Unspanned Factor Premia in Sovereign Bond Markets

Applying Value, Momentum & Carry to International Government Bond Futures

Based on Brooks & Moskowitz, "Yield Curve Premia" (2017)

Extended with Citi Economic Surprise Index (CESI)

Hedge Fund Strategies

March 2026

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1. Executive Summary

This report documents the implementation and analysis of a systematic multi-factor trading strategy for international government bonds, inspired by Brooks & Moskowitz's "Yield Curve Premia" (2017). The strategy trades 10-year government bond futures across six developed markets — United States, Germany, United Kingdom, Japan, Australia, and Canada — using four cross-sectional factors: Carry, Value, Momentum, and the Citi Economic Surprise Index (CESI).

The strategy is rebalanced monthly, going long the top 2 ranked countries and short the bottom 2, based on a composite z-score of the four factors. The backtest spans January 2004 to December 2025 (260 months), though factor availability varies: breakeven inflation data (required for the Value signal) is only available from July 2014, meaning the full 4-factor model operates from mid-2014 onward while earlier periods rely on a reduced factor set.

Key findings: The 4-Factor composite strategy delivers an annualized return of 0.98% with a Sharpe ratio of 0.27 and maximum drawdown of −7.7%. Value is the dominant factor (Sharpe 0.39, explaining 42.5% of composite return variance). Most importantly, style factors (Carry + Value + Momentum) explain 49% of strategy returns while yield curve shape factors (Level + Slope + Curvature) explain only 0.2% — directly confirming Brooks & Moskowitz's central finding that styles subsume the yield curve's principal components.

2. Introduction & Motivation

Government bonds have traditionally been analysed and traded using yield curve factors — Level, Slope, and Curvature — which correspond to the first three principal components of the yield curve and collectively explain over 99% of yield variation. Portfolio managers typically construct duration, curve, and butterfly trades based on views about these factors.

Brooks & Moskowitz (2017) challenge this paradigm by demonstrating that equity-style factors — Value, Momentum, and Carry — when applied to government bonds, not only explain bond return premia but completely subsume the pricing information contained in yield curve principal components. Their key findings include:

- Value (real yield) subsumes the Level principal component, capturing information about both the absolute level of yields and inflation expectations.
- Carry (term spread / roll-down) subsumes information from the Slope (second principal component).
- Momentum alone is weak, but the combination of Value, Momentum, and Carry subsumes the third PC (Curvature).
- Style factors capture significant unspanned information — pricing factors not contained in the yield curve itself, including macroeconomic growth and inflation surprises.

We implement their framework as a tradeable cross-country strategy and extend it by adding the Citi Economic Surprise Index (CESI) as a fourth factor, designed to capture real-time macroeconomic divergence across countries. Our research question is: do style factors deliver economically meaningful returns beyond what yield curve shape alone predicts, and does CESI add incremental value?

3. Universe Selection & Data Challenges

3.1 Initial Universe Considered

We initially considered a broader universe of 10 countries, including four emerging/frontier markets alongside six developed markets:

Developed Markets: United States, Germany, United Kingdom, Japan, Australia, Canada

Emerging/Frontier Markets (considered but dropped): Mexico, Poland, Sweden, South Africa

3.2 Why Emerging Markets Were Dropped

After extensive data sourcing from Bloomberg, we encountered systematic data gaps for the emerging/frontier markets that made them unsuitable for inclusion in a multi-factor model requiring consistent cross-country data. The specific issues were:

CESI Availability: The Citi Economic Surprise Index was not available for Mexico, Poland, Sweden, or South Africa. Since CESI is one of our four factors, these countries would have required a reduced model, creating inconsistent factor exposure across the portfolio.

Short-Tenor Yield Data: Several emerging markets lacked 3-month or 6-month government bond yield data, which is required for computing yield curve metrics (Level, Slope, Curvature) used in our regression analysis. Without these, we cannot test orthogonality to the yield curve.

Breakeven Inflation: Poland's 10-year breakeven inflation data does not exist in Bloomberg, making it impossible to compute the Value signal (real yield = nominal yield − breakeven).

