Factor Investing in the Corporate Bond Market

Patrick Houweling[a,b], Jeroen van Zundert[a,c]

November 2014

We provide empirical evidence that the Size, Low-Risk, Value and Momentum factors have economically meaningful and statistically significant risk-adjusted returns in the corporate bond market. Since the factors capture different effects, a combined multi-factor portfolio halves the tracking error compared to the individual factors. The returns are up to three times larger than the market, and cannot be explained by risk or the equivalent equity factors. The results are robust to transaction costs, alternative factor definitions and the specific portfolio construction settings. Finally, allocating to corporate bond factors has added value beyond allocating to equity factors in a multi-asset context.

JEL Classification: G11; G12; G14

EFM Classification: 310; 340; 350; 570

Keywords: corporate bonds, factor premiums, strategic asset allocation, size, low-risk, value, momentum

---

[a] Robeco Quantitative Strategies, Coolsingel 120, 3011 AG Rotterdam, The Netherlands. Views expressed in the paper are the authors' own and do not necessarily reflect those of Robeco. The authors thank Paul Beekhuizen, David Blitz, Bernhard Breloer, Winfried Hallerbach, Georgi Kyosev, Simon Lansdorp, Martin Martens and Pim van Vliet for feedback on an earlier version of this paper. Any remaining errors are the authors' own.

[b] p.houweling@robeco.com, +31-10-224.3538, corresponding author

[c] j.van.zundert@robeco.com, +31-10-224.3133.

1. Introduction

Academic research shows that alternative premiums exist beyond the traditional asset class premiums. Research on such alternative premiums, or 'factors', exists for decades, but is predominantly focused on equities. The best documented factors are Low-Risk (Haugen and Heins, 1972), Value (Basu, 1977), Size (Banz, 1981), and Momentum (Jegadeesh and Titman, 1993). For corporate bonds, research has been much more limited. Documented factors are Low-Risk (e.g. Ilmanen, Byrne, Gunasekera and Minikin, 2004 or more recently Frazzini and Pedersen, 2014) and Momentum (e.g. Pospisil and Zhang, 2010, and Jostova, Nikolova, Philipov and Stahel, 2013). However, evidence for corporate bonds on other factors is scarce. We are aware of only one paper on Value (Correia, Richardson and Tuna, 2012) and of none on Size. However, these existing studies on factors in the corporate bond market each focus on one particular factor. We are the first to jointly analyze the Size, Low-Risk, Value and Momentum factors using a consistent methodology on a single data set. This allows us to combine these factors in a multi-factor portfolio and study the added value of factor investing in a multi-asset context.

Using constituent data of the Barclays U.S. Corporate Investment Grade and U.S. Corporate High Yield indexes over the period 1994-2013, we provide empirical evidence that the Size, Low-Risk, Value and Momentum premiums are economically and statistically significant in the corporate bond market. Moreover, we show that the premiums are not a compensation for bearing higher risk. Our results confirm previous work on Low-Risk and Momentum. Further, we confirm and extend the relatively new evidence on Value by Correia et al. (2012). As far as we know, we are the first to demonstrate the existence of a Size premium in the corporate bond market. Our study goes beyond previous work by combining the factors in a multi-factor portfolio. We find that investing in the multi-factor portfolio doubles the Sharpe ratio versus investing in the market index. The annualized alpha of the multi-factor portfolio is 1.00% (3.21%) in Investment Grade (High Yield), which is sizable given the market premium of 0.59% (2.46%). These alphas show that the corporate bond factor premiums are not a compensation for risk as measured by an extensive set of bond and equity factors. Also after transaction costs, the alphas remain substantial. These findings are robust to a variety of sensitivity checks, including alternative factor definitions and portfolio construction choices. Our final contribution is the joint application of factor investing in the equity and the corporate bond market. The results show that the corporate bond factors have added value beyond their counterparts in the equity market: by not only applying factor investing in the equity market, but also in the corporate bond market investors increase the alpha of their multi-asset portfolio by about 1% per year.

Our results have strong implications for strategic asset allocation decisions. Most investors focus on traditional asset classes when determining their strategic investment portfolio. For example, by including stocks, government bonds and corporate bonds, they aim to earn the Equity, Term and Default premiums. Implementation of the actual investment portfolio is typically delegated to external managers. However, the results of our study, in line with results of similar studies on equity markets, suggest that investors should strategically and explicitly allocate to factors instead of relying on external managers to implement factor exposures. A seminal study on this topic is that of Ang, Goetzmann and Schaefer (2009) who were asked by the Norwegian Government Pension Fund to analyze the fund’s performance. The study finds that a large part of the fund’s outperformance versus its strategic benchmark could be explained by factor exposures that were implicitly present in the investment portfolios. Therefore, the authors recommend making the fund’s exposure to factors a “top-down decision rather than emerging as a byproduct of bottom-up active management” (Ang et al., 2009, p. 20). Blitz (2012) argues that investing in factors should be a strategic decision, because of the long-term investment horizon required to harvest the premiums. Bender, Briand, Nielsen and Stefek (2010) and Ilmanen and Kizer (2012) also make the case for strategic allocations to factors, stressing the diversification benefits. Ang (2014) devotes an entire book to factor investing.

The setup of our paper is as follows. In Section 2 we describe the data and methodological framework and in Section 3 the definitions of the four factors in the corporate bond market. Section 4 presents the main empirical results on the single-factor and multi-factor portfolios. In Section 5 we calculate factor premiums after transaction costs. In Section 6 we analyze the added value of factor investing in the corporate bond market in a multi-asset context. Section 7 verifies the robustness of our results using a variety of sensitivity analyses. Section 8 concludes.

2. Data and Methodology

Data

We use monthly constituent data of the Barclays U.S. Corporate Investment Grade index and the Barclays U.S. Corporate High Yield index from January 1994 to December 2013. The data set contains over 1.1 million bond-month observations, of which about 800,000 are in Investment Grade and 300,000 in High Yield. The minimum (maximum) amount of observations per month is 2,456 (4,768) in Investment Grade and 584 (2,086) in High Yield. For each bond in each month, Barclays provide various characteristics, including its market value, time-to-maturity, credit rating, credit spread and return. The data set is survivorship-bias free. Whenever a firm defaults, the final return of its bonds reflects the expected recovery rate.

To evaluate the factor portfolios, we use the excess return of a corporate bond versus duration-matched Treasuries. These excess returns are provided by Barclays as well and accurately remove the Term premium. The Term premium can be efficiently harvested by investing in government bonds, so the main purpose of investing in corporate bonds is to additionally earn the Default premium. By using excess returns over Treasuries we can focus on the Default premium component of the total corporate bond return.

Methodology

For each factor in each month, we construct an equally-weighted corporate bond portfolio, and hold it for 12 months using the overlapping portfolio methodology of Jegadeesh and Titman (1993). This is a realistic holding period and prevents extreme turnover. Following Blitz (2012) and as recommended by Huij, Lansdorp, Blitz and van Vliet (2014) we construct long-only portfolios instead of the long-short portfolios common in the academic literature. For corporate bonds this is even more important than for equities, because shorting corporate bonds is hard and costly in practice. Including the short-side would thus inflate potential benefits beyond those achievable in practice. Consistent with Jegadeesh and Titman (1993) for equities and with Jostova et al. (2013) for corporate bonds, each factor portfolio contains the 10% bonds with the highest exposure to that factor. Next to the four single-factor portfolios, we also analyze a multi-factor portfolio, which combines all four factors. In Section 7 we check the robustness of our results when the factor portfolios contain 20% of the bonds (instead of 10%) or when the bonds in the portfolio are market value-weighted (instead of equally weighted).

The factor portfolios are created separately for Investment Grade and High Yield, following the market convention of treating these segments of the corporate bond market basically as two asset classes. Evidence on the segmentation of the corporate bond market into Investment Grade and High Yield segments is provided by Ambastha, Ben Dor, Dynkin, Hyman and Konstantinovsky (2010) and recently by Chen, Lookman, Schürhoff and Seppi (2014). The segmentation can also be seen in the availability of market indexes, such as those provided by Barclays, J.P. Morgan, Merrill Lynch and Markit, which predominantly cover either Investment Grade or High Yield.

