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The Journal of Portfolio Management

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QUANTITATIVE STRATEGIES: *FACTOR INVESTING*

THIRD EDITION 2018

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Style premiums, or factor-based, investing has been applied in equity markets for over 20 years and has become increasingly popular, mainly in long-only applications (i.e., smart beta). Style investing has also been extended to long–short, market-neutral applications in several asset classes, including bonds, currencies, and commodities (Asness et al. [2015]). Still, style investing appears to have a smaller footprint in fixed income (FI) than in equities, both in the academic literature and in investment practice (for reference, a few of the limited number of papers include Brooks and Moskowitz [2017]; Houweling and van Zundert [2017], and Israel, Palhares, and Richardson [2018]).

FI markets are enormous. As of December 31, 2017, the Bloomberg Barclays Global Aggregate Index contained investment-grade-rated debt amounting to about $45 trillion. Inside this broad index are a variety of bonds issued by governments, government-related entities, and corporations, as well as asset-backed securities. Our purpose is to describe a general framework to measure well-known styles for both government and corporate bonds. These are large components of the global aggregate index (approximately 55% for government bonds and 20% for corporate bonds), and they have not been subject to much empirical analysis of cross-sectional determinants of excess returns.

We find that, despite the slower adoption of style investing in FI, well-established style premiums identified in other asset classes—value, momentum, carry, and defensive—could have enhanced returns in various FI markets over the past two decades. We demonstrate FI style investing efficacy with market-neutral country and maturity allocation strategies in global government bond markets and with individual issuer allocation strategies in U.S. corporate bond markets (our universe includes both investment-grade and speculative-grade, or high-yield, bonds). Using large samples of government and corporate bonds that span over 20 years of data, we find positive Sharpe ratios for all styles. For example, an equal risk allocation across the four well-known style premiums generates a gross Sharpe ratio of 0.98 (2.52) for a portfolio of government (corporate) bonds.

We further examine the diversifying potential of style-based FI portfolios for investors. First, we see strong evidence of low correlation across style portfolios both within and across government and corporate bonds. This is consistent with past research documenting the diversification benefit of investing across styles and across asset classes (see e.g., Asness, Moskowitz, and Pedersen [2013] and Asness et al. [2015]). Second, we see strong evidence that FI style portfolios can be built in such a way that they do not give exposure to traditional market risk (e.g., credit risk premium, equity risk premium, or term premium), nor do they give exposure to equity style portfolio returns (e.g., factors such as size, value, momentum, or quality within equity markets). Third, we see very little sensitivity of FI style portfolio returns to various macroeconomic state variables that are typically a concern for investors (e.g., shocks to inflation, shocks to economic growth, shocks to real yields, shocks to liquidity, and shocks to volatility) and meaningfully less sensitivity to these variables than the underlying asset classes themselves. These results are important because the excess returns of active FI managers as a group have substantial exposures to traditional market risk premiums, especially the credit risk premium (see, e.g., Mattu et al. [2016]; AQR Capital Management [2017]; Baz et al. [2017]).

Overall, our empirical analysis suggests a powerful role for style-based investing in FI. Although our analysis focuses on long–short academic style portfolios, we discuss potential implementation options. For fuller details of implementation challenges and optimized long-only portfolios in corporate bonds, please refer to Israel, Palhares, and Richardson [2018]. Common to both long–short and long-only implementations of style-based investing in FI is the low correlation between styles and the strategic style diversification benefit to an end investor. We find that both long-only style-tilted portfolios and long–short style portfolios have important uses, and the right allocation to the two approaches depends on investor constraints.

MEASURING STYLES IN FI

Style Definitions and Measures

There is an extensive literature in financial economics documenting robust evidence of a positive relation between value, momentum, carry, and defensive/quality styles and future asset returns across multiple asset classes (see, e.g., Koijen et al. [2018] for carry; Frazzini and Pedersen [2014] for quality; Asness, Moskowitz, and Pedersen [2013] for momentum and value; and Asness et al. [2015] for a combination of all four characteristics). With the exception of carry, this literature first focused on stock selection strategies and eventually found that these style premiums travel well to other domains and have generated long-run outperformance in several asset classes (stocks, bonds, currencies, and commodities) over the periods considered.

In this article, we apply style premiums to country and maturity selection across global government bond markets and to individual issuer selection across U.S. corporate credits. The results are closely related to two papers—by Brooks and Moskowitz [2017] and Israel, Palhares, and Richardson [2018]—which provide many extensions and further detail on style investing in government bond markets and corporate credit markets, respectively. The choice of measures we consider here mirror those in the original work of Brooks and Moskowitz [2017] and Israel, Palhares, and Richardson [2018]. Common to our choices for both government and corporate bonds is the desire to use simple and easily replicable measures.

Our style measures reflect the general intuition underlying the risk-based, mispricing and/or market-friction-based explanations that are typically provided as support for style-based investing (e.g., Asness et al. [2015]). However, we need to tailor the respective measures to reflect the returns and risks that matter for government and corporate bonds.

Value is the tendency for relatively cheap assets to outperform relatively expensive assets. Thus, for value portfolios we need a credible measure of fundamental value to compare against market prices. We measure market prices as yields in the case of government bonds and as credit spreads in the case of corporate bonds. For government bonds, we use real yield as our measure of value. Specifically, we compare nominal yields against maturity-matched inflation expectations. We use survey-based forecasts of inflation from Consensus Economics. Relative to their peers, government bonds with higher (lower) real yields are cheap (expensive). For corporate bonds, we compare credit-option-adjusted spreads against two fundamental anchors designed to capture the risk that the company may migrate to a poorer credit quality. Our first fundamental anchor is a structural model that measures the bond's distance to default, reflecting the number of standard deviations the asset value is away from the default threshold (for full details, please refer to Correia, Richardson, and Tuna [2012]). Our second fundamental anchor is an empirical model based on a regression of the spread on duration, rating, and return volatility (for full details, please refer to Israel, Palhares, and Richardson [2018]). In both cases, a corporate bond is deemed to be cheap (expensive) when the credit spread is high (low) relative to the respective fundamental anchor.[1]

Momentum is the tendency for an asset's recent performance to continue in the near future. Measures designed to reflect recent performance can be price and non-price based (see, e.g., Brooks [2017] for a discussion of non–price-based, or fundamental, measures of momentum within global macroasset classes). For the sake of simplicity, we only consider an asset's own momentum or that of a closely related asset. For government bonds, we use the prior 12-month excess return. For corporate bonds, we use an equal-weighted combination of the bond's prior 6-month credit excess returns and (for public issuers) the stock's prior 12-month returns.[2] Results are not sensitive to the choice of lagged 12-month excess credit returns, but we choose the prior 6 months to help increase data coverage.