Policy Rates: Central bank policy rate data for Poland and South Africa was either unavailable or unreliable in our Bloomberg source.

Sweden: While Sweden initially appeared viable as a developed market, its policy rate data became patchy around 2010, coinciding with the Riksbank's experimentation with negative interest rates. This created gaps in our data that would complicate signal construction.

Liquidity & Futures Availability: Emerging market bond futures are significantly less liquid than their DM counterparts, and some do not have standardised 10-year futures contracts on major exchanges.

3.3 Final Universe

Based on these constraints, we narrowed the universe to six developed markets with consistent data across all required fields. Even within this final universe, we note data compromises:

- Germany: No CESI data available — uses a 3-factor model (Carry, Value, Momentum only). Uses 1-year yield as a proxy for 3-month (3M data unavailable). Uses French 10-year breakeven as a proxy for Eurozone inflation expectations.
- Australia: 6-month yield data has approximately 11 years of gaps; we use 3-month data instead.
- Australia: Policy rate data is patchy before November 2008 (though policy rates are not used in signal construction).

4. Data Sources & Availability

All data is sourced from Bloomberg. The data file used is HFS_data_opus.xlsx, containing seven sheets: govt bonds (yields at multiple tenors), 10y breakeven (inflation-linked bond breakevens), FX spot (exchange rates), policy rate (central bank rates), TRI (total return indices), cesi (economic surprise indices), and futures to trade on (10-year bond futures prices).

4.1 Data Availability by Type

Data Type	Availability	Notes
FX Spot Rates	From 1 Jan 2004	All pairs available
CESI	From 4 Jan 2003	5 countries (excl. Germany)
Futures Prices	From 12 Jan 2000	All 6 countries
Total Return Indices	From 4 Jan 2005	Local currency; USD conversion needed
Breakeven Inflation	From 3 Jul 2014	Binding constraint for Value signal
Government Yields	From early 2000s	10Y, 2Y, 3M (Germany: 1Y proxy)

4.2 Implications for Backtest Start Date

We set the backtest start to January 2004, balancing data availability with sample length. However, factor availability varies:

- Carry: Available from 2004 onward (requires 10Y and 2Y yields only).
- CESI: Available from 2003 onward for 5 countries.
- Momentum: Requires TRI data (from Jan 2005) plus a 12-month lookback, so the first momentum signal appears around early 2006.
- Value: Requires breakeven data (from Jul 2014). The Value factor is therefore only active from mid-2014 onward.

This means the pre-2014 backtest runs on a reduced factor set (primarily Carry + Momentum + CESI where available), and the full 4-factor model only operates from mid-2014. The strongest results (COVID period Sharpe 0.72, Rate Hikes Sharpe 0.41) occur in the post-2014 period when all factors are active.

4.3 FX Conversion

Total Return Indices are converted from local currency to USD for momentum computation. The convention is: XXXUSD pairs (EURUSD, GBPUSD, AUDUSD) multiply local TRI by the rate; USDXXX pairs (USDJPY, USDCAD) divide. This means momentum captures both bond price moves and FX moves, appropriate for an unhedged USD investor.

5. Signal Definitions & Assumptions

5.1 Carry

Formula: Carry = 10Y Yield + (10Y Yield − 2Y Yield) × 0.8

The first term captures the yield income. The second approximates the roll-down return: as a 10-year bond ages, it moves to a lower-yield point on an upward-sloping curve, generating capital gain. The 0.8 multiplier approximates the modified-duration-weighted effect. A more precise approach would use (10Y − 9Y) × duration, but 9Y yields are not available. Higher carry = BUY signal.

5.2 Value

Formula: Value = 10Y Nominal Yield − 10Y Breakeven Inflation

Real yield represents the inflation-adjusted return. Higher real yields indicate bonds are "cheap" relative to inflation expectations. This is a mean-reversion signal consistent with Brooks & Moskowitz's definition of value as yield relative to a fundamental inflation anchor. For Germany, French 10Y breakeven is used as a proxy. Higher real yield = BUY signal.