3. Defining factors in the corporate bond market

For each factor definition, we purposely use only bond characteristics, such as rating, maturity and credit spread, and we do not use accounting data, such as leverage and profitability, or equity market information, such as equity returns and equity volatility. This choice makes sure that we can include all bonds in our analyses, and not only bonds issued by companies with publicly listed equity. Our definitions also facilitate the actual implementation of factors in investment portfolios. We acknowledge that accounting and equity market information, or the use of more sophisticated methods, could improve the performance of the factor portfolios. However, by using bond-only definitions we demonstrate that the factor premiums can already be earned using readily available data and methods. In Section 7 we investigate the sensitivity of our results to this specific choice for the factor definitions.

Size

To define the Size factor in the corporate bond market, we use the total index weight of each company, calculated as the sum of the market value weights of all its bonds in the index in that month. We thus look at the total size of a company's public debt instead of the size of individual bonds, because most explanations for the Size effect in equity markets relate to the company size, e.g. incomplete information about small firms, or size being a proxy for (default) risk; see van Dijk (2011) for a literature overview.[4,5] To the best of our knowledge we are the first to report evidence on the presence of a Size effect at the company level in the corporate bond market.

To define the Size factor portfolio, we construct every month a decile portfolio consisting of the 10% bonds with the smallest company index weight.

[4] We do analyze bond size as alternative factor definition in Section 7, although that definition picks up a potential illiquidity premium in the smallest bonds; see e.g. Sarig and Warga (1989).

[5] Alternatively, we could define Size as the market capitalization of the company's equity, the enterprise value or the value of its assets. However, these alternative definitions require that the company has publicly traded equity.

Low-Risk

Previous studies show that bonds with lower risk earn higher risk-adjusted returns. Most papers use maturity and/or rating as risk measures.[6] The short-maturity effect has been documented by for example Ilmanen et al. (2004) and Derwall, Huij and de Zwart (2009); the high-rating effect has been documented by amongst others Kozhemiakin (2007) and Frazzini and Pedersen (2014).

We follow Ilmanen (2011) by using both maturity and rating to construct our Low-Risk factor portfolio. For Investment Grade, we first select all bonds rated AAA to A-, hence excluding the most risky bonds rated BBB+, BBB or BBB-. From these bonds, we select each month all bonds shorter than M years such that the portfolio makes up 10% of the total number of bonds. This maturity threshold M thus fluctuates through time. We use this approach to allow a fair comparison with the other factor portfolios, which also contain 10% of the bonds by definition. For High Yield, we follow the same procedure, selecting bonds rated BB+ to B- in the first step. On average the maturity threshold equals 2.8 years for Investment Grade and 3.7 years for High Yield.[7,8]

[6] One could use more sophisticated risk measures, constructed from accounting and equity market information, see e.g. Houweling, van Vliet, Wang, and Beekhuizen (2014), but these are only available for companies with publicly traded equity.

[7] When choosing which ratings to exclude, we try to balance the rating and maturity effect. In Section 7 we test an alternative definition, which excludes more rating groups (leaving only AAA to AA- for Investment Grade and only BB+ to BB- for High Yield). That definition thus profits more from the rating effect, but less from the maturity effect.

[8] In Section 7 we also test other alternatives, using spread instead of rating, or using Duration Times Spread, like de Carvalho et al. (2014).

Value

The Value effect in equity markets is well-documented and can be summarized as buying companies that are cheap relative to their fundamentals. So, the market value of a company is compared to a fundamental measure, such as earnings or the equity book value. As far as we know, Correia et al. (2012) is the only paper on Value investing in the corporate bond market. They translate the Value concept from equities to credits by comparing the market's assessment of a company's riskiness (i.e. the credit spread) to fundamental risk measures. The study considers a variety of risk measures, including leverage, profitability and the distance-to-default measure of Merton (1974). For consistency with the definition of our Low-Risk factor, we choose rating and maturity as risk measures. The methodology is in the spirit of Correia et al. (2012).

To construct the Value factor portfolio each month, we first run a cross-sectional regression of credit spreads on rating (AAA, AA+, AA, … , C) dummies and time-to-maturity. Specifically, we run the following regression

$$S_i = \alpha + \sum_{r=1}^{21} \beta_r I_{ir} + \gamma M_i + \varepsilon_i, i = 1, \dots, N \qquad (1)$$

where S_i is the spread of bond i, I_{ir} is equal to 1 if bond i has rating r, and 0 otherwise, M_i is the maturity of bond i and N is the number of bonds. Then, following Correia et al. (2012), we calculate the percentage difference between the actual credit spread and the fitted credit spread for each bond. Finally, we select the 10% bonds with the largest percentage deviations.[9]

[9] Again, Section 7 tests alternative definitions of the Value factor, including another specification of the rating dummies and a direct, though naïve, translation of the book-to-market concept.

Momentum

Results in academic studies on the Momentum effect in corporate bonds are mixed. Investment Grade bond returns exhibit either reversal (Khang and King, 2004; Gebhardt, Hvidkjaer and Swaminathan, 2005) or no Momentum effect (Jostova et al., 2013). In the High Yield market, on the other hand, Momentum strategies have been shown to generate profits; see Pospisil and Zhang (2010) and Jostova et al. (2013).

We follow Jostova et al. (2013) by defining Momentum as the past 6-month return using a 1-month implementation lag.[10] As return measure, we use the excess return versus duration-matched Treasuries, for consistency with our return measure for evaluating factor portfolios. The 10% bonds with the highest past returns are selected for the Momentum factor portfolio.

4. The benefits of allocating to factors

In this section we present our main results that factor portfolios in the corporate bond market earn a premium beyond the Default premium and that these premiums are not a compensation for risk. We also highlight the tension between evaluating factors in an absolute or relative risk context and the importance of a long investment horizon. We conclude by showing the diversification benefits of combining the factors in a multi-factor portfolio.

[10] In the robustness checks in Section 7 we also evaluate shorter and longer formation periods for the Momentum factor.

Single-factor portfolios

Table 1 contains the results for the traditional corporate bond market premium (i.e. the Default premium), and the Size, Low-Risk, Value and Momentum factors. Panel A shows that for our sample period 1994-2013, the Default premium amounts to 0.59% a year for Investment Grade, and to 2.46% for High Yield. For both Investment Grade and High Yield we find substantial outperformances for Size (0.75% and 4.02%, respectively), Low-Risk (0.37% and 1.45%), Value (1.92% and 5.38%) and Momentum (0.37% and 2.16%) versus the Default premium; see Panel B. The magnitude of these factor premiums is substantial: investors could have quadrupled their long-term average investment returns by investing in factors as compared to passively investing in the market index. In Section 5 we investigate whether these premiums can still be harvested once transaction costs are taken into account.

For Size and Value the factor premiums are statistically significant for both Investment Grade and High Yield. For Momentum, we only find a statistically significant premium in the High Yield market; the absence of a significant Momentum effect in Investment Grade is in line with the findings in the literature; see e.g. Jostova et al. (2013). The premium for the Low-Risk factor is insignificant in both market segments. However, Low-Risk has a substantially lower volatility than the market, so it does not necessarily have to outperform the market. On the other hand, Value has a much higher volatility than the market, so the question arises whether its return is sufficiently higher to compensate for its higher risk. Therefore, we also calculate risk-adjusted returns to evaluate the factor portfolios.

We adjust for risk in three ways. First of all, in Panel A we measure returns relative to total risk using the Sharpe ratio measure. For Investment Grade the Sharpe ratios are 0.32, 0.42, 0.31 and 0.22 for Size, Low-Risk, Value and Momentum, respectively, which compare favorably to the Sharpe ratio of 0.13 of the market. For High Yield, the Sharpe ratios of the factors are 0.57, 0.57, 0.45 and 0.44, respectively, which are all higher than the Sharpe ratio of the High Yield market of 0.24. Except for Investment Grade Momentum, the Sharpe ratios of all factor portfolios are significantly higher than the Sharpe ratio of the market.

