlations were substantially reduced in the final factor set (see Figure 2).

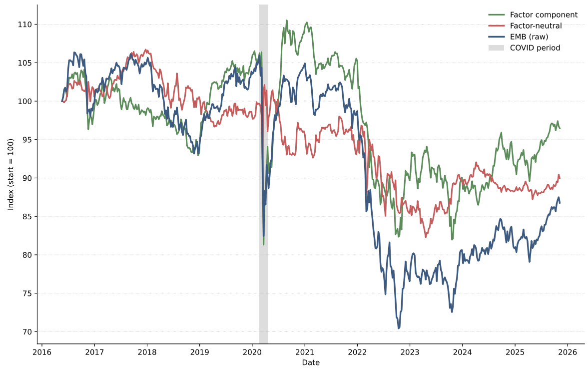

Figure 3: EMB factor decomposition.

For EMB, the decomposition indicates that the factor component captures broad directional movements in certain periods, but the co-movement with the raw return series is not consistent across the full sample. In particular, during the post-2022 period, the factor component diverges materially from the raw series and fails to capture the magnitude of drawdowns. The factor-neutral residual is substantial and persistent, indicating that a large share of EMB dynamics is not explained by the factor set.

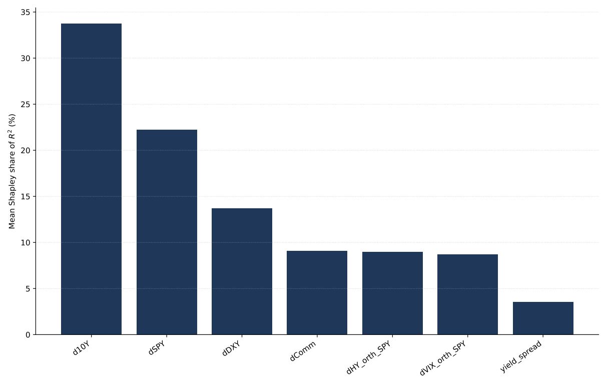

Figure 4: Mean Shapley share of R^2 for EMB.

Shapley importance for EMB is led by $\Delta 10Y$ and ΔSPY, followed by ΔDXY. $\Delta Comm$, orthogonalized high yield, and orthogonalized VIX contribute with comparable intermediate shares, indicating a more balanced multi-factor structure rather than a sharply concentrated one. The yield spread accounts for a clearly smaller share relative to the other factors (see Figure 4).

Results (cont.)

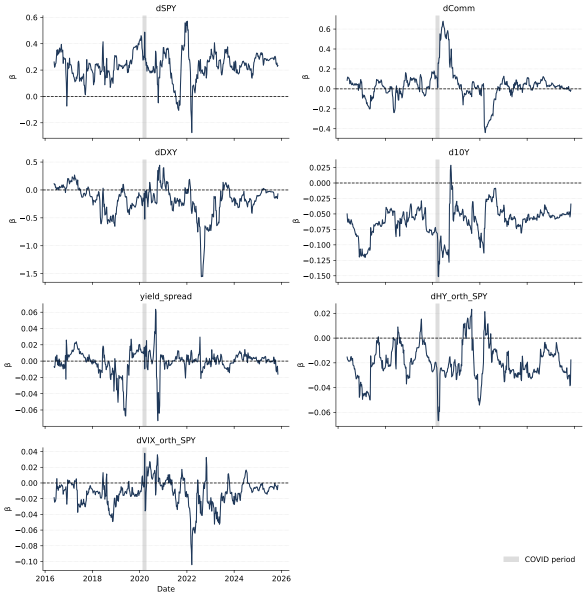

Figure 5: Rolling betas for EMB.

Rolling factor loadings for EMB show regime-dependent variation in both sign and magnitude. Exposure to US dollar strength is predominantly negative over extended periods, with episodes of weaker or near-zero sensitivity. Equity exposure stays consistently positive and economically meaningful, while commodity exposure shows larger swings and periods of elevated sensitivity. Rate-related exposures are mostly negative rather than centered around zero, pointing to a persistent relationship with yield changes. Overall, EMB's macro exposures reflect both regime variation and some relatively stable underlying patterns.