5.3 Momentum

Formula: Momentum = TRI_USD(t−1) / TRI_USD(t−12) − 1

This is the standard 12-minus-1 momentum: the 11-month total return in USD, skipping the most recent month to avoid short-term reversal effects. Implemented as pct_change(11).shift(1) on the USD-denominated TRI. Momentum is computed on USD-converted TRIs, meaning it captures both bond price moves and FX moves. Higher momentum = BUY signal.

5.4 CESI (Economic Surprise)

Formula: CESI Signal = −1 × CESI Level

The Citi Economic Surprise Index measures the gap between actual economic releases and consensus expectations. Positive CESI means the economy is beating expectations, which typically leads to higher yields (bearish for bonds). We invert it so that negative surprises (bullish for bonds) generate buy signals. Germany lacks CESI data and uses a 3-factor model. CESI z-scores are computed cross-sectionally over N=5 countries only, which introduces noise.

5.5 Yield Curve Metrics (for Regression Analysis)

These are NOT trading signals. They are used only to test whether the strategy's returns are orthogonal to yield curve shape:

- Level = (10Y + 2Y + 3M) / 3 — average yield across the curve
- Slope = 10Y − 3M — steepness of the curve
- Curvature = 2 × (2Y) − 10Y − 3M — butterfly spread

For Germany, 1Y yield is used as a proxy for 3M, which systematically overstates Level and understates Slope for Germany.

6. Portfolio Construction & Backtest Methodology

6.1 Cross-Sectional Z-Scoring

Each factor is standardised cross-sectionally at each point in time: Z = (Factor Value − Cross-Sectional Mean) / Cross-Sectional Std Dev. This ensures each factor contributes equally regardless of its natural scale. With only 5–6 countries, these are small-sample z-scores.

6.2 Composite Signal

For countries with all 4 factors: Composite = (Carry_Z + Value_Z + Momentum_Z + CESI_Z) / 4. For Germany: Composite = (Carry_Z + Value_Z + Momentum_Z) / 3. Equal weighting follows Brooks & Moskowitz's baseline approach.

6.3 Position Assignment

Countries are ranked by composite z-score each month. The top 2 receive a +1 (Long) position, the bottom 2 receive a −1 (Short) position, and the middle 2 are Neutral (0). The portfolio is dollar-neutral with equal weight within longs and shorts.

6.4 Timing Convention

Signals computed using end-of-month data from month t−1 determine positions for month t. This is implemented as a single shift(1) in the code. Returns are computed from futures price changes (pct_change on end-of-month futures levels), which correctly reflects the P&L of a futures-based strategy.

7. Results: Strategy & Factor Performance

7.1 Overall Performance

	Ann. Return	Ann. Vol	Sharpe	Max DD	Win Rate
4-Factor Composite	**0.98%**	3.63%	**0.27**	−7.7%	54.2%
Carry	0.98%	2.76%	0.35	−13.3%	51.4%
Value	**1.65%**	4.22%	**0.39**	−8.7%	51.5%
Momentum	0.38%	4.00%	0.10	−18.4%	53.7%
CESI	−0.47%	3.57%	−0.13	−18.4%	49.6%

Value is the strongest standalone factor with a Sharpe of 0.39 and annualized return of 1.65%. Carry delivers the same 0.98% return as the composite but with higher volatility risk (max drawdown −13.3% vs −7.7%). CESI loses money as a standalone factor (−0.47% annualised), acting primarily as a crisis alpha source. The composite's value-add is drawdown diversification: −7.7% max DD compared to −13% to −18% for individual factors.

7.2 Performance by Period

Period	4-Factor	Carry	Value	Mom	CESI	Avg Level
Pre-GFC (2004-07)	0.42	**0.99**	0.48	−0.12	−0.19	3.96%
GFC (2008-09)	0.26	0.49	0.59	−0.19	−0.16	1.90%
Post-GFC (2010-15)	−0.02	−0.05	0.09	−0.25	−0.27	0.98%
Pre-COVID (2016-19)	0.36	−0.49	−0.35	**0.54**	0.40	1.76%
COVID (2020-21)	**0.72**	0.20	**1.43**	**0.97**	−0.18	0.53%
Rate Hikes (2022-25)	**0.41**	**0.79**	**0.94**	−0.10	−0.65	3.98%

The table above reports Sharpe ratios by period alongside the average US yield Level for context. The Post-GFC period (2010–2015) was effectively dead — average yields of 0.98% left no room for cross-country differentiation, and all factors produced near-zero or negative Sharpes. The COVID and Rate Hikes periods (where the full 4-factor model is active) show the strongest performance, driven by massive cross-country divergence in monetary policy responses.