Second, in Panel C, we correct for the systematic risk of a factor portfolio by regressing its return on the Default premium, so

$$R_t = \alpha + \beta \mathrm{DEF}_t + \varepsilon_t \tag{2}$$

where R_t and DEF_t are the return on a factor portfolio and the Default premium in month t, respectively. One could interpret the intercept in this regression as a CAPM-alpha for the corporate bond market, using the Default premium as the market factor.[11] All alphas are positive, large and statistically significant (again except for Momentum in Investment Grade). For Investment Grade, alphas range from 0.43% to 1.52% and for High Yield from 2.28% to 4.25%. These alphas are sizeable compared to the average market returns of 0.59% and 2.46% for Investment Grade and High Yield, respectively.

Third, we correct for systematic risk using the Fama and French (1993) five factor model supplemented with the Carhart (1997) equity momentum factor. We run the following regression to estimate the 6-factor alpha

[11] Note that we do not need to include the Term factor as we use excess returns over duration-matched Treasuries.

$$R_t = \alpha + \beta_1 \text{RMRF}_t + \beta_2 \text{SMB}_t + \beta_3 \text{HML}_t + \beta_4 \text{MOM}_t + \beta_5 \text{TERM}_t + \beta_6 \text{DEF}_t + \varepsilon_t \quad (3)$$

where RMRF_t is the equity market premium, SMB_t the equity Size premium, HML_t the equity Value premium, MOM_t the equity Momentum premium, the TERM_t the default-free interest rate Term premium and DEF_t the Default premium. The four equity factors are downloaded from the website of Kenneth French[12]. The Term factor is constructed as the total return of the Barclays US Treasury 7-10 year index minus the 1-month T-bill rate from Kenneth French.[13] The Default factor is the corporate bond market factor as in the 1-factor model of Panel C. The 6-factor alphas are similar to those in the 1-factor model. For Investment Grade, the alphas vary between 0.18% (Momentum) and 2.23% (Value). For High Yield, the alphas range from 2.25% (Low Risk) to 4.86% (Size). This shows that the corporate bond factors have added value beyond the equity factors. Panels A, C and D show that the higher returns of the factor portfolios are not merely a compensation for risk, because also on a risk-adjusted basis the factor portfolios beat the market index.

Nonetheless, investing in factor portfolios could be considered risky in a *relative* sense, as evidenced by the substantial tracking errors (volatility of the outperformance) in Panel B. For Investment Grade, the tracking errors range from 1.88% to 4.47%, which are fairly large compared to the market volatility of 4.46%. For High Yield, tracking errors range from 3.96% to 9.21%, which are again substantial compared to the High Yield market volatility of 10.33%. As a

[12] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[13] We use this index, because it best matches the average maturity of the corporate bonds. For Investment Grade, the average maturity over our sample period is about 10.9 years, while for High Yield the average is 7.8 years. We could have taken an index containing all maturities, such as the Barclays US Treasury index. However, our results do not materially change as the excess return correlation of the Barclays US Treasury 7-10 year index with the Barclays US Treasury index is very high: 98.6%.

result, the information ratios of the single-factor strategies are not high. This is especially true for the Low-Risk factor, with information ratios of only 0.12 and 0.28 in Investment Grade and High Yield, respectively. On the other hand, the Low-Risk factor does have the highest Sharpe ratio of all individual factors. This highlights the importance of a long-term investment horizon for factor investing, because on shorter horizons factor portfolios may underperform the market index due to their large tracking errors. It also makes clear that single-factor portfolios are unattractive from the point of view of portfolio managers of delegated investment portfolios that are benchmarked to the market index.

[Insert Table 1 here]

Multi-factor portfolio

To determine possible diversification opportunities between the factors, we calculate the pairwise correlations; see Table 2. Panel A shows that most return correlations tend to be in the range of 80% to 90%, reflecting the common exposure to the market of the long-only factor portfolios. Correlations with the Low-Risk factor are somewhat lower, because this factor deviates most (in terms of beta) from the market; see Panel C of Table 1. Panel B of Table 2 shows the correlations between the factors' outperformances versus the market. All correlations are 51% or lower, and even mostly negative in the case of Value. This shows that the factors capture different effects.

[Insert Table 2 here]

Combining the various factors in a single portfolio thus benefits from diversification. We construct a multi-factor portfolio that has equal allocations to each of the factors.[14] Table 1 shows that both for Investment Grade and for High Yield, the multi-factor portfolio has a lower tracking error than each of the single-factor portfolios and a CAPM-beta that is closest to 1. Nonetheless, the alphas and Sharpe ratio are among the highest. The Investment Grade (High Yield) multi-factor portfolio has a Sharpe ratio of 0.33 (0.52), which is more than twice as high as the Sharpe ratio of the market of 0.13 (0.24). The 6-factor alphas are 1.00% and 3.21% per annum, for Investment Grade and High Yield respectively, which are substantial given the market premiums of 0.59% and 2.46%.

Note that one can easily improve upon the Sharpe ratio of the multi-factor portfolio, for example by allocating more to the Low-Risk factor, which has the highest stand-alone Sharpe ratio, or by omitting Momentum from the Investment Grade multi-factor portfolio. However, one should be careful in cherry-picking the results. A multi-factor approach, which balances the individual factors, is a robust method to harvest the various premiums offered in the corporate bond market.

5. Factor premiums after transaction costs

The results in Section 4 show that allocating to factors leads to higher risk-adjusted returns. However, this analysis does not take transaction costs into account. A Momentum strategy, for example, will experience high turnover by nature, and an investor can thus expect to incur higher

[14] Alternatively, one could conduct a portfolio optimization aimed at maximizing the Sharpe ratio. Blitz (2012) demonstrated that a portfolio that has equal allocations to each factor already captures most of the improvements of a multi-factor portfolio compared to single-factor portfolios.

transaction costs than tracking the market index. In this section we show that factor premiums are still present after accounting for transaction costs.

Setup

Recall from Section 2 that we use the overlapping portfolio approach of Jegadeesh and Titman (1993) with a 12-month holding period. This means that for each factor the return in month t is calculated as the average of the factor portfolios constructed from month t-11 to t. Therefore, we calculate the weight of each bond in a factor portfolio as the average weight across these 12 portfolios. The single-counted turnover from month t to month t+1 is subsequently determined as the sum over all weight increments across the portfolio constituents.

We use estimated bid-ask spreads for maturity-rating categories as provided by Chen et al. (2007, Table I). Basically, the higher the risk of the bond, as measured by a longer maturity or a lower credit rating, the larger the estimated transaction costs. We multiply the turnover of the bond with the estimated bid-ask spread to obtain the transaction cost per bond. The transaction cost of the portfolio is the sum of the costs of all bonds traded.

We follow the same methodology to calculate the turnover and the associated transaction costs for the Investment Grade and High Yield market indexes.

Single-factor portfolios

Panel A of Table 3 reports the turnover and transaction costs. First of all, note that the 32% (56%) annualized turnover of the market in Investment Grade (High Yield) indicates that tracking the market comes at a cost.[15] The average transaction costs in Investment Grade amount to 0.39% per bond; this is 0.69% in High Yield, reflecting their higher risk. Combining the turnover with these transaction costs lowers the gross market return by 0.12% for Investment Grade and by 0.39% for High Yield. The after-cost Sharpe ratios are 0.10 and 0.20, respectively.

The four single-factor portfolios have higher turnover than the market, with Size being on the lower end (small companies tend to remain small), and Momentum on the high end, with more than 100% turnover. One may have expected that the Low-Risk portfolio also has low turnover (because ratings tend be fairly sticky). However, as it contains only short-dated bonds, it has to regularly reinvest redeemed notionals from maturing bonds. However, buying short-dated bonds is cheaper than buying longer-dated bonds, so the average transaction costs are lower. Consequently, the costs of implementing a Low-Risk portfolio are among the lowest, together with Size.