Carry is the tendency for higher-yielding assets to outperform lower-yielding assets. The economic intuition is simple. Although value tends to profit if prices revert to fundamentals and momentum tends to profit if recent trends persist into the future, carry measures expected returns if nothing happens but for the passage of time (i.e., the shape of the risk-free and credit-term structure is unchanged). Ilmanen [2011] has provided a good summary of relevant literature here. In FI, carry (also known as *reaching for yield*) is a ubiquitous concept and one that is easily operationalized. For government bonds, we use the term *spread*, which is the simple difference between the bond's nominal yield and the local short-term yield, which measures the expected return to a government bond assuming the yield level remains unchanged. For corporate bonds, we use the bond's option-adjusted spread (OAS) versus Treasuries, as estimated by Bank of America Merrill Lynch, which measures the expected return to a corporate bond assuming the spread level remains unchanged.

Defensive or (*quality*) is the tendency of safer, lower-risk assets to deliver higher risk-adjusted returns than their low-quality, higher-risk counterparts. Measures of safety or high quality can be market based or fundamental based. For government bonds, we use effective duration as our measure. Although our other styles are applied across countries (they can be applied across maturities as well—see Brooks and Moskowitz [2017]), in this article, defensive is applied across maturities. Specifically, within each country, we buy short-dated bonds and sell a duration-equivalent amount of long-dated bonds. For corporate bonds, we also favor low duration, but we include two additional indicators based on profitability (gross profits over assets) and leverage (measured by the ratio of net debt to the sum of net debt and market equity).

Global Government Bond Data

Our sample of government bonds includes all bonds covered by the J.P. Morgan Government Bond Index (GBI). The GBI is a market-cap-weighted index of all liquid government bonds across 13 markets (Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, the United Kingdom, and the United States). It excludes securities with time to maturity (TTM) of less than 12 months, illiquid securities, and securities with embedded optionality (e.g., convertible bonds). We partition bonds in each country into three maturity buckets: 1–5-year TTM (short), 5–10-year TTM (medium), and 10–30-year TTM (long), weighting individual bonds by market cap within each. These country-maturity portfolios are the primitive assets we consider in our analysis.

We apply value, momentum, and carry styles across countries, whereas defensive is a pure maturity bet. That is, whereas value (likewise momentum and carry) favors countries with relatively high real yields, the defensive strategy favors shorter maturity bonds across all countries.

For value, momentum, and carry, we form country assets by taking an equal duration-weighted average across the three maturity buckets within each country. We then scale all country assets to have the same duration because we want to be sure we are making apples-to-apples comparisons when we apply our style measures across countries (i.e., comparing assets with the same duration risk). To form country-level style measures, we begin by forming style measures for each country-maturity bucket. Namely, for each country-maturity bucket, we compute real yield (yield minus maturity-matched inflation expectations), term spread (yield net of financing), and price momentum (past 12-month excess return). For each style, we combine the measures across maturities to come up with a country-level style factor, with each country-level style factor having the same overall duration.

At each point in time, the country style measures provide a ranking across the 13 country assets. For each style, at the beginning of each month, we form tercile portfolios of the country assets based upon their respective country style metrics. Country assets are equal-weighted in each tercile, and all returns are in excess of the local cash rate. We form long–short style portfolios by going long the third tercile (T3, most attractive) and short the first tercile (T1, least attractive) each month. Note that, because each country asset is constructed to have the same duration, the tercile portfolios, because they are equal-weighted averages across country assets, all have the same duration; the T3-T1 portfolios are, therefore, duration neutral. In other words, the long–short style portfolios should be neutral to an equal parallel shift across global yield curves.[3]

The defensive style in government bonds, as we have chosen to define it, is a pure maturity bet. The top tercile contains the short maturity bucket equal weighted across countries, and the bottom tercile contains the long maturity bucket equal weighted across countries. The T3-T1 portfolio is long short maturities and short long maturities, globally and in a duration-neutral, but dollar-imbalanced, manner. That is a curve steepener, with a larger notional short position on the shorter-dated bonds and smaller notional long position on the longer-dated bonds (see Frazzini and Pedersen [2014]).

Because we only use one indicator per style for government bonds here, we capture momentum only by each country's own past excess return. As discussed earlier, it is worth remembering that the momentum style is in many applications represented by both *own price momentum* and *fundamental momentum*. Similarly, the defensive style is often represented by both low-risk and high-quality proxies; here we only use short duration as a measure of low risk.

For our COMBO government bond portfolios, we equally weight across all four style measures (note that all of the underlying tercile portfolios are scaled to the same duration, so the style long–short portfolios all target similar levels of risk ex ante).

Corporate Bond Data

Our sample of U.S. corporate bonds includes both investment-grade and high-yield bonds. Investment-grade bonds are the constituents of the Bank of America Merrill Lynch U.S. Corporate Master Index (C0A0). High-yield bonds are the constituents of the Bank of America Merrill Lynch U.S. High Yield Master Index (H0A0). These two indexes represent the investable universe of U.S.-dollar-denominated investment-grade and high-yield corporate bonds publicly issued in the U.S. domestic market. We use corporate bond monthly returns and analytics (e.g., duration, option adjusted spread) from Bank of America Merrill Lynch. Monthly returns are computed based on daily end-of-day prices from Interactive Data Corporation. These returns are inclusive of default events. Corporate bond returns are in excess of key-rate duration exposures. The Bank of America Merrill Lynch bond analytics are computed using industry-standard methodology. We keep one bond (the most liquid) per issuer each month (more on this later). The typical cross section for our corporate bond analysis comprises an average of 1,300 bonds or firms (60% investment-grade and 40% high-yield) each month.

Following the criteria of Haesen, Houweling, and van Zundert [2013], we select a representative bond for each issuer every month. The criteria used for identifying the representative bond are selected so as to create a sample of liquid and cross-sectionally comparable bonds. Specifically, we select representative bonds on the basis of (1) seniority, (2) maturity, (3) age, and (4) size.