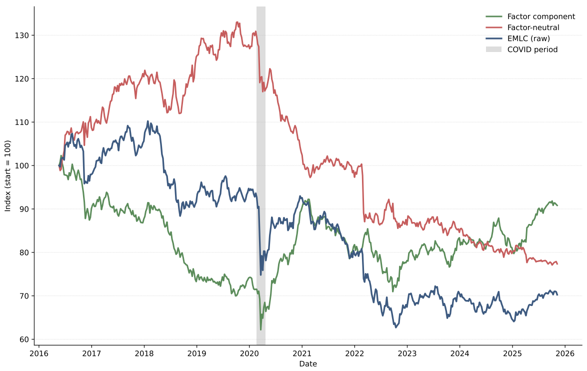

Figure 6: EMLC factor decomposition.

For EMLC, the decomposition shows that the factor component only partially tracks the raw return series and diverges materially over extended subperiods. The gap is particularly large during 2017–2020 and remains meaningful post-2022, indicating a substantial and persistent residual component.

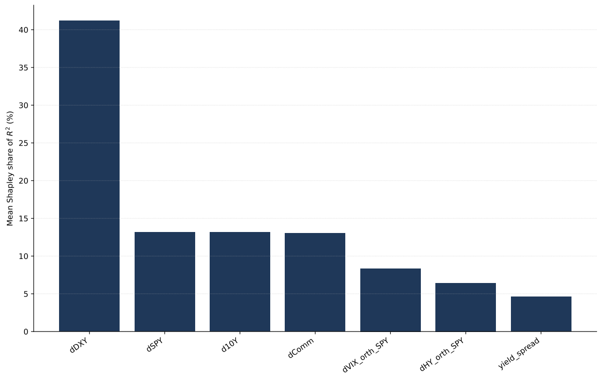

Figure 7: Mean Shapley share of R^2 for EMLC.

Shapley attribution for EMLC differs sharply from EMB. ΔDXY is the dominant driver of explanatory power, followed by ΔSPY, $\Delta 10Y$, and $\Delta Comm$ (see Figure 7).

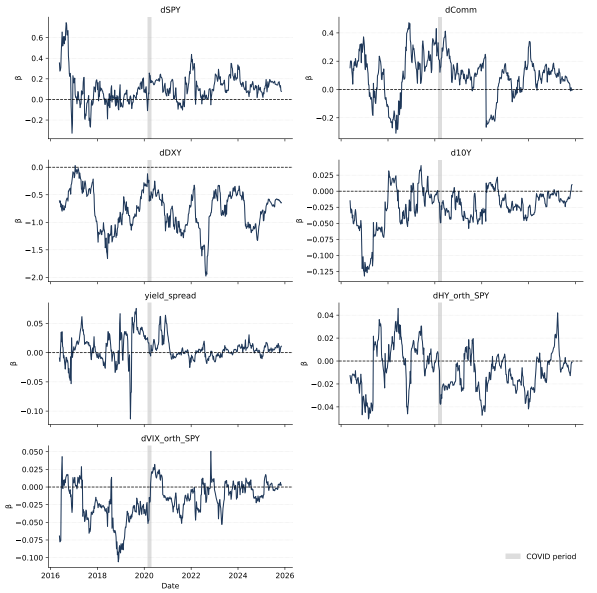

Figure 8: Rolling betas for EMLC.

Rolling betas show time-varying, regime-dependent exposures. ΔDXY is the most persistent factor, remaining negative throughout with occasional sharp swings. Equity and commodity betas vary over time, with changes in magnitude and occasional sign shifts. Interest-rate exposures are smaller overall, as $\Delta 10Y$ remains modest and mostly negative, while the yield-spread beta stays close to zero except for brief deviations.

Results (cont.) & Analysis

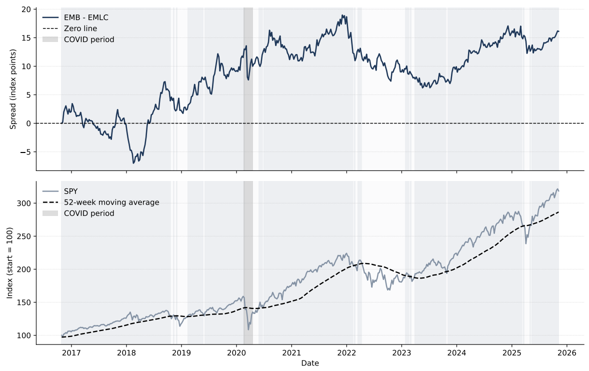

Figure 9: Spread and SPY-based risk-on regimes.

Figure 9 shows the EMB–EMLC spread in the upper panel and SPY together with its moving average in the lower panel. Periods in which SPY exceeds its moving average correspond to risk-on regimes. The spread varies substantially over time and exhibits pronounced shifts across major market episodes, including the COVID-19 period. Comparable regime classifications based on DXY and US 10Y are reported in Appendix I.