Most importantly, Panel B shows that the net Sharpe ratios of Size (0.28), Low-Risk (0.31) and Value (0.27) remain much larger than both the 0.13 gross Sharpe ratio and 0.10 net Sharpe ratio of the Investment Grade market. The net Sharpe ratio of Momentum is approximately equal to the Sharpe ratio of the market. In High Yield, the net Sharpe ratios of all four factors are also higher than both the gross (0.24) and net (0.20) Sharpe ratio of the market: 0.52 for Size, 0.49 for Low-Risk, 0.41 for Value and 0.35 for Momentum (suffers from its high turnover). Panel C shows that the alphas remain substantial and statistically significant after taking transaction costs into account.

[15] The index turnover comes from new bonds entering the index (due to bond issuance or migrations from Investment Grade to High Yield or vice versa) and from bonds leaving the index (due to redemptions, calls, and migrations, or from no longer satisfying the index inclusion rules, e.g. a maturity of less than one year).

Multi-factor portfolio

Combining the factors into a multi-factor portfolio leads to strong performances, also after accounting for transaction costs. In Investment Grade, the after-cost Sharpe ratio is 0.26, versus 0.10 for the market. The annualized after-cost alpha amounts to 0.58% per year. In High Yield, the after-cost Sharpe of the multi-factor portfolio is 0.46, versus 0.20 for the market. Thus, as in Investment Grade, the Sharpe ratio is more than doubled. The alpha is 2.58% per year. Even if the transaction cost estimates of Chen et al. (2007) would be doubled, the single- and multi-factor portfolios would still look favorably (except for Momentum in Investment Grade). Our results thus indicate that the factor premiums remain substantial after accounting for transaction costs.

[Insert Table 3 here]

6. Strategic allocation to factors in a multi-asset context

Investors do not only hold corporate bonds in their portfolios, but also government bonds and equities. In this section we show that allocating to factors leads to improvements in a multi-asset context, also if investors already apply factor investing for their equity investments.

Data

For the equity factors Size, Value and Momentum we use the decile portfolio returns from Kenneth French' website.[12] For Size, we take the equally weighted portfolio consisting of the 10% stocks with lowest market value of equity ("Lo 10"). For Value, we take the equally weighted portfolio containing the 10% stocks with the highest equity book-to-market ratio ("Hi 10"). For Momentum, we take the equally weighted portfolio containing the 10% stocks with the highest past 12-1 month returns ("High"). The construction of these portfolios is most similar to the methodology used in this paper. Unfortunately, Kenneth French does not provide a series for the equity Low-Risk factor. Therefore, we use the returns of the MSCI Minimum Volatility Index, obtained via Bloomberg[16]. For all four equity factor series, we subtract the 1-month T-bill rate ("RF") of Kenneth French. The RMRF factor is used to reflect the equity market premium. We construct the government bond market premium (Term) as the total return of the Barclays US Treasury 7-10 year index minus the 1-month T-bill rate; see also Section 4.

So far, we used excess returns over duration-matched Treasuries to analyze the corporate bond market premiums and factors. To compare them with the equity and government bond premiums, which are all measured as excess returns over the risk-free rate, we add the Term premium to our corporate bond series. This implies that the corporate bond total returns thus constructed have the same interest rate return as the Term factor, so that duration differences do not affect our results.

[16] Bloomberg code: M00IMV$T index

Correlations of individual factors across markets

Table 4 shows the correlations between the corporate bond market and factor portfolios and their respective counterparts in the equity market. For example, we calculate the correlation between the Size portfolio in the equity market and the Size portfolio in the Investment Grade corporate bond market. The first line shows the correlations of the excess returns over the risk-free rate. As the Investment Grade market return is dominated by the Term premium, the correlation between the Investment Grade market premium and the equity market premium is only 18%. For High Yield, the correlation is 58%, reflecting the higher credit risk. We observe a similar difference for the factor portfolios. In Investment Grade, the correlations range from 2% to 36%, whereas for High Yield the correlations are between 30% and 72%. The correlations become lower for the factor outperformances versus their own market, which are shown in the second line in Table 4. The multi-factor portfolios have correlations of 23% and 45% for Investment Grade and High Yield respectively. The third line shows the correlations between the alphas, thus adjusting the outperformances for market exposures. Low-Risk is the only factor for which the beta-adjustment has a large impact on the correlations: they drop from 48% (54%) to 15% (19%) for Investment Grade (High Yield). As the betas of the multi-factor portfolios are close to one, the correlations between the alphas are similar: 24% and 46%. This shows that the alphas of the corporate bond multi-factor portfolios diversify with the alpha of the equity multi-factor portfolio. Hence, factor investing in corporate bond market captures different, though partially similar, effects as factor investing in the equity market.

[Insert Table 4 here]

Multi-asset portfolios

Table 5, Panel A, shows the performance statistics of the market portfolios for equities, government bonds, and Investment Grade and High Yield corporate bonds. As Treasury yields have declined substantially over this sample period, government bonds have generated a large 3.46% annualized excess return over the risk-free rate with a Sharpe ratio of 0.54. This also leads to high Sharpe ratios for the Investment Grade and High Yield market portfolios of 0.61 and 0.64. Note that these Sharpe ratios are higher than the 0.13 and 0.24 mentioned in Table 1, because the return series in Table 5 additionally benefit from the Term premium. The equity market Sharpe ratio of 0.47 is the weakest across the four asset classes.

Panel B shows the same statistics for the multi-factor portfolios in equities and Investment Grade and High Yield corporate bonds. All three multi-factor portfolios have higher returns and Sharpe ratios than their own market portfolios. The Sharpe ratios range from 0.73 (equities) to 0.92 (High Yield). Panel C shows that the multi-factor portfolios also did well in a relative sense, significantly outperforming their market indexes with information ratios between 0.64 and 0.86.

[Insert Table 5 here]

To analyze the added value of factor investing in a multi-asset context, we analyze four portfolios based on Table 5. The first portfolio ("Traditional") consists of 40% equities, 20% government bonds, 20% Investment Grade and 20% High Yield corporate bonds.[17] The second portfolio, "Equity Factor Investing", allocates the 40% equities to the equity multi-factor portfolio instead of the equity market portfolio. The third portfolio, "Corporate Bond Factor

[17] The allocation chosen is arbitrary, and only serves as an example.

Investing", replaces the Investment Grade and High Yield allocations of the Traditional portfolio with their respective multi-factor portfolios. The fourth portfolio, "Equity + Corporate Bond Factor Investing", allocates both to the multi-factor portfolios in the equity market and in the Investment Grade and High Yield corporate bond markets. Panel A of Table 6 summarizes the portfolio weights of these four multi-asset portfolios.

Panel B shows the return statistics of the four portfolios. Clearly, both equity and corporate bond factor investing lead to higher Sharpe ratios: 0.89 and 0.81 versus 0.70 for the Traditional portfolio. However, investing in factors in both the equity and the corporate bond market leads to an even higher Sharpe ratio of 0.97. Panel C shows that not only investing in the equity multi-factor portfolio but also in the corporate bond multi-factor portfolio improves the outperformance from 2.39% to 3.21% and the information ratio from 0.64 to 0.76. Panel D shows the 4-factor alpha relative to the four market portfolios. The alphas of the three portfolios that include at least one multi-factor portfolio are large and highly significant. The "Equity + Corporate Bond Factor Investing" portfolio has an alpha of 3.44%, versus 2.49% for "Equity Factor Investing". This shows that the corporate bond factors add almost 1% alpha for investors beyond their equity counterparts.

[Insert Table 6 here]

7. Robustness checks

In this section we check whether our findings are robust to the specific definition of the factors, the portfolio weighting, the portfolio size, and the performance across subperiods.

Alternative definitions

Although we believe that the definitions presented are suitable representations of the factors, they are by no means the only way to define them. This is similar to the choices one faces when applying factor investing in the equity market, where multiple definitions could be used to capture a factor. For instance, the equity Value factor can be defined as the book-to-market ratio, the price-earnings ratio or the dividend yield. Likewise, Momentum can be calculated over various formation periods. In Appendix A we describe our alternative definitions for the corporate bond market.