First, we filter bonds on the basis of seniority, limiting ourselves to only senior debt. We then select only the bonds corresponding to the most prevalent rating of the issuer. To do this, we first compute the amount of bonds outstanding for each rating category for a given issuer. We keep only those bonds that belong to the rating category that contains the largest fraction of debt outstanding; this category of bonds tends to have the same rating as the issuer. Next, we filter bonds on the basis of maturity. If the issuer has bonds with TTM between 5 years and 15 years, we remove all other bonds for that issuer from the sample. If not, we keep all bonds in the sample. We then filter bonds on the basis of time since issuance. If the issuer has any bonds that are at most two years old, we remove all other bonds for that issuer. If not, we keep all bonds from that issuer in the sample. Finally, we filter on the basis of size by picking the bond with the largest amount outstanding among the remaining bonds. The resulting bond is our attempt to identify a representative bond per issuer such that we have a sample of relatively liquid and cross-sectionally comparable bonds. As a deliberate consequence of our bond selection criteria, we will not be exploiting a liquidity premium (such as issue size) for our primary empirical analyses. Palhares and Richardson [2018] examined liquidity premiums in the cross section of corporate credit and found weak empirical support for its existence.

Corporate Bond Portfolio Construction

For corporate bonds, we form portfolios by first using the full set of measures within each style. For all styles except for carry and the duration component of defensive, we explicitly account for the beta exposure of each characteristic. As Israel, Palhares, and Richardson [2018] discussed, there is considerable cross-sectional variation in risk within credit markets, and failing to account for this can lead to erroneous inferences between a characteristic and future credit excess returns. For example, measures of value compare credit spreads to a fundamental measure of default risk. Such a measure will inherit a direct correlation with credit spread, which in turn is directly related to the credit risk premium. To help mitigate this effect, we adjust each style measure by the average style measure of bonds with similar ex ante beta (note that this is conceptually analogous to our duration adjustment for government bonds). We use spread duration times credit spread (DTS) as a measure of beta for the purpose of this adjustment (see, e.g., Ben Dor et al. [2007]). We do this by subtracting the average style measure for the respective DTS quintile each month. We do not use this approach for carry or duration because they explicitly capture risks embedded in the credit risk premium. We want our other style measures to be orthogonal to carry and low duration (and hence credit beta). This choice is similar in spirit to how Fama and French [1993] constructed high minus low (HML) and small minus big (SMB) to be uncorrelated to each other, which facilitates an easier analysis of marginal contribution across factors.

For our analysis of quintile portfolios for each style, we rank all corporate bonds on the relevant set of style measures (e.g., short duration, low leverage, and high profitability for defensive). This gives a continuous measure of the attractiveness of each bond each month. For the quintile portfolios reported in Exhibit 1, Panel B, we use the overall rank to sort bonds into five equal-sized portfolios and value weight corporate bond excess returns within each quintile. For the long–short style portfolios considered in the remaining empirical analysis, we construct zero-cost, constant-volatility portfolios. To do so, we follow Asness, Moskowitz, and Pedersen [2013], and for each signal, we weight each bond proportionally to its signal rank minus the cross-sectional average of that signal. This makes full use of the information content of the respective style score. We scale weights for each long–short style portfolio such that it has an ex ante volatility of 5%, using realized volatility over the prior 24 months. This choice helps ensure that any style with higher volatility will not dominate any across factor comparison.

For our COMBO corporate bond portfolios, we allocate an equal amount of risk across the four long–short style portfolios. Again, we use information from the prior 24 months for the purpose of determining risk levels for each style portfolio.

RESULTS

FI Long–Short Style Portfolio Returns

We start with the evidence on the returns of single-style-sorted long-only portfolios: tercile portfolios for governments and quintile portfolios for corporates. The choice of three portfolios for government bonds versus five portfolios for corporates reflects the narrower cross section: 13 countries compared to approximately 1,300 corporates. For governments, bonds within each bucket are equal weighted; for corporates, they are value weighted. Our results are unaffected by equal weighting within corporate bond portfolios, but we prefer the value-weighting choice as an attempt to incorporate liquidity and the cost of trading into the analysis (Palhares and Richardson [2018] noted that larger bonds tend to have higher daily trading volumes and tighter bid–ask spreads). All returns used in this report are gross of trading costs and fees. Government bond returns are in excess of cash, whereas corporate bond returns are in excess of key-rates-duration-matched Treasuries to isolate the credit component of corporate bond returns from the embedded interest component.

Panels A and B of Exhibit 1 report portfolio statistics for government and corporate bonds, respectively. In each panel, the rows are broken into blocks of three, with the first sub-row reporting the annualized average return (μ), the second sub-row reporting the annualized standard deviation (σ), and the third sub-row reporting

EXHIBIT 1
Quintile/Tercile Portfolio Performance for FI Style Portfolios

Panel A: Government Bonds

		T1	T2	T3
Value	μ	3.35%	4.07%	5.42%
	σ	3.88%	4.40%	5.06%
	Sharpe	0.87	0.92	1.07
Momentum	μ	3.89%	4.18%	5.14%
	σ	4.72%	4.25%	4.89%
	Sharpe	0.82	0.98	1.05
Carry	μ	3.48%	4.14%	4.84%
	σ	4.25%	4.34%	4.76%
	Sharpe	0.82	0.95	1.02
Defensive	μ	3.79%	4.61%	4.83%
	σ	4.17%	4.47%	4.31%
	Sharpe	0.91	1.03	1.12
COMBO	μ	2.94%	4.24%	6.17%
	σ	3.87%	4.36%	4.99%
	Sharpe	0.76	0.97	1.24

Panel B: Corporate Bonds

		Q1	Q2	Q3	Q4	Q5
Value	μ	–0.52%	0.90%	2.26%	2.71%	3.84%
	σ	5.49%	5.95%	6.25%	6.54%	5.94%
	Sharpe	–0.09	0.15	0.36	0.41	0.65
Momentum	μ	–0.27%	1.46%	1.56%	2.01%	3.10%
	σ	7.50%	5.68%	5.30%	5.38%	6.30%
	Sharpe	–0.04	0.26	0.29	0.37	0.49
Carry	μ	–0.18%	1.26%	1.71%	3.90%	3.99%
	σ	2.88%	4.38%	6.57%	8.68%	13.89%
	Sharpe	–0.06	0.29	0.26	0.45	0.29
Defensive	μ	0.03%	1.69%	1.77%	2.48%	3.20%
	σ	6.17%	5.84%	6.17%	6.46%	5.17%
	Sharpe	0.01	0.29	0.29	0.38	0.62
COMBO	μ	–0.65%	1.10%	1.79%	3.02%	5.37%
	σ	5.75%	5.70%	6.14%	6.85%	6.02%
	Sharpe	–0.11	0.19	0.29	0.44	0.89