8. The Core Test: Styles vs. Yield Curve

This section replicates the central test from Brooks & Moskowitz: do style factors subsume yield curve principal components?

8.1 Alpha Regression Results

We regress the 4-Factor composite strategy returns on various combinations of factor returns and yield curve metrics:

Control For	Alpha (ann.)	R^2	Interpretation
Nothing (raw return)	0.98%	—	Starting point
Value alone	0.06%	42.5%	Value explains almost everything
C + V + M	0.06%	49.0%	Zero alpha over style factors
C + V + M + CESI	0.26%	55.6%	CESI adds 6.6% incremental R^2
L + S + C (curve shape)	**1.14%**	**0.2%**	**Curve explains NOTHING. Alpha fully survives.**
All Factors + Curve	−0.14%	55.8%	Curve adds 0.2% on top of styles

8.2 Factor Loadings

In the full C+V+M+CESI regression, the factor loadings are: β(Value) = 0.426 (t=4.58, significant at 1%), β(CESI) = 0.263 (t=3.27, significant at 1%), β(Momentum) = 0.243 (t=4.45, significant at 1%), β(Carry) = 0.181 (t=1.99, significant at 5%). The alpha is 0.26% (t=0.51, not significant). Value's loading is 2–3 times larger than any other factor.

8.3 Mapping to Brooks & Moskowitz

Our results confirm all five major claims from the paper:

1. Value subsumes Level: Value R^2 = 42.5% vs Level R^2 = 0.2%. Confirmed.
2. Carry subsumes Slope: Carry R^2 = 6.4% vs Slope R^2 = 0.2%. Confirmed (weaker magnitude, likely due to our smaller cross-section).
3. Momentum is weak alone but contributes in combination: Momentum Sharpe = 0.10 standalone. Confirmed.
4. Styles capture unspanned macro information: CESI adds R^2 from 49% to 55.6% on top of C+V+M. Confirmed.
5. Styles subsume all three PCs: C+V+M R^2 = 49% vs L+S+C R^2 = 0.2%. Confirmed.

9. Regime Analysis

9.1 By Yield Level Quartile

Quartile	Avg Level	4F Sharpe	Carry	Value	Momentum
Q1 Low	0.69%	0.36	0.34	0.28	0.22
Q2	1.25%	**−0.09**	−0.13	0.10	−0.30
Q3	2.58%	0.49	−0.00	0.44	0.21
Q4 High	4.48%	**0.62**	**0.77**	**0.68**	0.08

9.2 By Yield Curve Slope Quartile

Quartile	Avg Slope	4F Sharpe	Carry	Value	Momentum
Q1 Flat	−0.44%	**0.84**	**0.64**	**0.67**	0.10
Q2	0.84%	0.38	0.33	0.28	0.57
Q3	1.79%	**−0.04**	0.14	0.47	−0.31
Q4 Steep	2.82%	0.16	−0.10	0.15	−0.11

The strategy thrives when yields are high (creating room for cross-country carry and value differentiation) and curves are flat or inverted (typically late-cycle conditions where monetary policy divergences are most pronounced). It struggles in the “boring middle” — Q2 yield levels and Q3 slopes — where yields are moderate and curves are moderately steep, offering little cross-country dispersion.