Table 7 shows key statistics for the alternative factor definitions as well as for the base case definitions to facilitate the comparison. For the Size factor, we consider bond size as alternative to company size. The bond size measure yields a significant Sharpe ratio for High Yield of 0.56, but not for Investment Grade (0.23). There are two possible explanations. Firstly, the alternative definition measures *bond* size rather than *company* size, so that it proxies bond illiquidity; see Sarig and Warga (1989). Since Investment Grade bonds are generally more liquid than High Yield bonds (see Chen et al., 2007, Table I), the illiquidity premium is likely to be lower in Investment Grade. Secondly, a large part of the companies in the High Yield market has only one bond in the index (on average 65% versus 30% for Investment Grade), so that the difference between selecting small bonds or small companies is smaller.

For the Low-Risk factor there is a strong consistency in the results, because all three alternative definitions generate significantly positive alphas and Sharpe ratios that are significantly above that of the market. The Sharpe ratios vary between 0.34 (0.52) and 0.68 (0.66) for Investment Grade (High Yield), and the alphas vary between 0.57% (1.47%) and 0.72% (2.44%).

For the Value factor the results are also very robust. For Investment Grade, all alphas (1.40% to 1.65%) and Sharpe ratios (0.29 to 0.32) pass the significance tests; for High Yield all alphas (2.40% to 4.54%) are significant and only one definition fails the Sharpe ratio significance test, even though it is still higher than the Sharpe ratio of the market.

Finally, for Momentum we find that all formation periods up to 9 months have significant results, but that the 12-month momentum results are not significant. For Investment Grade, only the shortest formation period of 3 months generates a significantly positive alpha of 0.59%. In High Yield, the alphas range from 2.49% (3-month) to 0.83% (12-month). As noted before, the absence of a Momentum effect in Investment Grade is a common finding in the literature.

It is evident from Table 7 that the results are robust to alternative definitions of the factors.

[Insert Table 7 here]

Other robustness checks

Besides testing alternative definitions, we conduct three additional robustness checks.[18] First, we evaluate market value-weighted portfolios instead of equally weighted. This means that the portfolios do not benefit from the Size premium, leading to lower returns. The return of the multi-factor portfolio decreases from 1.44% (5.72%) to 1.20% (5.13%) for Investment Grade

[18] The tables of these analyses are not included in the paper for space reasons, but are available on request.

(High Yield). The Sharpe ratios also drop to 0.27 and 0.46 from 0.33 and 0.52 respectively, but are still highly significant with *t*-statistics larger than 2.5. A similar picture emerges for the 1-factor alphas. The alphas drop from 0.89% (3.27%) to 0.63% (2.61%) for Investment Grade (High Yield). The *t*-statistics remain high, at 2.61 (3.10).

Second, we evaluate the factors using quintile portfolios instead of decile portfolios. In general, the results become a bit weaker, as the portfolios are less tilted to the factors. The return decreases from 1.44% (5.72%) to 1.17% (4.36%) for Investment Grade (High Yield). The Sharpe ratios drop to 0.29 and 0.43 respectively. However, the *t*-statistics remain large, 3.13 and 2.91, indicating that the multi-factor portfolios still perform significantly better than the market. Also, the alphas remain large and highly significant at 0.65% and 2.05% for Investment Grade and High Yield.

Third, we check the robustness of our results in subsamples. It could, for example, be that our results are driven by the higher market volatility since 2007. We split our 20-year sample period in two subsamples of 10 years each: 1994-2003 and 2004-2013. The Sharpe ratio of the Investment Grade multi-factor portfolio over the subperiod 1994-2003 (2004-2013) is 0.50 (0.30), versus 0.33 full sample. The alpha is 0.83% (0.96%) with a t-statistic of 2.78 (1.97). In High Yield, the Sharpe ratio of the multi-factor portfolio is 0.37 and 0.64 for 1994-2013 and 2004-2013 respectively. The alphas are 3.06% (with a *t*-statistic of 2.48) and 3.33% (*t*-statistic of 2.84) respectively.

All robustness checks clearly indicate that the results are robust.

8. Conclusions and implications

In this paper, we provide empirical evidence that explicitly allocating to the four well-known factors Size, Low-Risk, Value and Momentum, delivers economically meaningful and statistically significant premiums in the corporate bond market. These premiums cannot be explained by risk or by exposures to the equivalent equity factors. Both single-factor and multi-factor portfolios show strong improvements versus the market in the Sharpe ratio over the period 1994-2013. The Investment Grade multi-factor portfolio has a Sharpe ratio of 0.33, versus 0.13 for the market. In High Yield, the Sharpe ratio improvement is of a similar magnitude, from 0.24 to 0.52. The alphas are 1.00% and 3.21% per annum, for Investment Grade and High Yield respectively. These alphas are statistically significant and are of large magnitude compared to the Investment Grade (High Yield) Default premiums over this period of 0.59% (2.46%). Also after transaction costs, the returns and alphas of the single-factor and multi-factor portfolios remain large and statistically significant. In addition, we find that the corporate bond factors have added value to the equity factors. Investors that already apply factor investing in the equity market can add approximately 1% alpha and 0.1 Sharpe ratio by allocating to factors in the corporate bond market too.

Our results are robust to various checks regarding the construction of the factor portfolios. Importantly, we find a strong consistency between the results using a variety of alternative factor definitions. We purposely limited our scope to factor definitions that only use readily available bond characteristics. We leave it for follow-up research to investigate the added value of incorporating data beyond the bond market, e.g. accounting and equity market information, or applying more sophisticated computational methods.

We see several advantages of investing in a multi-factor portfolio over selecting only the most successful factor in the past. Firstly, diversifying across factors protects against the possible underperformance of one or more factors for prolonged periods of time; see also Bender et al. (2010) and Ilmanen and Kizer (2012) for a more detailed exposition on the diversification benefits of allocating to factors. Secondly, the tracking errors of individual factors to the market are relatively large, but given the modest correlations between the factors' outperformances, the tracking error of the multi-factor portfolio is well below the average of the tracking errors per factor. Thirdly, the magnitude of the premiums realized in the past may not be representative for the future. So, the best-performing factor in the past might not be the winning factor in the future.

What about the implementation of factors in actual investment portfolios? Traditionally, investors delegate the implementation of their investment portfolios to contracted external managers. However, these investment managers, being benchmarked to the market index, might not be willing to implement certain factors, because of their large tracking errors or limited information ratios. The Low-Risk factor, for example, does not yield a high information ratio in either Investment Grade or High Yield. Therefore, the traditional paradigm of delegated and benchmarked asset management, at best leads to implicit and time-varying exposures to factors, and at worst to no exposures at all.

In an absolute-risk framework, evaluated by the Sharpe ratio instead of the information ratio, allocating to factors does offer clear benefits. Factor investing is thus a strategic choice: in the short run, the tracking error versus the market may be large, but in the longer run higher risk-adjusted returns lure on the horizon. Investors should therefore seek managers that explicitly and consistently implement factor exposures in their investment strategy.

At the moment investors do not have many investment vehicles available to harvest factor premiums in the corporate bond market.[19] In equity markets, Value, small cap and low-vol funds are numerously available. Therefore, with the increasing popularity of the factor investing concept, we expect this to change in the near future in the corporate bond market too.

[19] The exceptions are various funds exclusively investing in short-dated corporate bonds, hence partially offering exposure to the Low-Risk factor.