Notes: This exhibit reports summary statistics for respective FI long-only style portfolios from January 1996 through June 2017 inclusive. See text for more detail.

the Sharpe ratio. The final set of rows is the equal risk allocation across the four style measures (COMBO). In both Panels A and B, there is a clear monotonic pattern in Sharpe ratios when moving from the least to most attractive style portfolio, particularly so for the COMBO portfolio. The one exception to this pattern is for carry for the corporate bond portfolios. Corporate

EXHIBIT 2
Long–Short Portfolio Performance for FI Style Portfolios

	Value	Momentum	Carry	Defensive	COMBO
Panel A: Government Bonds					
μ	2.54%	1.34%	2.21%	1.04%	3.23%
σ	3.92%	4.26%	3.90%	2.74%	3.32%
Sharpe	0.65	0.31	0.57	0.38	0.98
ρ	0.14	0.07	0.12	–0.10	0.14
α	2.02%	1.06%	1.79%	1.30%	2.80%
t-stat	2.37	1.14	2.10	2.18	3.89
Panel B: Corporate Bonds					
μ	11.58%	7.58%	1.01%	8.62%	15.90%
σ	5.99%	6.56%	5.74%	6.32%	6.31%
Sharpe	1.93	1.16	0.18	1.36	2.52
ρ	0.02	–0.30	0.82	–0.47	–0.09
α	11.55%	8.15%	–0.34%	9.48%	16.06%
t-stat	8.75	5.91	–0.47	7.71	11.61

Notes: This exhibit reports summary statistics for FI long–short style portfolios from January 1996 through June 2017 inclusive. See text for more detail.

bonds, with wider credit spreads, earn higher average returns than those with the tightest spreads, but the volatility of credit excess returns dampens the risk-adjusted return earned by an investor for this carry exposure.

We next compute long–short FI style portfolios for government and corporate bonds using the methods described earlier in this section. In Exhibit 2, we report the annualized average return (μ), annualized standard deviation (σ), and Sharpe ratios for each style portfolio. We also report the correlation (ρ) of each long–short style portfolio return to the respective market return, the intercept (α), and the associated test-statistic (*t*) from a one-factor market model (a portfolio of government bonds is the market for our government bond style portfolios, and a portfolio of corporate bonds is the market for our corporate bond style portfolios). The final column reports the same set of statistics for the equal-risk-weighted COMBO portfolio that reflects exposure to all four style portfolios. Panel A (B) reports statistics for government (corporate) bonds separately.

Panel A of Exhibit 2 shows that, for government bonds, all styles performed well, whether measured by Sharpe ratio or alpha to the cap-weighted J.P. Morgan government bond index. The one exception is the insignificant alpha for the momentum style portfolio.

Among single styles, the value style offered the highest average return, Sharpe ratio, and alpha. Thanks to diversification, the COMBO offered an even higher Sharpe ratio of 0.98. Diversification across style premiums is so effective because the average pairwise correlation across the four respective long–short style portfolios is close to zero (see Panel A of Exhibit 3).

Turning to corporate bonds, Panel B of Exhibit 2 shows that all style premiums earned positive Sharpe ratios and most had positive alphas. The notable exception is the insignificant alpha for carry, which is not surprising because carry is directly related to the credit risk premium. From Exhibit 1, we saw that value and carry styles had comparable returns across quintiles, but carry was more volatile. As a consequence, when examining the constant-volatility, long–short portfolios in Exhibit 2, we see that the returns and Sharpe ratio for carry is an order of magnitude lower than value (e.g., the Sharpe ratio for value is 1.93, and that for carry is only 0.18). Carry also has a high correlation (0.90) with the credit market, reducing its stand-alone diversification benefits. The Sharpe ratios for corporate bond long–short style portfolios are exceptionally high, but it should be noted that the returns here are all gross of trading costs. Trading costs for corporate bonds are substantial, especially relative to their underlying volatility (see, e.g., Israel, Palhares, and Richardson [2018] for a detailed discussion). These trading costs can be significant and could compromise an investor's ability to access these style returns in a real-world portfolio; we return to this implementation challenge in the last section of our article. Of note is the relative improvement in Sharpe ratio from an equal risk allocation across the four style themes, with the COMBO portfolio having a Sharpe ratio of 2.52. Just as we see in government bonds and in other asset classes, the four styles tend to provide excellent diversification to one another, with the average pairwise correlations across style portfolios close to zero (see Panel B of Exhibit 3).

A small discussion on the efficacy of carry as a style within corporate bond portfolios is necessary at this point. If we assess the relative attractiveness of the four styles within corporate credit, clearly carry is the least attractive of the four. Furthermore, after accounting for the credit beta, the returns for a carry exposure seem to disappear. Should investors seek to have carry within their portfolio? First, exposure to carry is an efficient way to offset the lower beta introduced from the preference for shorter-dated bonds within the defensive style (remember that duration is one of our defensive measures for corporate bonds). Thus, in a COMBO portfolio, it can be easier to achieve a beta-balanced portfolio. Second, as discussed by Israel, Palhares, and Richardson [2018], an allocation to carry can help diversify the overall portfolio across macroeconomic regimes. This is because exposures to value, momentum, and defensive themes perform marginally better in periods of negative shocks to economic growth and positive shocks to volatility.

Panel A of Exhibit 3 displays the correlations between the different government bond long–short style portfolios. The largest correlation is between carry and value. Although both styles incorporate yields in their computation (carry is the difference between longer-term yields and short rates, and value is the difference between yields and duration-matched inflation expectations), they are still meaningfully different. The lowest correlation is between momentum and carry, which is also intuitive: Bond markets that have outperformed tend to have relatively flatter term structures. Momentum is also meaningfully negatively correlated with value, as documented by Asness, Moskowitz, and Pedersen [2013].

Panel B of Exhibit 3 shows the style portfolio correlations for corporate bonds. Here, it is important to remember that for all styles, with the exception of carry, the portfolio construction methodology accounts for difference in betas (see the "Corporate Bond Portfolio Construction" section for more details). The highest correlation here is between defensive and momentum. The correlation is intuitive: The defensive style goes long the bonds issued by low-market-leverage, highly profitable firms. It is not surprising that firms whose equity and debt have done well recently will end up with lower leverage and higher profits. The two lowest correlations are between carry and momentum and carry and defensive. Bonds issued by stronger firms that have done well recently tend to have lower credit spreads.