Changes in the spread and their correlations with underlying macro factors are reported in Appendix II. For SPY, these relationships are summarized in Table 1.

Metric	In regime	Out of regime
Correlation	0.052077	0.305659
Mean Δspread	0.057637	-0.072093

Table 1: SPY (risk-on): correlation with Δspread and mean Δspread in and out of regime.

Analysis

Results show that emerging market bond ETF returns are associated with global macro conditions, but also contain dynamics not captured by the factor set. The decomposition indicates that the factor component explains broad directional movements during major events, particularly during episodes such as the COVID-19 shock and the 2022 rate hike cycle. The factor-neutral residual remains substantial over extended periods, indicating that macro factors alone cannot explain persistent multi-month dynamics. This suggests the presence of additional drivers, such as index composition changes and investor flows.

Rolling betas show that exposure is state-dependent, not constant. Several exposures show sustained levels, followed by sharp breaks around stress periods rather than noise-like oscillations. This result directly supports the claim that risk evolves in a contemporaneous regime-based way. A given macro move can transmit differently depending on prevailing market conditions. At some times, equity or rate exposures are more influential, while in other periods dollar sensitivity becomes more important, altering both the direction and the size of the impact.

Comparison between EMB and EMLC is most clearly reflected in the Shapley attribution. For EMB, explanatory power is led by interest rates and equity changes, with US dollar strength and the remaining factors contributing smaller, but still meaningful, shares. This contrasts with EMLC, where US dollar strength dominates explanatory power, which is consistent with its local-currency exposure.

A sizeable idiosyncratic component in both ETFs indicates that the factor set does not capture the full span of risk. This is particularly evident for EMLC, where the dominance of DXY suggests the model mainly captures a broad USD and global financial conditions channel, leaving local-currency drivers unaccounted for. Larger residual deviations in the EMLC decomposition further indicate that more of its return variation remains unexplained.

Rolling exposures reinforce these findings. EMLC exhibits a more persistent negative sensitivity to dollar movements, while EMB shows weaker and less stable exposure. This suggests that EMLC is structurally more exposed to currency conditions, whereas EMB is more closely linked to global rate-driven risk premia.

A natural extension of the model is therefore to incorporate EM-specific and local-currency-specific factors to better capture these residual dynamics. Additional robustness checks, such as confidence intervals for $\hat{\beta}_{f,t}$ and diagnostics for residual autocorrelation, would further strengthen the interpretation of the estimated exposures.

The spread-based results indicate that relative performance between EMB and EMLC varies systematically across market regimes. A consistent pattern is observed: periods of equity strength (risk-on) align with increasing spreads, while dollar strength aligns with widening spreads, whereas rising yields are associated with declining spreads in risk-off regimes.

To further characterize these patterns, changes in the spread and their relationship with macro factors are analyzed through correlations and average changes across regimes. Changes in the spread are positively related to equity movements and, to a lesser extent, to dollar movements, and negatively related to changes in long-term interest rates. In risk-on environments, the spread tends to increase, consistent with relative outperformance of EMB. In contrast, during risk-off regimes, the spread stabilizes or decreases, implying improved relative performance of EMLC.

For equity conditions, there is a clear difference in mean spread changes across regimes (see Appendix II). During SPY-based risk-on periods, the average change in the EMB-EMLC spread is positive, whereas outside these periods it is negative. This indicates relative outperformance of EMB in risk-on environments and relative outperformance of EMLC outside them. A similar contrast is observed for US 10Y-based regimes, where the mean change in the spread is slightly negative during risk-off periods but clearly positive outside them.

Overall, these results show that while EMB dominates in unconditional performance, the relative performance between EMB and EMLC is strongly regime-dependent. Risk-on environments are associated with relative outperformance of hard-currency exposure, whereas risk-off conditions reduce and occasionally reverse the relative disadvantage of local-currency debt. This suggests that allocation between EMB and EMLC may be conditioned on observable macro regimes, providing a potential basis for systematic timing strategies.

Conclusion

The analysis shows that EMB and EMLC returns are systematically linked to global macro conditions, but that these relationships are neither stable nor fully captured by a standard factor specification. While the factor model explains broad directional movements, a substantial and persistent residual remains, particularly for EMLC, indicating that important drivers of emerging market debt returns lie outside the included macro proxies.