References

Ang, A. (2014), Asset Management: A Systematic Approach to Factor Investing, Oxford University Press

Ang, A., Goetzmann, W.N., and Schaefer, S.M. (2009), Evaluation of Active Management of the Norwegian Government Pension Fund – Global

Ambastha, M., Ben Dor, A., Dynkin, L., Hyman, J., and Konstantinovsky, V. (2010), Empirical Duration of Corporate Bonds and Credit Market Segmentation, *The Journal of Fixed Income*, Vol. 20, No. 1, pp. 5-27

Banz, R.W. (1981), The Relationship Between Return and Market Value of Common Stocks, *Journal of Financial Economics*, Vol. 9, No. 1, pp. 3-18

Basu, S. (1977), Investment Performance of Common Stocks in Relation to Their Price-Earnings Ratios: A Test of the Efficient Market Hypothesis, *The Journal of Finance*, Vol. 32, No. 3, pp. 663-682

Ben Dor, A., Dynkin, L., Hyman, J., Houweling, P., van Leeuwen, E., and Penninga, O. (2007) DTS (Duration Times Spread): A New Measure of Spread Exposure in Credit Portfolios, *The Journal of Portfolio Management*, Vol. 33, No. 2, pp. 77-100

Bender, J., Briand, R., Nielsen, F., and Stefek, D. (2010), Portfolio of Risk Premia: A New Approach to Diversification, *The Journal of Portfolio Management*, Vol. 36, No. 2, pp. 17-25

Blitz, D.C. (2012), Strategic Allocation to Premiums in the Equity Market, *The Journal of Index Investing*, Vol. 2, No. 4, pp. 42-49

Carhart, M. M. (1997), On Persistence in Mutual Fund Performance, *The Journal of Finance*, Vol. 52, No. 1, pp. 57-82

Chen, L., Lesmond, D.A., and Wei, J. (2007), Corporate Yield Spreads and Bond Liquidity, *The Journal of Finance*, Vol. 62, No.1, pp. 119-149

Chen, Z., Lookman, A.A., Schürhoff, N., and Seppi, D.J. (2014), Rating-Based Investment Practices and Bond Market Segmentation, working paper

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

de Carvalho, R.L., Dugnolle, P., Lu, X., and Moulin, P. (2014), Low-Risk Anomalies in Global Fixed Income: Evidence from Major Broad Markets, *The Journal of Fixed Income*, Vol. 23, No. 4, pp. 51-70

Derwall, J., Huij, J., and de Zwart, G. (2009), The Short-Term Corporate Bond Return Anomaly, working paper

Fama, E. F., and French, K. R. (1993), Common Risk Factors in the Returns on Stocks and Bonds, *Journal of Financial Economics*, Vol. 33, No. 1, pp. 3-56

Frazzini, A., and Pedersen, L. H. (2014), Betting against Beta, *Journal of Financial Economics*, Vol. 111, No. 1, pp. 1-25

Gebhardt, W. R., Hvidkjaer, S., and Swaminathan, B. (2005), Stock and Bond Market Interaction: Does Momentum Spill Over?, *Journal of Financial Economics*, Vol. 75, No. 3, pp. 651-690

Haugen, R.A., and Heins, A.J. (1972), On the Evidence Supporting the Existence of Risk Premiums in the Capital Market, working paper

Houweling, P., van Vliet, P., Wang, R., and Beekhuizen, P. (2014), The Low-Risk Effect in the Corporate Bond Market, working paper

Huij, J., Lansdorp, S.D., Blitz, D., and van Vliet, P. (2014), Factor Investing: Long-Only versus Long-Short, working paper

Ilmanen, A. (2011), Expected Returns: An Investor's Guide to Harvesting Market Rewards. John Wiley & Sons

Ilmanen, A., Byrne, R., Gunasekera, H., and Minikin, R. (2004), Which Risks Have Been Best Rewarded?, *The Journal of Portfolio Management*, Vol. 30, No. 2, pp. 53-57

Ilmanen, A., and Kizer, J. (2012), The Death of Diversification Has Been Greatly Exaggerated, *The Journal of Portfolio Management*, Vol. 38, No. 3, pp. 15-27

Jegadeesh, N., and Titman, S. (1993), Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency, *The Journal of Finance*, Vol. 48, No. 1, pp. 65-91

Jobson, J.D., and Korkie, B.M. (1981), Performance Hypothesis Testing with the Sharpe and Treynor Measures, *The Journal of Finance*, Vol. 36, No. 4, pp. 889-908

Jostova, G., Nikolova, S., Philipov, A., and Stahel, C.W. (2013), Momentum in Corporate Bond Returns, *Review of Financial Studies*, Vol. 26, No. 7, pp. 1649-1693

Khang, K., and King, T. H. D. (2004), Return Reversals in the Bond Market: Evidence and Causes, *Journal of Banking and Finance*, Vol. 28, No. 3, pp. 569-593

Kozhemiakin, A.V. (2007), The Risk Premium of Corporate Bonds, *The Journal of Portfolio Management*, Vol. 33, No. 2, pp. 101-109

Merton, R. C. (1974), On the Pricing of Corporate Debt: The Risk Structure of Interest Rates, *The Journal of Finance*, Vol. 29, No. 2, pp. 449-470

Pospisil, L., and Zhang, J. (2010), Momentum and Reversal Effects in Corporate Bond Prices and Credit Cycles, *The Journal of Fixed Income*¸ Vol. 20, No. 2, pp. 101-115

Sarig, O., and Warga, A.D. (1989), Bond Price Data and Bond Market Liquidity, *Journal of Financial and Quantitative Analysis*, Vol. 24, No. 3, pp. 367–378

van Dijk, M. (2011), Is Size Dead? A Review of the Size Effect in Equity Returns, *Journal of Banking and Finance*, Vol. 35, No. 12, pp. 3263-3274

Appendix A: Alternative definitions

Our base case definition for Size**,** to which we will now refer as S0, is the total market capitalization of all bonds of an issuer in the index. Our alternative definition, S1, does not look at *company* size, but at *bond* size, by selecting the 10% of the bonds with the smallest market capitalization in the index.

For Low-Risk the base case definition LR0 selects the 10% shortest-maturity bonds within the highest ratings: AAA/AA/A for Investment Grade and BB/B for High Yield. Our first alternative definition, LR1, is more restrictive in the rating dimension by choosing from AAA- and AA-rated bonds in Investment Grade and from BB-rated bonds in High Yield. Otherwise, LR1 uses the same construction method. Our second alternative definition for Low-Risk, LR2, uses spread and maturity as risk measures, instead of rating and maturity like in the base case. LR2 selects the 1/3 of the bonds with the shortest maturities within the 1/3 of the bonds with the lowest credit spreads. It thus contains 11% of the bonds, which is very close to the 10% used in the previous definitions. The final alternative definition, LR3, selects the 10% of the bonds with the lowest Duration Times Spread (DTS). Ben Dor et al. (2007) provide strong evidence that DTS is a predictor of the volatility of a corporate bond. De Carvalho et al. (2014) demonstrate the existence of a low-risk effect across various fixed income markets using DTS as risk measure.

The Value base case definition V0 conducts a regression of spread on minor rating (AAA, AA+, AA, … C) dummies and maturity and selects the 10% bonds for which the percentage deviation between the market spread and the fitted spread is the largest. The first alternative definition, V1, uses less rating dummies, only for the major ratings (AAA, AA, A, BBB, BB, B, CCC, CC and C). The next definition, V2, also uses rating and maturity just like the base case, but instead of a regression, it first creates three equally populated maturity buckets within each major rating group[20] and then selects the 10% highest spreads within each rating x maturity peer group. Finally, Value definition V3 is a direct translation of the book-to-market measure in the equity market by selecting the 10% of the bonds with the highest ratio of its notional amount to its market value (i.e. the reciprocal of the bond price).

For Momentum we use a formation period of 6 months in the base case definition M0. For the alternative definitions M1, M2 and M3 we change the formation period to 3 months, 9 months and 12 months, respectively.

[20] We add AAA's to AA's and CC's and C's to CCC's as these groups are otherwise too small to create meaningful comparisons.