The main results are that all style premiums had positive Sharpe ratios for government and corporate bonds, the style premiums had low correlation with each other, and their combination had low correlation with relevant market indexes, providing valuable diversification benefits. Diversifying across FI segments (i.e., capturing style exposures across government bonds and corporate bonds within the same portfolio) would potentially raise risk-adjusted returns further, but we do not pursue that avenue here (see Asness, Moskowitz, and Pedersen [2013] for an example of the diversification benefit of style exposures across asset classes).

We remind readers again that the results shown are gross of trading costs and fees. This is especially important for corporate bonds because trading costs are relatively high and shorting can be hard. Note, however, that Israel, Palhares, and Richardson [2018] explicitly examined whether a long-only portfolio can be constructed with optimal exposure to styles while also respecting the challenges of trading corporate bonds. They found that, even after explicitly accounting for trade sizes, turnover constraints, and expected costs to trade, it was possible to implement a long-only corporate bond strategy with a Sharpe ratio of 1.03 and an information ratio of 0.86 net of assumed realistic trading costs. Readers will also note the relatively higher gross Sharpe ratios for corporate bond style portfolios relative to government bond style portfolios. A large part of that difference will be attributable to the differential trading costs between corporate bonds and government bonds (corporate bonds being considerably higher), but a portion of that difference is also attributable to the difference in breadth. Each month, we have around 1,300 corporate issuers from which to choose, whereas we only have 13 sovereign entities. As discussed by Brooks and Moskowitz [2017], breadth in a government bond portfolio could be enhanced by extending style views to the shape of the yield curve, such as flatter/steeper views and/or curvature views.

How Diversifying are FI Style Portfolios?

In the previous section, we established that FI style portfolios have positive Sharpe ratios, but that alone is not enough to justify their relevance for investors' portfolios. A related question is whether those positive risk premiums are due to exposures that investors can already obtain through other investments or whether they are unique to the FI portfolios that we study here. For example, does the value factor in credit deliver its positive risk-adjusted returns through a positive exposure to well-known risk premiums such as the equity risk premium or the value-minus-growth premium in the cross section of stocks?

To answer that question, we examine the exposure of FI style long-and-short returns to three prominent

EXHIBIT 3

Correlation Structure across Long–Short FI Style Portfolios

	Value	Momentum	Carry	Defensive
Panel A: Government Bonds				
Value	1			
Momentum	–0.32	1		
Carry	0.51	–0.42	1	
Defensive	0.21	–0.22	0.15	1
Panel B: Corporate Bonds				
Value	1			
Momentum	–0.27	1		
Carry	0.13	–0.43	1	
Defensive	0.25	0.47	–0.49	1

Notes: This exhibit reports correlations for FI long-and-short style portfolios from January 1996 through June 2017 inclusive. See text for more detail.

market risk premiums and to equity styles. For traditional market risk premiums, we examine (1) the credit risk premium (CRP), measured as the returns of a market-cap-weighted portfolio of corporate bonds in excess of duration-matched treasuries; (2) the equity risk premium (ERP), measured as the excess (of T-bill) returns of the S&P 500; and (3) the bond term premium (TP), measured as the return of 10-year bond future over the risk-free rate. For equity styles, we examine the size (SMB), value (HML), and momentum (up minus down [UMD]) portfolios from Ken French's data library as well as the QMJ portfolio from the AQR data library (Asness, Frazzini, and Pedersen [2014]). Exhibit 4 reports the results of time-series regressions in which we project the various FI long–short style portfolio returns (STYLE) onto the traditional market risk premiums and equity style factor returns described earlier. Specifically, we run the following regression using monthly data over the period January 1997 through July 2017 inclusive for government (corporate) bonds:

$$\begin{aligned} STYLE_{i,t} &= \alpha + \beta_{CRP} CRP_t + \beta_{ERP} ERP_t + \beta_{TP} TP_t \\ &\quad + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{UMD} UMD_t \\ &\quad + \beta_{QMJ} QMJ_t + \varepsilon \end{aligned}$$

Panel A of Exhibit 4 contains the results of time-series regressions of government bond long–short style portfolio returns. Value has no significant exposures to

Exhibit 4

FI Style Loadings on Markets and Equity Styles

Panel A: Government Bonds

	Value	Momentum	Carry	Defensive	COMBO-4
α	1.17%	0.86%	2.13%	1.53%	2.40%
	[1.3]	[0.9]	**[2.3]**	**[2.3]**	**[3.0]**
β_{CRP}	0.03	–0.04	0.15	–0.06	0.05
	[0.4]	[–0.6]	**[2.5]**	[–1.4]	[1.0]
β_{ERP}	0.04	0.01	–0.02	–0.04	–0.01
	[1.5]	[0.6]	[–0.9]	**[–2.7]**	[–0.4]
β_{TP}	0.05	0.02	0.10	–0.05	0.06
	[1.3]	[0.5]	**[2.6]**	[–1.7]	[1.6]
β_{SMB}	0.00	0.01	–0.05	0.00	–0.01
	[0.1]	[0.4]	**[–2.0]**	[0.2]	[–0.4]
β_{HML}	–0.01	0.01	0.03	0.00	0.01
	[–0.5]	[0.4]	[1.4]	[0.0]	[0.3]
β_{UMD}	–0.01	0.04	–0.01	–0.02	0.00
	[–0.4]	**[2.5]**	[–0.8]	**[–2.0]**	[–0.1]
β_{QMJ}	–0.01	0.01	–0.05	–0.01	–0.01
	[–0.2]	[0.2]	[–1.4]	[–0.5]	[–0.4]
R^2	4%	4%	8%	8%	1%
Sharpe	0.31	0.22	0.58	0.57	0.74