A key result is that exposures are clearly regime-dependent. Rolling estimates show that sensitivities shift in a structured manner rather than fluctuating randomly, suggesting that risk transmission depends on prevailing market conditions. This is reinforced by the cross-ETF comparison: EMB is primarily driven by interest rate and equity conditions, while EMLC is dominated by US dollar exposure, reflecting its structural sensitivity to currency dynamics.

The spread analysis strengthens these findings by translating factor exposures into relative performance. While EMB dominates in unconditional performance, the relative behavior of EMB and EMLC varies systematically across regimes. Risk-on environments are associated with outperformance of hard-currency exposure, whereas risk-off conditions reduce and at times reverse this gap. This indicates that the choice between EMB and EMLC is not static, but conditional on observable macro signals such as equity trends, dollar strength, and interest-rate movements.

Taken together, the results point to a more general insight: emerging market bond ETFs embed regime-sensitive exposures that may be exploited through dynamic allocation. Rather than treating EMB and EMLC as complementary diversifiers in a static portfolio, they can be viewed as instruments whose relative attractiveness shifts with the macro environment. This opens a clear avenue for further research, in particular the development of systematic allocation strategies based on regime indicators and the inclusion of EM-specific factors to better capture the residual dynamics identified in this study.

Appendix I – Regimes DXY & 10Y yield

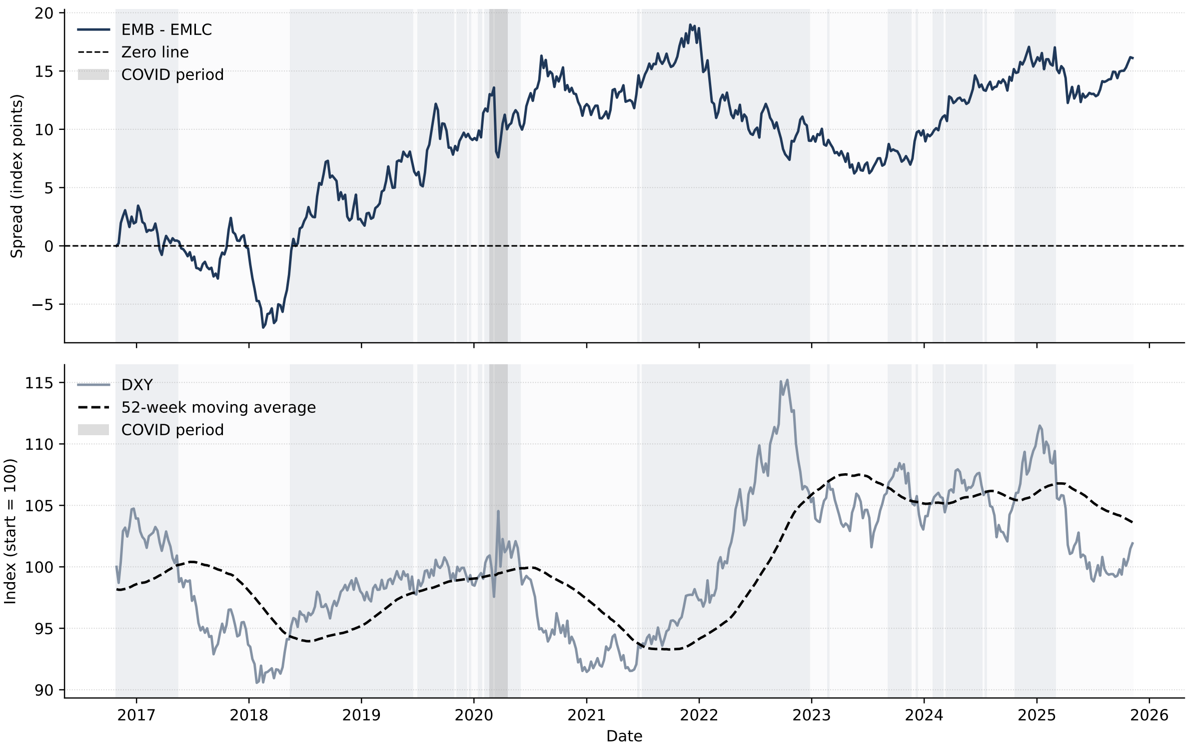

Figure 10: Spread and DXY-based risk-off regimes.