Table 1: Performance statistics of factor portfolios

This table shows performance statistics of the market and the Size, Low-Risk, Value and Momentum factors for U.S. Investment Grade and U.S. High Yield corporate bonds over the period January 1994 - December 2013. The factor return in month *t* is calculated as the average of the factor portfolios constructed from month *t-11* to *t*. Each month, a factor portfolio takes equally-weighted long positions in 10% of the bonds: for Size, the bonds with the smallest market value of debt of their issuer in the index; for Value, the bonds with the highest percentage deviation between their market spread and the fitted spread from a regression on rating dummies and maturity; for Momentum, the bonds with the highest past 6-month return, implemented with a 1-month lag; for Low-Risk, the short-maturity bonds within AAA/AA/A (BB/B) in Investment Grade (High Yield). The multi-factor portfolio is an equally weighted combination of Size, Low-Risk, Value and Momentum. Panel A shows the return statistics. Panel B shows the outperformance statistics. Panel C shows the CAPM-alpha and -beta, where the market factor is the factor in the first column. Panel D shows the 6-factor (RMRF, SMB, HML, MOM, TERM and DEF) alpha. Mean, volatility, outperformance, tracking error and alphas are annualized. *,** and *** indicate statistical significance at the 90%, 95% and 99% confidence levels, respectively, of one-sided tests whether the Sharpe ratio of a factor portfolio is larger than the Sharpe ratio of the market (Panel A, Jobson and Korkie (1981)-test), whether the outperformance of a factor portfolio versus the market is larger than 0 (Panel B, *t*-test), and whether the alphas of a factor portfolio are larger than 0 (Panel C and D, *t*-tests).

	Investment Grade						*High Yield*					
	Market	Size	Low-Risk	Value	Momentum	Multi-factor	Market	Size	Low-Risk	Value	Momentum	Multi-factor
Panel A: Return statistics												
Mean	0.59%	1.34%	0.96%	2.51%	0.96%	1.44%	2.46%	6.48%	3.91%	7.85%	4.63%	5.72%
Volatility	4.46%	4.13%	2.26%	8.20%	4.39%	4.38%	10.33%	11.37%	6.91%	17.38%	10.60%	10.94%
Sharpe ratio	0.13	0.32**	0.42**	0.31**	0.22	0.33***	0.24	0.57***	0.57***	0.45**	0.44***	0.52***
t-stat JK test		1.65	1.93	1.91	0.91	3.17		2.48	3.07	2.13	2.33	3.53
Panel B: Outperformance statistics												
Outperformance		0.75%*	0.37%	1.92%**	0.37%	0.85%***		4.02%***	1.45%	5.38%***	2.16%***	3.25%***
Tracking error		2.25%	3.06%	4.47%	1.88%	1.22%		6.49%	5.24%	9.21%	3.96%	3.81%
Information ratio		0.33	0.12	0.43	0.20	0.70		0.62	0.28	0.58	0.55	0.86
t-stat		1.49	0.54	1.92	0.88	3.14		2.77	1.24	2.61	2.44	3.82
Panel C: CAPM-statistics												
alpha		0.87%**	0.72%**	1.52%**	0.43%	0.89%***		4.25%***	2.44%***	4.11%***	2.28%***	3.27%***
beta		0.80	0.39	1.69	0.90	0.94		0.91	0.60	1.52	0.95	0.99
t-stat		1.87	2.26	2.08	1.06	3.31		2.94	3.45	2.44	2.59	3.83
Panel D: 6-factor												
alpha		0.77%*	0.81%***	2.23%***	0.18%	1.00%***		4.86%***	2.25%***	3.34%**	2.41%***	3.21%***
t-stat		1.64	2.59	2.99	0.46	3.69		3.36	3.47	2.03	2.78	3.82

Table 2: Correlation statistics of factor portfolios

This table shows pairwise correlations between the market, the Size, Low-Risk, Value and Momentum factors and the multi-factor portfolio for U.S. Investment Grade and U.S. High Yield corporate bonds over the period from January 1994 to December 2013. See Table 1 for details on the factors and the multi-factor portfolio. Panel A shows the pairwise correlations between the returns of the market and the factors. Panel B shows the pairwise correlations of the outperformance of the factors over the market.

	US Investment Grade						*US High Yield*					
	Market	Size	Low-Risk	Value	Momentum	Multi-factor	Market	Size	Low-Risk	Value	Momentum	Multi-factor
Panel A: Return correlations												
Market	1.00	0.87	0.78	0.92	0.91	0.96	1.00	0.82	0.89	0.90	0.93	0.94
Size		1.00	0.60	0.83	0.85	0.92		1.00	0.77	0.86	0.87	0.93
Low-Risk			1.00	0.82	0.54	0.79			1.00	0.89	0.80	0.90
Value				1.00	0.81	0.97				1.00	0.88	0.97
Momentum					1.00	0.90					1.00	0.94
1/N						1.00						1.00
Panel B: Outperformance correlations												
Size		1.00	0.25	-0.14	0.37	0.63		1.00	0.20	0.31	0.51	0.81
Low-Risk			1.00	-0.46	-0.07	0.29			1.00	-0.26	0.00	0.27
Value				1.00	-0.27	0.46				1.00	0.13	0.68
Momentum					1.00	0.26					1.00	0.56
1/N						1.00						1.00

Table 3: Performance statistics of decile portfolios after transaction costs

This table shows turnover statistics and net performance of the market, the Size, Low-Risk, Value and Momentum factors and the multi-factor portfolio for U.S. Investment Grade and U.S. High Yield corporate bonds over the period from January 1994 to December 2013. See Table 1 for details on the factors and the multi-factor portfolio. Panel A shows single-counted turnover, average transaction costs per bond and total transaction costs. Transaction costs are calculated as in Chen, Lesmond and Wei (2007). Panel B shows the net return statistics. Turnover, transaction costs, gross return, net return and volatility are annualized. Panel C shows the CAPM-alpha and -beta, where the market factor is the factor in the first column. *,** and *** indicate statistical significance at the 90%, 95% and 99% confidence levels, respectively, of one-sided tests whether the alpha of a factor portfolio is larger than 0 (Panel C, *t*-test).

	Investment Grade						*High Yield*					
	Market	Size	Low-Risk	Value	Momentum	Multi-factor	Market	Size	Low-Risk	Value	Momentum	Multi-factor
Panel A: Turnover and transaction costs												
Turnover	32%	51%	95%	80%	105%	83%	56%	74%	92%	98%	119%	96%
Avg. transaction	0.39%	0.39%	0.26%	0.40%	0.44%	0.37%	0.69%	0.83%	0.56%	0.70%	0.78%	0.72%
Transaction costs	0.12%	0.20%	0.25%	0.32%	0.46%	0.31%	0.39%	0.61%	0.52%	0.69%	0.93%	0.69%
Panel B: Net return statistics												
Gross return	0.59%	1.34%	0.96%	2.51%	0.96%	1.44%	2.46%	6.48%	3.91%	7.85%	4.63%	5.72%
Net return	0.47%	1.14%	0.71%	2.19%	0.50%	1.14%	2.08%	5.87%	3.39%	7.16%	3.70%	5.03%
Volatility	4.46%	4.13%	2.26%	8.20%	4.39%	4.38%	10.33%	11.37%	6.91%	17.37%	10.59%	10.94%
Net Sharpe ratio	0.10	0.28	0.31	0.27	0.11	0.26	0.20	0.52	0.49	0.41	0.35	0.46
Panel C: Net CAPM-statistics												
Net alpha	-0.12%	0.67%*	0.48%*	1.19%*	-0.03%	0.58%**	-0.39%	3.63%***	1.93%***	3.43%**	1.35%*	2.58%***
Beta	1.00	0.80	0.39	1.69	0.90	0.95	1.00	0.91	0.59	1.52	0.95	0.99
Net t-stat		1.43	1.50	1.64	-0.07	2.16		2.52	2.72	2.03	1.54	3.03

Table 4: Correlations between corporate bond and equity market and factor portfolios

This table shows the correlations of the Size, Low-Risk, Value and Momentum factors for U.S. Investment Grade and U.S. High Yield corporate bonds over the period from January 1994 to December 2013 with their U.S. equity counterparts. For the corporate bond single-factor and multi-factor portfolios we use the series as described in Table 1, where we add the Term premium to each series to obtain total returns. For the equity factors we download data from Kenneth French's website: "RMRF" for the market factor, "Lo 10" for Size, "Hi 10" for Value and "High" for Momentum; for the equity Low-Risk factor we download the "M00IMV$T" series from Bloomberg, which contains the MSCI Minimum Volatility Index. The left-hand side of the table shows correlations for Investment Grade, the right-hand side shows the same for High Yield. We calculate correlations between the equity and corporate bond series using (A) the excess return of each series over the 1-month T-bill rate ("RF" from Kenneth French' website), (B) the outperformance of each factor portfolio versus its own market and (C) the alpha of each factor portfolio, calculated as the intercept of a regression of the portfolio on its own market.