Panel B: Corporate Bonds

	Value	Momentum	Carry	Defensive	COMBO
α	13.29%	7.03%	0.44%	9.98%	17.13%
	[9.2]	**[4.7]**	[0.6]	**[7.4]**	**[11.2]**
β_{CRP}	0.10	–0.38	0.68	–0.46	–0.17
	[1.0]	**[–3.8]**	**[12.8]**	**[–5.1]**	[–1.7]
β_{ERP}	–0.12	0.09	0.02	–0.06	–0.02
	[–3.5]	**[2.4]**	[1.0]	[–1.7]	[–0.5]
β_{TP}	0.00	–0.10	–0.07	–0.10	–0.17
	[–0.1]	[–1.5]	**[–2.0]**	[–1.7]	**[–2.5]**
β_{SMB}	–0.07	0.03	0.01	0.02	0.01
	[–1.6]	[0.6]	[0.3]	[0.5]	[0.2]
β_{HML}	–0.04	0.03	–0.01	–0.01	–0.01
	[–1.1]	[0.8]	[–0.5]	[–0.4]	[–0.4]
β_{UMD}	–0.01	0.06	–0.01	–0.02	0.02
	[–0.2]	**[2.6]**	[–0.5]	[–0.7]	[0.9]
β_{QMJ}	–0.14	0.11	–0.06	0.05	–0.03
	[–2.5]	[1.8]	**[–2.0]**	[0.9]	[–0.5]
R^2	6%	15%	69%	25%	4%
Sharpe	2.29	1.16	0.14	1.83	2.78

Notes: This exhibit reports time-series regressions of the long–short FI style portfolio on market and equity styles. See text for more detail.

$$
\begin{aligned}
STYLE_{i,t} = \alpha &+ \beta_{CRP} CRP_t + \beta_{ERP} ERP_t \\
&+ \beta_{TP} TP_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t \\
&+ \beta_{UMD} UMD_t + \beta_{QMJ} QMJ_t + \varepsilon
\end{aligned}
$$

The bold numbers indicate that the coefficients are statistically significant at the 5% significance level.

any market or style returns, but the alpha falls to an annualized 1.17% after controlling for market and equity style exposures. Momentum in government bonds is somewhat correlated with momentum in equities, as evidenced by the positive loading on UMD. Carry in government bonds has a small exposure to both CRP and TP and a small negative exposure to size. Finally, defensive in government bonds has a negative exposure to both the equity risk premium and UMD. Given the low average pairwise correlation across the various government bond style portfolios (from Panel A of Exhibit 3), the equal-risk-weighted combination portfolio, COMBO, has no significant exposure to any traditional market risk premiums or equity alternative risk premiums: It is a highly diversified and well-compensated portfolio, as evidenced by the significant intercept. Across all styles and the COMBO portfolio, R^2 is extremely low, indicating return variability in government bond styles is mostly unexplained by traditional market risk premiums and equity style returns.

Panel B of Exhibit 4 shows the results of regressions of corporate bond long–short style portfolio returns. Value is negatively exposed to the stock market and to QMJ; these exposures explain only 6% of its return variability, and the alpha (intercept) remains highly statistically significant. Momentum is negatively exposed to CRP and positively exposed to both ERP and UMD, with its alpha (intercept) highly significant and only 15% of its return variability explained by these risk premiums. Carry, unsurprisingly, has a large, positive, and highly significant exposure to the credit market. It has much smaller and negative but marginally significant exposures to the term premium and the equity quality factor. Its alpha is not statistically significant after controlling for exposure to CRP. Defensive has a negative exposure to CRP and a highly significant alpha. As we saw with government bonds, due to the low average pairwise correlation across the various corporate bond style portfolios (from Panel B of Exhibit 3), COMBO has very muted exposures to traditional market risk premiums (small and negative to TP) and no significant exposures to equity style returns. This is an important aspect of diversification: Although corporate bond returns are structurally related to stock returns (they are related claims in the capital structure of firms), differences in firms that have liquid credit and equity and differences in measures we use to identify style themes across credit and equity instruments mean that a potentially diversifying set of returns is available to investors via credit style portfolios. This difference between equity and credit returns is also evident at the index level (see, e.g., Asvanunt and Richardson [2017]).

What Macroeconomic Sensitivities Do FI Style Portfolios Contain?

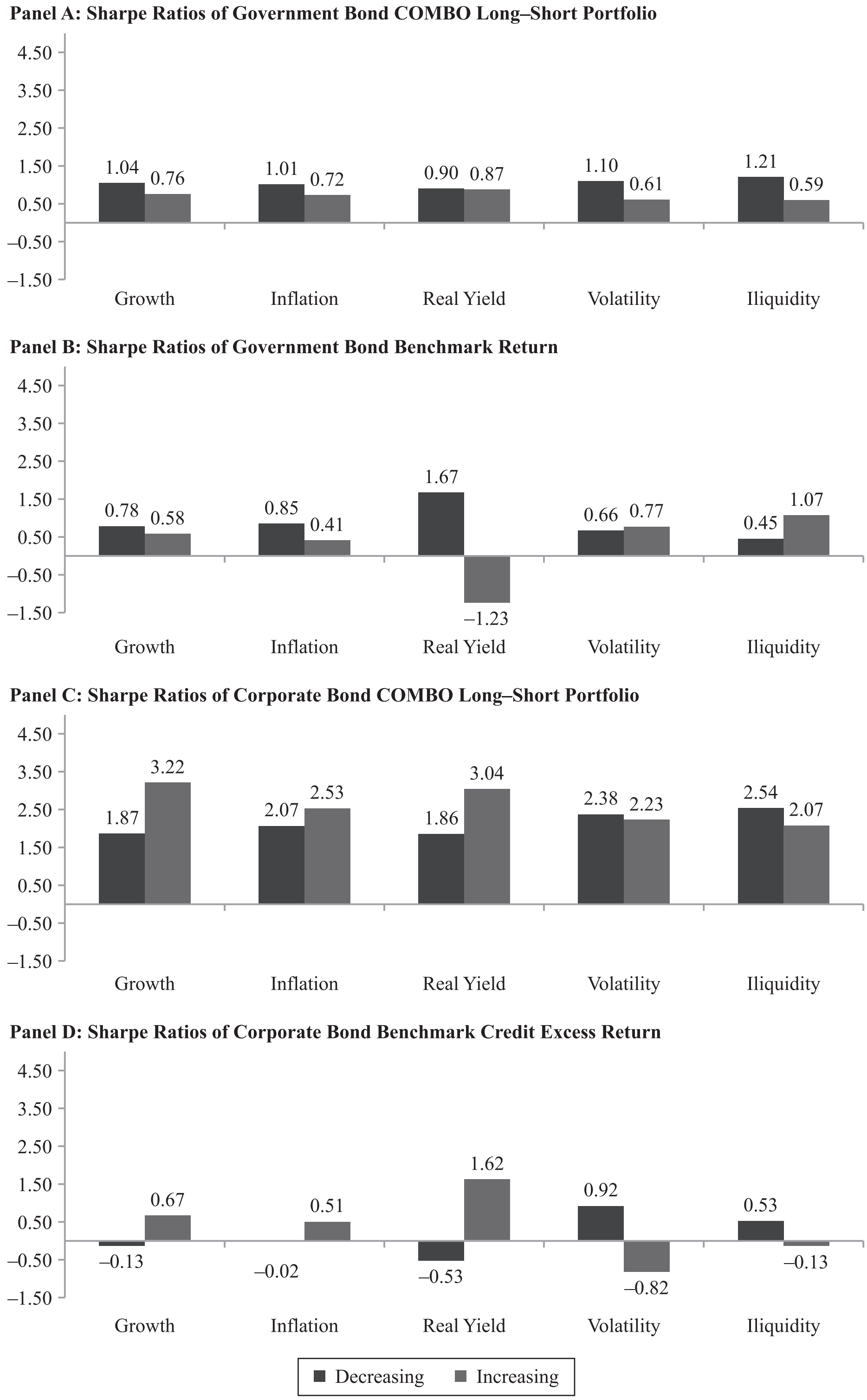
We next examine the Sharpe ratios of FI style portfolios over various macroeconomic environments. Specifically, we decompose the sample according to measures of growth, inflation, real yield, volatility, and illiquidity. We split our sample of data for government (corporate) bonds into 82 nonoverlapping calendar quarterly periods for the period January 1997 through June 2017. For each of the five macroeconomic variables, we assign quarters into increasing or decreasing bins, and then we assess the return profile of our FI long–short style portfolios across each bin. We focus on changes because we want to understand the sensitivity of style returns to shocks in macroeconomic and financial conditions (i.e., how style portfolios react to new information). That said, we must caution against reading too much into this analysis because we only have about 20 years of data (due to data limitations for reliable historical market returns data for government and corporate bonds).