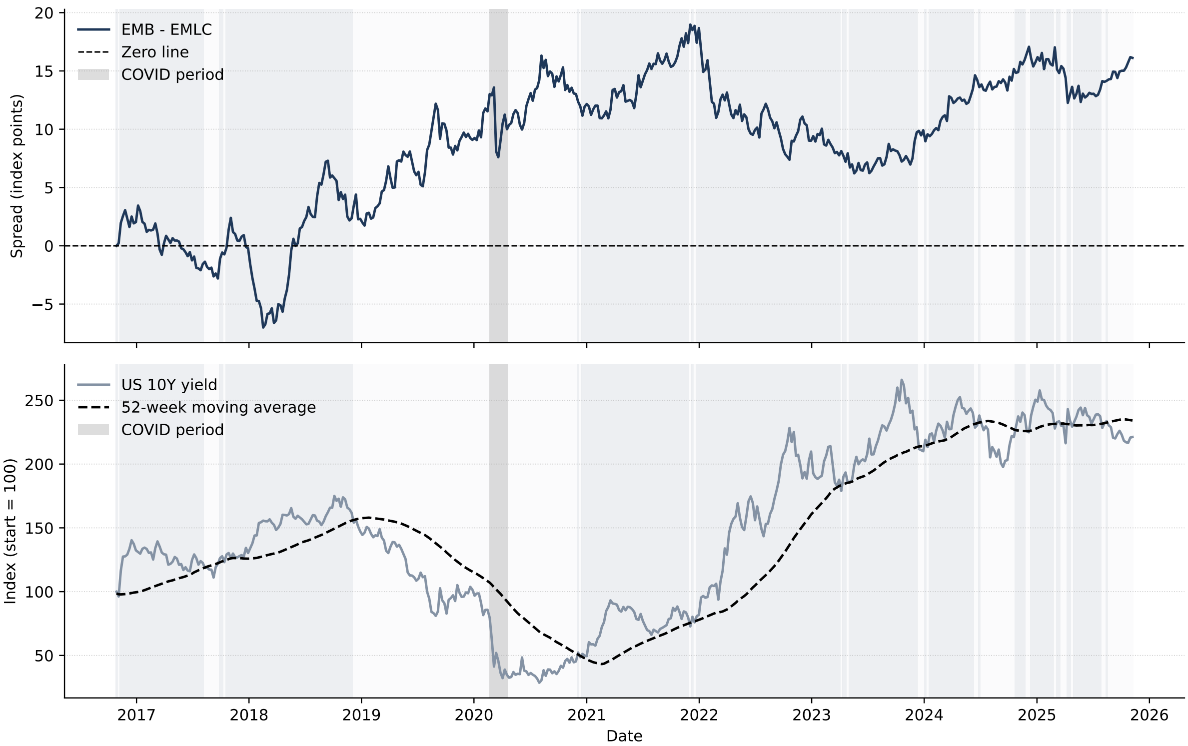

Figure 11: Spread and US 10Y yield-based risk-off regimes.