	Investment Grade						*High Yield*					
	Market	Size	Low-Risk	Value	Momentum	Multi-factor	Market	Size	Low-Risk	Value	Momentum	Multi-factor
A: Return	0.18	0.09	0.02	0.36	0.14	0.15	0.58	0.51	0.30	0.72	0.51	0.60
B: Outperformance		0.08	0.48	0.41	0.13	0.23		0.22	0.54	0.62	0.22	0.45
C: Alpha		0.08	0.15	0.39	0.10	0.24		0.29	0.19	0.53	0.25	0.46

Table 5: Performance statistics government bonds market, corporate bond and equity market and factor portfolios

This table shows the performance statistics for equities, government bonds and U.S. Investment Grade and U.S. High Yield corporate bonds over the period from January 1994 to December 2013. The government bond index is the Barclays US Treasury 7-10 year index. See Table 4 for details on the corporate bond and equity series. Panel A shows the mean, volatility and Sharpe ratio of the excess return over the 1-month T-bill rate for the market portfolios. Panel B shows the same statistics for the multi-factor portfolios for equities and Investment Grade and High Yield corporate bonds. Panel C shows the outperformance statistics. Mean, volatility, outperformance and tracking error are annualized. *,** and *** indicate statistical significance at the 90%, 95% and 99% confidence levels, respectively, of one-sided tests whether the Sharpe ratio of a factor portfolio is larger than the Sharpe ratio of the market (Panel B, Jobson and Korkie (1981)-test), and whether the outperformance of a factor portfolio versus the market is larger than 0 (Panel C, *t*-test).

		corporate bonds		
	government bonds	Investment Grade	High Yield	equities
Panel A: Market				
Mean	3.46%	4.05%	5.93%	7.43%
Volatility	6.39%	6.60%	9.31%	15.66%
Sharpe ratio	0.54	0.61	0.64	0.47
Panel B: Multi-factor portfolio				
Mean		4.90%	9.18%	13.41%
Volatility		6.38%	9.96%	18.35%
Sharpe ratio		0.77***	0.92***	0.73**
t-stat JK test		3.65	3.17	2.13
Panel C: Outperformance statistics				
Outperformance		0.85%***	3.25%***	5.98%***
Tracking error		1.22%	3.81%	9.38%
Information ratio		0.70	0.86	0.64
t-stat		3.14	3.82	2.85

Table 6: Performance statistics multi-asset portfolios

This table shows performance statistics of four multi-asset portfolios consisting of government bonds, corporate bonds and equities over the period from January 1994 to December 2013. All portfolios are constructed using the portfolios displayed in Table 5. The Traditional portfolio invests 40% in equities, 20% in government bonds, 20% in Investment Grade corporate bonds and 20% in High Yield corporate bonds. The "Equity Factor Investing" portfolio only applies factor investing in the equity market. The "Corporate Bond Factor Investing" only applies factor investing in the corporate bond market. The "Equity + Corporate Bond Investing" portfolio applies factor investing in both the equity and corporate bond markets. Panel A shows the portfolio weights. Panel B shows the statistics of the excess return over the 1-month T-bill rate. Panel C shows the outperformance statistics. Panel D shows the alpha of a regression of the portfolio return on the four market returns (Table 5, Panel A). Mean, volatility, outperformance, tracking error and alpha are annualized. *, ** and *** indicate statistical significance at the 90%, 95% and 99% confidence levels, respectively, of one-sided tests whether the Sharpe ratio of portfolio is larger than the Sharpe ratio of the traditional portfolio (Panel B, Jobson and Korkie (1981)-test), whether the outperformance of a portfolio versus the traditional portfolio is larger than 0 (Panel C, *t*-test), and whether the alpha of the portfolio is larger than 0 (Panel D, *t*-test).

	Traditional	Equity Factor Investing	Corporate Bond Factor Investing	Equity + Corporate Bond Factor Investing
Panel A: Weights				
Government bond market	20%	20%	20%	20%
Investment Grade corporate bond market	20%	20%		
High Yield corporate bond market	20%	20%		
Equity market	40%		40%	
Investment Grade corporate bond multi-factor			20%	20%
High Yield corporate bond multi-factor			20%	20%
Equity multi-factor		40%		40%
Panel B: Return statistics				
Mean	5.66%	8.05%	6.48%	8.87%
Volatility	8.13%	9.05%	8.03%	9.13%
Sharpe ratio	0.70	0.89**	0.81***	0.97***
t-stat JK test		1.98	4.18	2.50
Panel C: Outperformance statistics				
Outperformance		2.39%***	0.82%***	3.21%***
Tracking error		3.75%	0.93%	4.23%
Information ratio		0.64	0.89	0.76
t-stat		2.85	3.96	3.40
Panel D: Alpha				
alpha		2.49%***	0.95%***	3.44%***
t-stat		3.13	4.50	3.78

Table 7: Performance statistics of factor portfolios for various factor definitions

This table shows performance statistics of the base case and alternative definitions of the Size, Low-Risk, Value and Momentum factors for U.S. Investment Grade and U.S. High Yield corporate bonds over the period from January 1994 to December 2013. See Table 1 for details on the construction of the factor portfolios and Appendix A for the definition of the factors. The left-hand side of the table shows the mean, volatility, Sharpe ratio and CAPM-alpha for Investment Grade, the right-hand side shows the same for High Yield. Mean, volatility and alpha are annualized. *,** and *** indicate statistical significance at the 90%, 95% and 99% confidence levels, respectively, of one-sided tests whether the Sharpe ratio of a factor portfolio is equal to the Sharpe ratio of the market (Jobson and Korkie (1981)-test) and whether the CAPM-alpha of a factor portfolio is larger than 0 (*t*-test).

	Investment Grade				*High Yield*			
	Mean	Volatility	Sharpe ratio	CAPM-alpha	Mean	Volatility	Sharpe ratio	CAPM-alpha
Panel A: Size								
S0: Company size	1.34%	4.13%	0.32**	0.87%**	6.48%	11.37%	0.57***	4.25%***
S1: Bond size	1.30%	5.60%	0.23	0.67%	8.94%	15.96%	0.56***	5.80%***
Panel B: Low Risk								
LR0: AAA/AA/A, BB/B; short maturity	0.96%	2.26%	0.42**	0.72%**	3.91%	6.91%	0.57***	2.44%***
LR1: AAA/AA, BB; short maturity	0.90%	2.66%	0.34**	0.57%***	3.60%	6.00%	0.60***	2.27%***
LR2: Spread x Maturity	0.79%	1.32%	0.60***	0.64%***	2.49%	4.76%	0.52***	1.47%***
LR3: DTS	0.73%	1.08%	0.68***	0.61%***	2.61%	3.98%	0.66***	1.78%***
Panel C: Value								
V0: Spread regression maturity minor rating	2.51%	8.20%	0.31**	1.52%**	7.85%	17.38%	0.45**	4.11%**
V1: Spread regression maturity major rating	2.53%	8.30%	0.30**	1.52%**	6.61%	17.48%	0.38*	2.85%**
V2: Rating x maturity x spread	2.65%	8.18%	0.32**	1.65%***	6.24%	17.68%	0.35	2.40%*
V3: Book-to-market	2.43%	8.37%	0.29**	1.40%**	9.05%	21.99%	0.41*	4.54%**
Panel D: Momentum								
M0: 6-month	0.96%	4.39%	0.22	0.43%	4.63%	10.60%	0.44***	2.28%***
M1: 3-month	1.23%	5.10%	0.24*	0.59%*	5.07%	11.49%	0.44***	2.49%***
M2: 9-month	0.66%	3.95%	0.17	0.21%	3.74%	9.93%	0.38*	1.58%**
M3: 12-month	0.42%	3.83%	0.11	-0.01%	2.92%	9.72%	0.30	0.83%