We first define how we measure changing expectations across the five macroeconomic variables. For economic growth we measure the quarterly revision in the one-year-ahead median real U.S. gross domestic product growth forecast as captured by Consensus Economics. The inflation shock is the quarterly revision in one-year-ahead U.S. Consumer Price Index inflation forecast. Change in real yields is measured as the quarterly change in the real 10-year bond yield, where the real 10-year bond yield is the difference between the yield on the 10-year benchmark bond from Bloomberg and the 10-year inflation expectation from Consensus Economics. For volatility, we average the normalized quarterly changes in bond (MOVE) and equity (VIX) volatility indexes. Finally, for liquidity, we measure the quarterly change in the TED spread (the spread between three-month T-bill rates and the London Interbank Offered Rate). We have chosen simple and intuitive indicators of macroeconomic and financial market shocks. One can certainly argue about alternative measures and alternative methods to identify shocks in our selected measures.

Panels A and B of Exhibit 5 show the Sharpe ratios of government bond style portfolios (Panel A) and a government bond benchmark market portfolio (Panel B) across the increasing and decreasing quarters across the five macroeconomic variables. In Panel B, it is clear that a benchmark government bond portfolio does poorly when real yields rise; over this 20-year period, government bond portfolios benefitted from periods of illiquidity (flight to safety) and, to a lesser extent, suffered during periods of increasing expectations of growth and inflation. In contrast, the patterns for government bond style portfolios are significantly more muted, showing little sensitivity to macroeconomic or financial market shocks, particularly for changing expectations of growth and inflation and across rising/falling real yield periods.

Panels C and D of Exhibit 5 display similar sets of results for corporate bond style and benchmark portfolios. In Panel C, it is clear that a benchmark portfolio of corporate bonds has the expected exposures to growth and volatility. Asvanunt and Richardson [2017] noted that the credit risk premiums are higher in periods of stronger economic growth and lower aggregate default rates (which is correlated with market volatility). The strong differential performance of the benchmark corporate bond portfolio across rising and falling real yield environments is interesting and is likely a direct manifestation of the strong negative correlation between stock returns and government bond returns over the last 20 or so years (remember that the returns we are considering here are excess of interest rate exposures). As we saw for government bond style portfolios in Panel C of Exhibit 4, we see that corporate bond style portfolios perform consistently well across different macroeconomic periods. In unreported analyses, we find that the only statistically significant difference in Sharpe ratios is across periods of economic growth. However, this difference in Sharpe ratios is due to the difference in volatility across style portfolios, not a difference in returns: Corporate bond returns are more volatile in periods of low economic growth. For complete details on the sensitivity of corporate bond long–short style portfolios to macroeconomic regimes, please see Israel, Palhares, and Richardson [2018]. They performed single and multiple regression analysis using a similar set of macroeconomics variables and found that a COMBO portfolio with exposures to all four styles has less than 20% of its return variation

EXHIBIT 5
Macroeconomic Sensitivities for FI Style Long–Short Portfolios



Notes: This exhibit reports macroeconomic sensitivities of FI style long–short portfolios from January 1997 through June 2017. See text for more detail.

explained by a combination of traditional market risk premiums, equity style and returns, and macroeconomic variables.

Overall, whereas the underlying credit and government bond benchmark portfolios inherit well-known and understood exposures to macroeconomic variables, the multistyle portfolios have a much reduced set of macroeconomic sensitivities. This is a potentially welcome source of diversification for investors in FI, where the typical active FI manager's active returns are largely explained by well-known market risk premiums (see, e.g., Mattu et al. [2016] and Baz et al. [2017]). A well-balanced set of style exposures within FI can offer investors a set of excess returns without traditional market risk exposures and reduced macroeconomic sensitivity. This is intuitive because the FI style portfolios are designed to be neutral with respect to traditional market risk premiums (e.g., term premiums for government bonds and credit risk premiums for corporate bonds).

Discussion: How to Capture Styles in an FI Portfolio

We have presented academic style backtested long–short FI style portfolio returns. A natural question is whether these academic portfolio returns could be captured in a traditional long-only benchmark-aware FI portfolio. Israel, Palhares, and Richardson [2018] examined this issue directly in the context of corporate bonds, but we remind readers that capturing FI style premiums is a nontrivial task due to a combination of data quality issues and liquidity challenges in FI markets.