Appendix II – Regime Correlations and Spread Changes

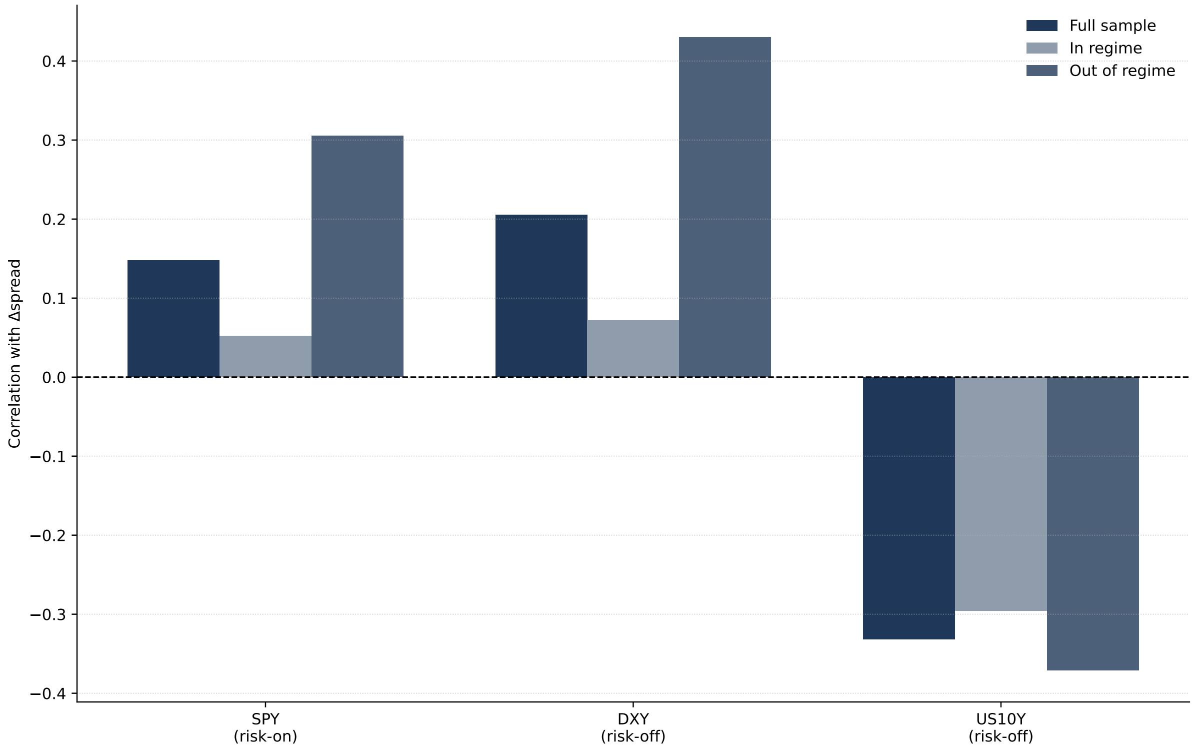

Figure 12: Correlation between changes in spread and macro factors across regimes.

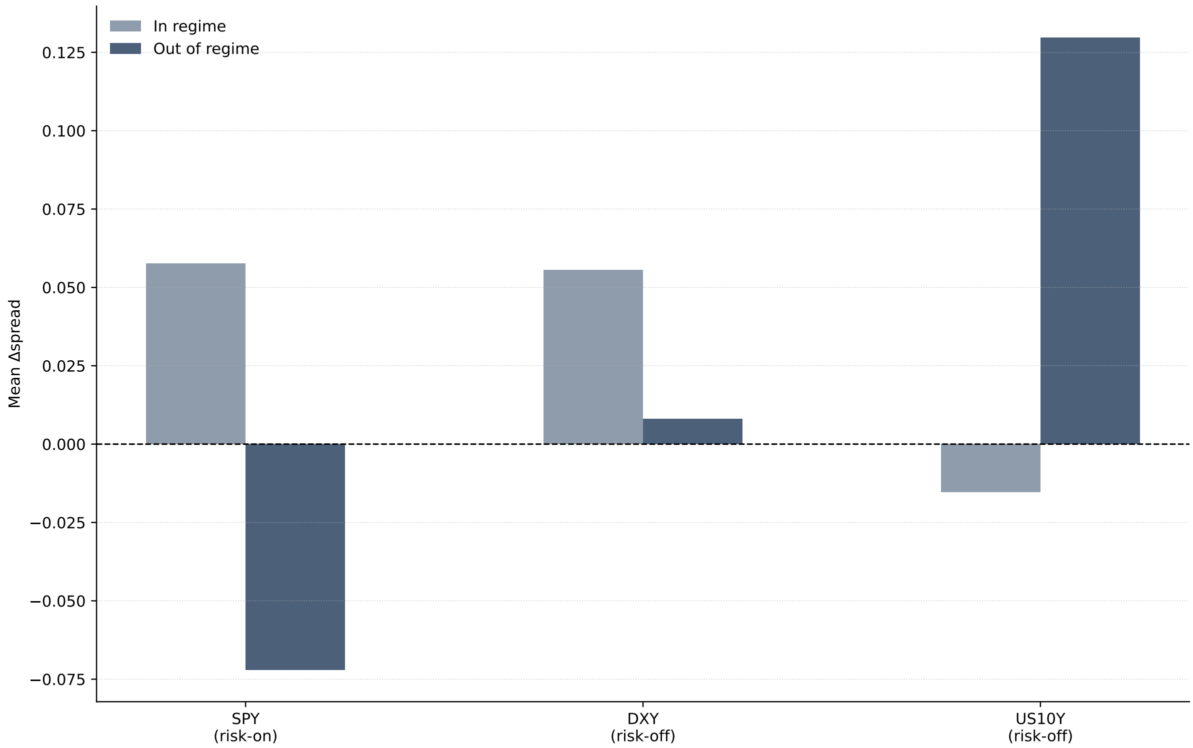

Figure 13: Average change in spread across regimes.

References

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[3] Eugenio Cerutti, Stijn Claessens, and Damien Puy. Push factors and capital flows to emerging markets: Why knowing your lender matters more than fundamentals. IMF Working Paper WP/15/127, International Monetary Fund, 2015.

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Other