10. Current Positioning (December 2025)

Country	Carry Z	Value Z	Mom Z	CESI Z	Composite	Position
Australia	+1.07	+1.32	+0.52	−0.19	**+0.68**	**LONG**
UK	+0.85	+0.11	+0.52	+1.08	**+0.64**	**LONG**
US	+0.50	+0.62	−0.16	−0.89	+0.02	**SHORT**
Germany	−0.81	−0.49	+0.93	N/A	−0.12	**SHORT**
Japan	−1.49	−1.61	−1.89	N/A	N/A	NEUTRAL
Canada	−0.13	+0.06	+0.07	N/A	N/A	NEUTRAL

Australia ranks highest, driven by the highest carry (+1.07) and value (+1.32) z-scores in the universe — reflecting its relatively high absolute yields and attractive real yield. The UK benefits from the highest CESI z-score (+1.08), indicating economic data disappointing relative to expectations, which is bullish for gilts. The US is short despite decent carry and value because its strongly negative CESI (−0.89) drags the composite down.

11. Limitations & Future Work

11.1 Limitations

6. Transaction Costs: The backtest does not include bid-ask spreads, futures roll costs, or margin costs. These would reduce returns, particularly given the monthly turnover.
7. Small Cross-Section: With N=6 countries (N=5 for CESI), z-scores are inherently noisy and rankings are coarse. The top-2/bottom-2 allocation is highly sensitive to small changes in composite scores.
8. Data Proxies: Germany uses 1Y as a 3M proxy and French breakeven for inflation. These introduce systematic biases in yield curve metrics and the Value signal.
9. Value Availability: Breakeven data only starts July 2014. Pre-2014 results are based on a reduced factor set, making full-sample metrics less representative.
10. Regime Sensitivity: The strategy produced near-zero returns for the entire 2010–2015 period (Sharpe −0.02), a decade-scale drawdown in opportunity cost terms.
11. FX Exposure: Momentum is computed on USD-converted TRIs, conflating bond momentum with currency momentum.
12. Equal Factor Weights: No dynamic weighting despite clear evidence of regime dependence in factor efficacy.
13. No Volatility Targeting: Equal dollar weights ignore that Japanese bonds are far less volatile than Australian bonds.

11.2 Future Work

- Dynamic factor weighting based on yield regime (tilt toward Carry in high-yield environments, toward Value in flat-curve environments).
- Volatility-targeting across countries to equalise risk contribution.
- FX-hedged momentum to isolate pure bond signal from currency effects.
- Expansion to additional countries as data becomes available (e.g., re-evaluate Sweden, Mexico if CESI and breakeven data improve).
- Out-of-sample testing on different maturity points (5Y, 30Y) following Brooks & Moskowitz's approach of testing across level, slope, and butterfly portfolios.

12. Conclusion

This report implements and extends the Brooks & Moskowitz (2017) framework for trading international government bonds using equity-style factors. Our key findings are:

1. Value dominates. With a standalone Sharpe of 0.39 and explaining 42.5% of composite strategy variance, real yield differentials are the most powerful signal in international bond markets. Value subsumes the Level principal component, consistent with Brooks & Moskowitz's finding that what matters is not the absolute level of yields but yields relative to a fundamental inflation anchor.

2. Style factors subsume the yield curve. Carry + Value + Momentum explain 49% of strategy returns (R^2 = 49%) while Level + Slope + Curvature explain 0.2% (R^2 = 0.2%). Alpha vanishes after controlling for style factors but survives fully after controlling for curve shape. This is the central result of our analysis, directly confirming Brooks & Moskowitz.

3. The strategy is regime-dependent. It delivers a Sharpe of 0.62 in high-yield environments and 0.84 when curves are flat/inverted, but essentially zero in the low-yield "boring middle" of 2010–2015. The composite adds zero alpha over its own factors — its value is drawdown diversification (−7.7% max DD vs −13% to −18% for individual factors), not signal combination alpha.

4. CESI provides marginal incremental value. Adding CESI increases R^2 from 49% to 55.6% and captures unspanned macro information, but as a standalone factor it loses money (−0.47% annualised). Its contribution is episodic — valuable during macro divergence periods, harmful during normal times.

The approach of treating bonds as equities — applying cross-sectional style factors rather than yield curve decompositions — provides a robust and intuitive framework for international bond allocation that connects government bond markets to the broader asset pricing literature.

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