Another implementation decision is between single-style and multistyle investing and, if the latter, between hiring specialist single-style managers or integrated multistyle managers. We firmly favor an integrated multistyle approach for its better diversification and efficiency. As noted by Fitzgibbons et al. [2017], in the context of equity portfolios, integrating multiple well-compensated themes into one portfolio rather than combining single style portfolios generates a superior after-trading-cost portfolio. FI securities, especially corporate bonds, are even more expensive to trade, strengthening our belief in an integrated multistyle portfolio approach.

Finally, style investing can be applied through long-only tilts or through long–short strategies. Both can make sense. Long–short strategies provide better diversification, but investor constraints and limited shorting ability/capacity may make the long-only path more realistic for many investors.

CONCLUSION

Style investing has become quite popular in stock selection and has been gradually gaining popularity in multi-asset-class investing, but this adoption has not carried over to FI. The ideas behind style investing travel well across asset classes and, as shown empirically here, appear to have similar efficacy for both government bonds and corporate bonds over the past two decades.

A well-diversified style-oriented strategy serves as both a return-enhancer—which is especially important in today's low-yield world—and as a portfolio diversifier, thanks to the documented low or negative correlations between style premiums and market premiums and the low sensitivity to macroeconomic and financial market environments.

ENDNOTES

We thank Andrea Eisfelt, Tony Gould, Antti Ilmanen, Ronen Israel, Toby Moskowitz, and Rodney Sullivan for helpful discussion and comments.

[1]For value, momentum, and defensive in corporate bonds, we employ multiple measures. This is in contrast to government bonds, for which we opt for a single measure. The driving factor behind this decision is that, for corporates, we want to be sure to include measures that we are able to construct for non–publicly traded companies in addition to bonds issued by publicly traded entities. For example, our structural fair value measure requires certain inputs not readily accessible for nonpublic companies, but our empirical fair value measure—because it only consumes duration, rating, and return volatility—can be constructed for all companies within our cross section.

[2]Fundamental momentum refers to the empirical ability of certain fundamental indicators or news (firm-specific news on a single security or macronews on a country) to predict future asset returns. News that moves the market contemporaneously often also predicts market moves mildly in the same direction in later weeks or months—an apparent underreaction effect. For example, negative growth and inflation surprises tend to boost government bond prices instantly, but they also predict positive future performance. The best-known

fundamental momentum indicators are earnings momentum (and analyst forecast revisions in stock selection), but the concept applies elsewhere (see, e.g., Abarbanell and Bernard [1992] and Brooks et al. [2014]). Fundamental momentum may also be proxied by related assets' past returns; for example, when equity returns are used to predict future bond returns (positively for corporates, inversely for governments).

[3]Although the T3–T1 portfolio is duration neutral, it need not be beta neutral.

REFERENCES

Abarbanell, J.S., and V.L. Bernard. "Tests of Analysts' Overreaction/Underreaction to Earnings Information as an Explanation for Anomalous Stock Price Behavior." *The Journal of Finance*, Vol. 47, No. 3 (1992), pp. 1181–1207.

AQR Capital Management. "The Illusion of Fixed Income Diversification." AQR Alternative Thinking, 4Q (2017).

Asness, C.S., A. Frazzini, and L.H. Pedersen. "Quality Minus Junk." Working paper, AQR, 2014.

Asness, C.S., A. Ilmanen, R. Israel, and T.J. Moskowitz. "Investing with Style." *Journal of Investment Management*, Vol. 13, No. 1 (2015), pp. 27–63.

Asness, C.S., T.J. Moskowitz, and L.H. Pedersen. "Value and Momentum Everywhere." *The Journal of Finance*, Vol. 68, No. 3 (2013), pp. 929–985.

Asvanunt, A., and S. Richardson. "The Credit Risk Premium." *The Journal of Fixed Income*, Vol. 26, No. 3 (2017), pp. 6–24.

Baz, J., R. Mattu, J. Moore, and H. Guo. "Bonds Are Different: Active versus Passive Management in 12 Points." PIMCO Quantitative Research, 2017.

Ben Dor, A., L. Dynkin, J. Hyman, P. Houweling, E. Van Leeuwen, and O. Penniga. "DTS (Duration Times Spread)." *The Journal of Portfolio Management*, Vol. 33, No 2 (2007), pp. 77–100.

Brooks, J. "A Half Century of Macro Momentum." Working paper, AQR Capital Management, 2017.

Brooks, J., A. Frieda, D. Kupersmith, and L.N. Nielsen. "Building a Better Global Macro Portfolio." White paper, AQR, 2014.

Brooks, J., and T.J. Moskowitz. "Yield Curve Risk Premia." Working paper, AQR, 2017.

Correia, M., S. Richardson, and İ. Tuna. "Value Investing in Credit Markets." *Review of Accounting Studies*, Vol. 17, No. 3 (2012), pp. 572–609.

Fama, E., and K. French. "Size and Book-to-Market Factors in Earnings and Returns." *The Journal of Finance*, Vol. 50 (1993), pp. 131–155.

Fitzgibbons, S., J. Friedman, L. Pomorski, and L. Serban. "Long-Only Style Investing: Don't Just Mix, Integrate." White paper, AQR, 2017.

Frazzini, A., and L. H. Pedersen. "Betting against Beta." *The Journal of Financial Economics*, Vol. 111 (2014), pp. 1–25.

Haesen, D., P. Houweling, and J. van Zundert. "Residual Equity Momentum for Corporate Bonds." Working paper, Robeco Quantitative Strategies, 2013.

Houweling, P., and J. van Zundert. "Factor Investing in the Corporate Bond Market." *Financial Analysts Journal*, Vol. 73 (2017), pp. 100–115.

Ilmanen, A. *Expected Returns*. Hoboken, NJ: Wiley, 2011.

Israel, R., D. Palhares, and S. Richardson. "Common Factors in Corporate Bond Returns." *Journal of Investment Management*, (2018), forthcoming.

Koijen, R.S.J., T.J. Moskowitz, L.H. Pedersen, and E.B. Vrugt. "Carry." *Journal of Financial Economics*, Vol. 127, No. 2 (2018), pp. 197–225.

Mattu, R., M. Devarajan, S. Sapra, and D. Nikalaichyk. "Fixed Income Manager Selection: Beware of Biases." PIMCO Quantitative Research, 2016.

Palhares, D., and S. Richardson. "(Il)liquidity Premium in Credit Markets: A Myth?" Working paper, AQR Capital Management, 2018.

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